Savannization of Tropical Montane Cloud Forests in the Bamenda Highlands, Cameroon

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ABSTRACT

Savannization is a flora degradation process that reduces natural tall forest to a xerophilous environment. The paper investigates this process in both quantitative and qualitative terms and establishes that pyrogenic and anthropogenic influences have contributed to the origin and maintenance of the Bamenda grasslands. The complex mosaic of montane woodlands, tree/shrub savanna, grass savanna, farms and follow fields are derived from tropical montane cloud forest. It finally concludes that savannizaiton is a manifestation of poor biological resource management and as it, concerns mountain regions, it has serious implications for agriculture, livelihoods dependent on cloud forests, rates of soil erosion, slope stability, magnitude of floods, biodiversity, downstream water supplies, energy availability and sediment transfer. Urgent action is therefore needed in the rehabilitation, sustainable management, conservation and monitoring of mountains in the region.

Key words: Savana, biodiversity, forest, management, genetics, vegetation .

RESUME

La savanisation est un processus de dégradation dela flore qui réduit la forêt dense naturelle vers un environnement xérophile. L'article examine ce processus en termes à la fois qualitatif et quantitatif et étrablit que les influences pyrogéniques et anthropologiques sont à l'origine et le maintien des savanes de Bamenda. La mosaique complexe des montagnes arborées, des savanes arbustives, des savanes herbacées, des champs et des jachères de prairies proviennent de la dense forêt tropicale de montagne. Enfin l'article débouche sur la conclusion que la savanisation est une manifestation de la mauvaise gestion des ressources naturelles et comme elle concerne les régions montagneuses, elle présente de sérieuses implications sur l'agriculture, la vie des populations rivairaines des forets motagneuses, le taux d'érosion des sols, la stabilité des zones en pentes, la fréquence des crues et inondations, la biodiversité, les sources d'eau souterraine, l'énergie disponible,et le transfert des sédiments. Ainsi,une action urgente est nécessaire pour la réabilitation, la gestion durable , la conservation et la surveillance des montagnes dans la région.

Mots clé: Savane, biodiversité, foret , gestion, génétiques, végétations.

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INTRODUCTION

It has long been held that grasslands, whether temperate or tropical , are a response to climatic conditions with alternating seasons of rainfall and drought. Many authorities, however, now question this traditional view of a climatic origin and agree that the grasslands do not represent a true climax vegetation. It is averred that the grasslands as they now appear, are entirely or at least man – made, being the product of tree clearance, shifting cultivation and periodic burning over a long period (Robinson,1982). The Bamenda Highlands, otherwise, also known as the "Grassfields" have been described as derived savanna (Nkwi and Warnier, 1982; Letouzey, 1979; Tamura,1986; Kadomura, 1982). Some authorities have advanced the pyrogenic theory to explain the origin of savannas (Hori, 1986; Haruki, 1984; Keay, 1955). In addition to this theory some biogeographers have suggested pedological causes of savannization, paleoclimatic influences and present day biotic and edaphic influences (Cerrado, Caatinfa and Pantanal,1960). These authorities recognize the essential dynamic nature of vegetation and explain the savanna in terms of the age of the flora and the geomorphological evolution of the landscape. An argument favouring the antiquity and widespread occurrence of natural grasslands relates to the character of its fauna. Grasslands were essential to provide a habitat for the evolution of grazing animals. How else can be explained the development of the herbivores, especially the rich grazing fauna of the African savannas?

It will be clear that there is no simple and no conclusive answer to the problem of the origin of grasslands. Climatic conditions in the Bamenda Highlands do not seem to reject the existence of moist montane forest. The actual distribution of forest is restricted to mountain peaks, mountain slopes, escarpments and deep mountain valleys. The dominant grassland vegetation is in disequilibrium with the abundant rainfall which exceed 1800mm annually and is distributed in more then 8 months. The paper seeks to establish the genetic relationship between the montane cloud forest, montane woodland, tree/shrub savanna and the grassland ecosystems of the Bamenda Highlands as an aid to the sustainable management of the natural vegetation of mountain regions and to establish the potential environmental and resource availability implications.

STUDY AREA

The study area is located in the montane belt from 1250 to 2900m above sea level. The area is characterised by mountains and the vegetation consists mainly of degraded mountain cloud forests. The forest refugia are found on mountain peaks, steep slopes and escarpments and in deep montane valleys in locations such as Kilum, Ijim, Sabga, Tubah uplands, Mendankwi, Njising, Tabenken, Mbu- Pinyin range, Kovifem-Mbiame and Acha-Tugi range. These forests are greatly fragmented and their lower limits down to the 800m elevation are characterized by montane woodlands, tree/shrub savanna and grassland savanna. The climate in areas above 1000meters is cool and misty. Mean annual maximum temperature is 16.7°c and 18.9°c while the mean annual minimum is between 8.9°c and 10.6°c. Rainfall varies from 1780 to 2290mm per year. Most rain falls between July and September. There is a drought season from mid November to about mid March. Relative humidity exceeds 80% in July-August and is lowest in January to February(45 to 52%). During the rainy season, mist and low cloud occur frequently. Temperature inversions at night in narrow valleys which suffer from air drainage lead to some ground frost, mainly in January or February.

The soils are formed on trachytes and basalts. Soils formed on trachytes are characterized by dark clay loams. They are moderately deep and well drained and contain fragments of weathered rock throughout the profile. Where cultivated, they are characterized by a strong, very fine, granulated structure aggravated by burning. