Indigenous Trees and Shrubs in Silvopastoral Systems of the Bamenda Highlands of Cameroon

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***Abstract*-In the dry savannas characterized by seasonal fluctuations in pasture ecological resources and extensive grazing systems involving transhumance, trees and shrubs are essential perennial components of rangelands. This tree and shrub germplasm helps in alleviating dry season forage shortages. Unfortunately, it is being eroded for multipurpose uses and also data on these resources are haphazardly documented for the afro-alpine areas. The study uses a combination of primary and secondary data sources to describe the significance of afro-alpine ecological niches for silvopastoral development, the current range condition and its potential in trees and shrubs as browse plants that can alleviate dry season forage shortages. Three pasture ecological zones based on altitude are identified. Zone 1, 2, and 3; possess 17, 25 and 6 browse plants respectively. These form large plant communities in the transition zones (zone 2). The study identifies the scope for their integration in crop-livestock production systems and finally, recommends that further research should focus on the analysis of the nutritive quality of the plants, the frequency of occurrence in each habitat and their methods of propagation. These could be sufficiently rich in their crude protein content so as to maintain animals during the drought season.**

Keywords-Indigenous trees and shrubs, browse plants, silvopastoral, afro-alpine, crop-livestock production system.

I. INTRODUCTION

The roles of trees and shrubs in traditional farming systems in general are very wide and have been described by many authors (Everist, 1972; Walker, 1980; Le Houerou, 1987; Beets, 1989; Behmel and Neumann, 1982; Boudet and Toutan, 1980; Getahun, 1984; Getahun, 1979; Harowitz and Badi, 1981). Their roles are extremely varied and dependent to a large extent, on indigenous land use practices, ecology and vegetation, population density, indigenous knowledge base, beliefs and values, level of household income and socio-cultural habits. Over the years information on multipurpose trees and shrubs in the highlands of Cameroon has been haphazardly recorded. Most of the previous research effort has focused on agroforestry and tended to neglect silvopastoral development. This explains to a large extent, why the potentials of these germplasm are not rationally exploited by graziers. This paper describes the afro-alpine range ecological niches of the Bamenda Highlands and assesses the potential of trees and shrubs as browse plants that can alleviate dry season forage shortages for ruminants in different ecological niches. With increasing pressure on land, rapid biogenetic erosion in alpine regions and drastic seasonal fluctuations in range ecological resources in the drier tropics, there is a need to improve the utilization efficiency of trees and shrubs in crop-livestock production systems.efficiency of trees and shrubs in crop-livestock production systems.

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II. THE STUDY AREA CHARACTERIZATION

The dominant geographical feature is the high lava plateau, above 1500 m with its mountainous backbone composed of Mount Lefo (2550 m), Foleshele (2621 m), Mount Oku (3011 m), and Mount Binka (2222 m). At the foot of the west and northeast facing scarps is an undulating erosion surface (1000 to 1500 m). Embayed in the mountain block are valleys and depressions between 300 and 900 m above sea level.

The study area is found in the North West Province of Cameroon. It has a land surface area of 17,836 km2. The area is characterized by very diverse ecological zones described by Keay (1953), Hawkins and Brunt (1965) and Champaud (1973). Topographically, it is a varied relief of mountains, plateaux, valleys and flood plains in intermontane basins. The soils are ultisols derived from basalts, trachytes and granites with varying degrees of weathering. Precisely, the soils are acidic, low in major ‘nutrients and have high phosphorus requirements (Yamoah *et al*., 1984). Furthermore, some food crops fields and the main natural pastures are found on steep slopes in upland areas where erosion losses are phenomenal as decline in soil fertility.

The climate is highly varied and is influenced by topography which ranges from an altitude of 300 m to 3010 m above seal level. It has been described by Moby (1979) as a tropical montane climate characterized by 1500 to 3000 mm of rainfall per year, 0 to 3 dry months; a mean annual temperature of 21°c and a mean annual temperature range of 2.2°c. Moist montane forest is the climax vegetation community of the wetter mountains. Lowland evergreen forest is found at elevations below 300m above sea level. These climax floristic communities have been anthropogeneically degraded and what exists today is a complex mosaic of montane woodlands, tree and shrub savanna, grass savanna, farms and fallow fields derived from tropical montane forests (Nkwi and Warnier, 1982; Tamura, 1986; Ndenecho, 2005). In these diverse ecological circumstances tree and shrub germplasm is extremely varied and reflects to a large extent the

differences in ecological factors such as climate, altitude, land use management and edaphic conditions.

III. Materials and Methods

The study focused on the Bamenda Highlands. Using vegetation — altitude correlation maps established for the region by Hof et al. (1987); Hawkins and Brunt (1965); Macleod (1986) and Champaud (1973) a pasture ecological zoning of the highlands was made and presented using quantitative and qualitative terms and also in cartographic form. A combination of primary and secondary data sources enabled a mapping of the distribution of natural pastures, the identification of tse-tse fly infested zones, critically degraded areas, critically invaded sites by undesirable plant species, available infrastructure for pastoral development and the principal transhumance routes. Using quadrant analysis, the pasture composition and structure of Hyperrhenia grassland and Sporobolus grassland were established. Archival material of the Provincial Delegation of the Ministry of Livestock and Animal Industries was used to derive quantitative data on stocking rates, cattle distribution on natural pastures and transhumance. In order to identify the browse resource potentials for each ecological zone, 6 transects originating from the high lava plateau (areas above 1600 m) and ending in river valleys (areas between 300 and 900 m) were used. These coincided with major transhumance routes. Drovers generally transhume with herds ranging from 35 to 60 cattle. Two drovers representing two herds were identified for each route or transhumance zone monitored by a veterinary post. They were each allocated red paint and a brush to mark the stems of the frequently browsed trees and shrubs as they descend from the high lava plateau down to the river valleys and vice — versa. The main transhumance zones monitored were: Ndop plain, Lip plain, Njinikimbi valley, Lower Menchum valley, Baligham and Dumbo. With the assistance of the veterinary technicians samples of the identified trees and shrubs were collected as per ecologic zone using an altimeter to determine the elevation of samples. The samples so collected were forwarded to the herbarium of the Zoo - Technical Research Station in Bambui for identification by the range ecologists.

IV. Presentation of Results

Figure 1 presents the location of the study area, the relief and pasture ecological zonation. The main browse resource niches identified are (Figure 1):

- Zone 1: 300 to 900 m above sea level. This is a very moist zone. The mean annual rainfall exceeds 2000 mm with 0 to 1 dry months. The main ecological niches in the zone are:

- Moist evergreen forest (Celsalpinaceae dominant). The trees are not very tall and Myristicaeceae are more abundant at the 800m to 900m elevation.
- Moist semi — deciduous forest found where the rainfall ranges from 1500 to 2000 mm per year and has 1 to 2 dry months. The main tree and shrub elements are Triplochiton schieroxyton, Sterculia spp., Cola Spp., Mansonia altisima, Celtis spp., Terminalia superba and Khaya sp. There is a complex of moist semi — deciduous forest on valley slopes and grassland on the ridges, woodland savanna (Burkea africanna, Daniella oliveri) generally with a dense network of gallery forest, tree savanna and shrub savanna (Terminalia glauceens, Lophira lanceolata, Annona senegalensis) generally with a dense network of gallery forest. The main graminae found in the tree and shrub savannas are Pennissetum purpurum (25%), Hyparrhenia spp (40%), Andropogon (10%), Pennisetum clandestinum (15%) and weeds (10%). These are mainly dry season range sites.

- Zone 2: 900 to 1600 m above sea level. These are medium altitude zones. It is sub — humid with 1400 to 1700 mm of rainfall per year and 2 to 4 dry months. The main floristic elements are:

Moist semi - deciduousforest (Alfzelia africana, Albizia spp., Chioroplora excelsa),
Degraded semi — deciduous forests;
Woodland savanna (Burkea africana, Daniellia oliveri, Borassus aethiopum),
Tree and shrub savanna (Daniellia oliverii, Lophira lanceolata) generally with a dense network of gallery forest, and
Grasslands (Sporobolus africanus (35%), Pennisetum clandestinum (15%), Hyperrhenia spp. (15%). These are mainly transitional range sites.

- Zone 3: These are elevations above 1600 m above sea level. The mean annual rainfall generally exceeds 1500 mm. This is the montane zone with the following floristic elements:

Evergreen mountain forest at 1700 to 2100 m above sea level. It is dominated by Schefflera abyssinica, and Carapa grandflora. Other common trees are Syzygium staudtti, Schefflera mannii, Pygeum africanus, Rapanea neurophylla and Barsama abyssinica. Small trees include Nuxia con gesta, Ixora foliosa, Pittosporum mannii and Clausena aniseta. Most of the forests have been degraded to shrub and tree savannas dominated by Lasiosiphon glaucus, Hypericum lanceolatum, Pteridim aqulinum and numerous forest edge species. Afro-alpine grasslands exist above 2100 m altitude and cover the high lava plateaux and mountain crests. The grasslands are dominated by Hyparrhenia spp. Montane short grassland occurs between 2360 m and 3000 m elections. It is derived from bamboo forest and thickets due to fire hazard, deforestation, and retreating tree species. The main grasses include Eragrostis volkensii and Tristachya. These are mainly wet season range sites.

Table 1: Pasture ecological zonation of the Bamenda Highlands (Area in km2)

Division	*Total area (km²)*	*Zone l*		*Zone 2*		*Zone 3*	
		300 to 900 m		*From 900 to 1600 m*		*Above 1600 m*	
		Area	*%*	*Area*	*%*	*Area*	*%*
Mezam	1841	-	-	69.5	1,279.25	30.5	561.75
Boyo	1636	8.3	136.6	82.4	1347.9	9.3	151.5
Momo	1734	9.3	334	46.3	803.5	34.4	596.5
Menchum	4489	35.7	1603.3	64	2873.7	0.3	11.9
Donga Mantung	4340	34.6	1503.2	54.6	2371.3	10.8	460.45
Ngoketunjia	1117	0	0	88.7	991.4	11.25	125.6
Bui	2252	5.5	124.74	42.8	963.85	51.7	1162.4
Total	17401	21.3	3702	61.1	10630.9	17.6	3076.1
Transhumance		*Dry season grazing ,zones (December to March)*		*Transitional grazing zones (Temporal encampment sites)*		*Wet seasons grazing zones (June to December)*	

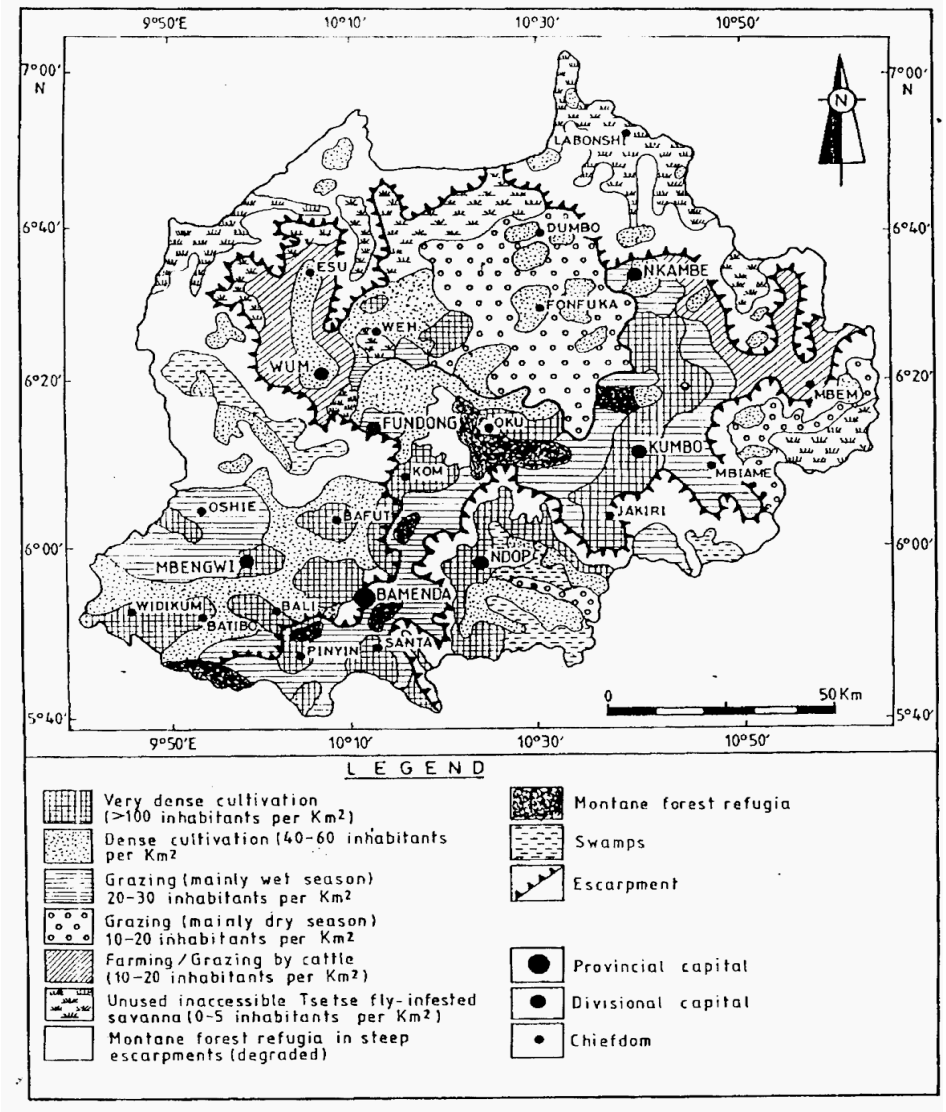
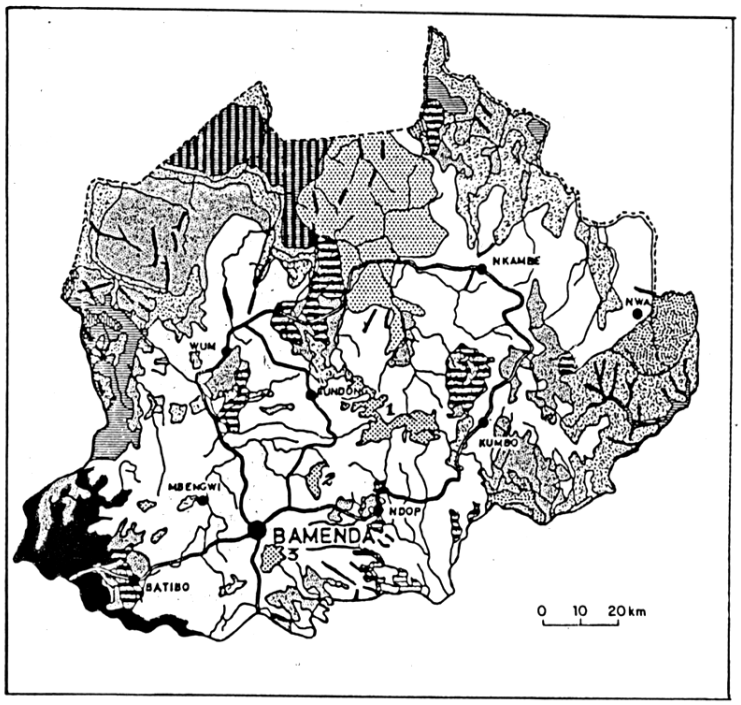


Figure 1: Bamenda Highlands – Land use intensity and the main range sites



Vegetation map of the Bamenda Highlands

LEGEND

ECO-FLORISTIC ZONES AT LOW AND MEDIUM ALTITUDE (generally below 1800m)

Very moist zone at low and medium altitude (rainfall exceeding 2000mm, 0-1 dry months)

Moist evergreen forest (*Cesalpinaceae dominant*). Trees less tall and *Myristicaceae* more abundant at medium altitude (> 800m).

Sub-humid zone at low and medium altitude (1500-2000mm, 1-2 dry months)

Moist semi-deciduous forest (*Triplochiton scleroxylon, Sterculia* spp., *Cola* spp., *Mansonia altissima, Celtis* spp., *Terminalia superba, Khaya* spp.).

Complex of moist semi-deciduous forest (slopes and valleys) and grassland (ridges)

Woodland savanna (*Burkea africana, Daniellia Oliveri*; generally with a dense network of gallery forest.

Tree savanna and shrub savanna (*Terminalia glaucescens, Lophira lanceolata, Annona senegalensis*) generally with a dense network of gallery forest.

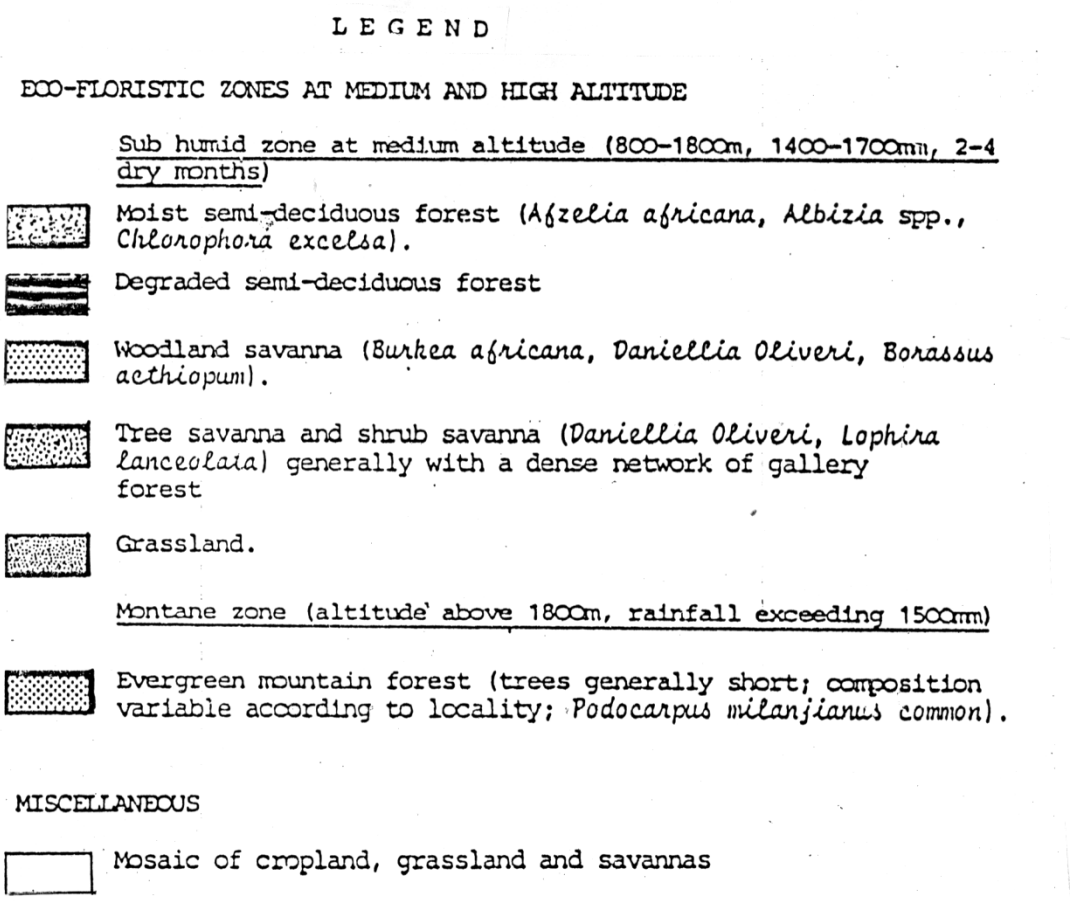


Figure 2: Vegetation map of Bamenda Highlands (Modified after Hof *et al*. 1987)

The intermediate and high altitude zones are characterized by a mosaic of cultivated fields, fallow plots, homesteads and natural pastures. This system faces a number of range ecological problems:

- Overgrazing of wet season pastures: Santa, Sabga, Pinyin, Mnem, Abar, Esu, Tatum, Jakiri, Kishong, Mbiame, Misaje, (dry season) Nkambe. (Figure 2).
- Invasion of pastures by undesirable plant species: Bracken fern *(Pteridium aquilinum)* in wet season pastures: Fungom, Tchabal, Wum, Oku and Dumbo. *Chromolena adorata* and toxic plants *(Spondiathus Preuesii)* in Wum, Ngwo and dry season (wet land) pastures of Donga plain and Mbaw plain. (See figure 2).
- Infestation of pasture lands by tse-tse fly. Mainly the dry season low-lying pasture lands. Mbaw plain, Misaje, Menchum valley, Ako, Lower Fungom, Furu Awa.
- Inaccessibility of pasture lands to markets leading to overstocking and overgrazing: Wum central, Mmen, Kuk and Yemngeh.

Table 2: Total grazing area and available grazing land for ruminants

Division	*Available grazing land (ha)*	*% of grazing land per division*	*Available grazing land (hectare per animal)*	
			Year: 1990	*Year: 2000*
Mezam	105,667	7.2	1.5	1.2
Momo	124,200	11.7	3.9	4.1
Menchum	41,533	37.2	3.6	2.8
Bui	108,000	17.2	1.7	1.5
Donga – Mantung	305,714	26.7	2.3	2.5
Total	**1,054,914**	**100**	**2.3 (averages)**	**1.44 (averages)**

Source: Archival material of MINEPIA (1990 and 2000 Annual Reports)

Table 2 presents the available grazing land. Rumnants account for 90% of the total breeding stock. Each ruminant is entitled to about 4 square metres of grazing land per day on the average. The stocking rate in 1990 was 1.44 hectares per animal. Experts consider that the ideal stocking rate in the highlands is 2.21 hectares per animal per year. We can also assume that the grazing area in 1990 has been considerably reduced as a result of demographic pressure. Consequently, the stocking rate is much higher and there is clear evidence of overgrazing and pasture degradation. The major obstacle to cattle raising is the shortage of forage and water in high altitude pasture zones during the dry season. Factors such as water shortage, low nutrition and grazing on dry parched bracken infested pastures contribute to bracken poisoning on rangelands. Fresh bracken is more toxic than dry bracken.

Bracken fern invades the wet season pastures on the High Lava Plateaux. It is believed to have originated from forest margins and galleries in the intermediate and low altitude zones. It progressively invaded pastures right up to plateaux summits. The spread of the plant is accelerated by land management practices such as bush burning for both shifting cultivation and pasture renewal, forest conversion to farmland and rangelands, intensive annual cropping of land and over-grazing. The extent of invasion varies with soil type; nature of vegetation associated with it and land management practices. It is estimated that about 65% or 685,694 hactares of available grazing land in the high lava plateaux is infested with bracken fern (IRZ Bambui Annual Report, 1987).

Although several trees and shrubs are browsed during the dry season, very few of these trees are deliberately planted for this purpose. Tree planting in this,system is limited to the fencing of night paddocks. As the dry season sets in fodder soon becomes scarce as forages mature and lignify

to become straw of very low nutrition value. Cattle soon resort to browse plants. Many trees and shrubs occur on range sites. These remain green all year round.

Table 3: Common browse plants identified in the Bamenda Highlands

Family	Species	Habitat
Anacardiaceae	Magnifera indica	Zone 1
Boraginaceae	Cordia milleniy	Zone 3 Zone 3
	Cordia Africana	
Celsalpiniaceae	Daniellia oliveri	Zone 1 Zone 1
	Piliostigma thonningii	
Vernon iaceae	Veronica amygdalina	Zone 2 and 3
	Veronica leucocalyx	Zone 2 and 3
	Veronica corferta	Zone 2
Ebanaeceae	Dalberghia oligophylla	Zone 2 Zone 2
	Diospyros sp.	
Euphobiaceae	Bridelia micrantha	Zone 2
	Bridelia stenocarpa	Zone 2
	Antidesma membranaccum	Zone 1
	Bridelia grandflora	Zone 1
	Parinari spp.	Zone 2
Hyperiaceae	Psorosperum aurantiacum	Zone 2
	Pseudarthria hookeri	Zone 2
	Psychotria succulenta	Zone 2
Maliaceae	Khaya grandifolia	Zone 1 Zone 1
	Khaya sp.	
Mimosaceae	Albizia adianthifolia	Zone 2 and 3
	Albizia gumifera	Zone 1, 2 and 3
	Albizia zygia	Zone 1
	Entanda abyssinica	Zone 2
Moraceae	Ficus vogeliana	Zone 2 Zone 2
	Ficus spp.	
Rubiaceae	Can thium vulgare	Zone 2
	Carapa grandflora	Zone 2
	Cola anomala	Zone 2
	Mitragyna stipulosa	Zone 1
Saptaceae	Croton macrostachyus	Zone 2
	Nuxia congesta	Zone 2
	Uapaca heudlotii	Zone 1
Sapindaceae	Aleurotes cordifolia	Zone 1 Zone 2
	Allophylus bullatus	
Papillionanceae	Millettia conraui	Zone 2 Zone 2
	Erythrina signoides	
Pittosporaceae	Pittosporum mannii	Zone 2 Zone 1
	Podocarpus milanjianus	
Ulmaceae	Celtis brownii	Zone 1
Verbenaceae	Vitex sp.	Zone 1
	Voacanga africana	Zone 1
Total (species)	42 plant species	Zone 1 = 17 Zone 2 = 25 Zone 3 = 06

NB Some plants occur in more than one zone.

Table 3 presents the distribution of browse plants for each ecological zone. 42 trees and shrubs occur on range lands of the Bamenda Highlands as native vegetation of the area (Zone 1=17, Zone 2 = 25 and Zone 3 =06) . Some trees and shrubs occur in more than one zone. Shrub species make up the bulk of the browse plants. These are present in relatively high proportion in the transition zones or intermediate altitude zones (zone 2). In terms of species composition, quite a number of different shrub browses and occasionally trees can be found in most grazing areas, particularly in the transition zones, where they form large plant communities. In ruminant production, malnutrition during the dry season due to low forage availability and poor nutritive quality is the most significant factor affecting production in the area (Asah, 1984).

V. Discussion

The bulk of these woody plants are multipurpose trees that do not only serve as animal feed but are used for fuel wood and construction wood. These are rapidly disappearing as a result of exploitation for the above purposes, increasing browsing pressure, expanding crop fields and annual burning. Ndenecho(2005) established that the grasslands in the highlands are derived from moist montane, sub-montane, bamboo and lowland evergreen forests and that pyrogenic and anthropogenic factors have created the complex mosaic of montane woodlands, tree and shrub savanna, and grass savanna. The process of savannization involves the reduction of natural tall forest to a xerophilous environment. This on-going process threatens the browse resource potential of the highlands. As the most desirable food-plants are consumed, they are replaced by less desirable plants. Intense dry season grazing of the intermediate and low altitude range sites therefore degrades the wooded savanna, tree and shrub savanna. Eventually, these trees die out causing widespread loss of feed sources for ruminants and nesting and roasting habitats for 53 species of montane forest birds and 85 species of sub-montane areas (Macleod, 1986). There is therefore an urgent need for the integration of trees and shrubs in the pastoral livestock production systems of sub-saharan Africa.

Integration of trees and shrubs on rangelands and among pastoral men to improve utilization in their production system has two major objectives (Asah, 1984):

- to improve management and utilization efficiency of the natural rangeland's woody vegetation, and
- to increase integration of miltipurpose browse plants into current rangeland management production system.

The scope of the former is large and has a high probability of success while that of the latter has limited adoption among the Fulani and Aku cattle men as they rely mostly on transhumance. Due to insecurity in land tenure, they are unwilling to cultivate forages in their grazing lands. Also, cattle are the major enterprise of the pastoral men and since

cattle are mainly grazers, when compared to goats, pastoral men find no economic benefits in tree and shrub farming. However, due to the poor nutritional quality of forages in the dry season, trees and shrubs should serve as important protein sources for grazing animals. Encouraging efficient utilization of the existing resources offers a much broader scope of adoption among Fulani and Aku cattle men. Three major strategies are proposed for this approach:

- Encourage diversification of animal enterprises on rangelands to exclude goats that are principally browsers to optimize utilization of range browse plants;
- Encourage the use of browse plants for fencing land and establishing contour bunds on grazing areas as these could be important reserves for protein supplement in the drought period and
- Over-seeding of pastures with improved legumes such as *Calliandra*, *Leucaena* and *Cassia sp.*

Under free ranging conditions and when other forage species are available, cattle prefer grass species to browse plants even when the feed value is poor (Peyre de Fabrigues, 1975 and Dicko-Touré, 1980). Dicko-Touré (1980) found that cattle spent less than 4% of grazing time per day on grass during vegetation growth but increased browse fodder time to 26% in the drought period. Adopting cattle enterprises that incorporate goats would optimize utilization of these resources on rangelands.

Plants of the Moraceae family, particularly Ficus spp. are readily browsed by ruminants and are also recommended for life fencing. Their use on rangelands could be of advantage to range resource utilizers since they are readily browsed by ruminants and are fire resistant. Principal niches for the incorporation of tree and shrubs for this system are natural rangelands, contour bunds and fence lines. The planting of leguminous shrubs in compound gardens and sleeping paddocks appears promising in the future as many of the Akus and some Fulanis are already doing small scale subsistence agriculture and are becoming sedentary. Although large quantities of organic manure is produced in this system most of the manure is not used for crop production as only limited crop cultivation is done in this system. All the manure produced is lost in pastures and almost very little is sold to crop farmers. The use of organic manure has been shown to be profitable in establishing woody vegetation (Yamoah et al, 1993).

In this system there is considerable loss of range resources as mostly extensive and semi intensive production practices are used. Incorporation of trees and shrubs will for a long time be limited to fence lines and contour bunds. It is also possible that over-seeding pastures, in strips or zones, with legume browses may be a common practice in the future.

VI. Conclusion

Desertification is an environmental concern in the tropics and in the savannas of Africa in particular. Overgrazing is a major cause of desertification. The pastoralists are also affected by over cultivation by farmers resulting in decreases in areas of pasture available to them. Weather systems such as droughts in sub — Saharan Africa together with the actions of man triggering desertification call for urgent action in the development of browse resources (trees and shrubs) for multi-purpose uses. Research should focus on the analysis of the nutritive quality of browse plants in terms of average dry matter and crude protein, mineral content of phosphorus, calcium and magnesium; the frequency of occurrence in each habitat, and method of propagation. These could be sufficiently rich in their crude protein content as to maintain animals during the drought season. Secondly, many of these trees and shrubs could be found throughout the afro-alpine ecological zones and should be an incentive for both agroforestry and ruminant nutrition. Trees and shrubs will for a long time continue to play a vital role in traditional farm families despite their neglect in the region. This study therefore serves as a basis of research for improving the utilization efficiency of trees and shrubs in traditional crop-livestock production systems in the afro-alpine ecosystems. More elaborate research is required to fully characterize the potentials of these plants for agroforestry and silvopastoral purposes.

VII. Acknowledgements

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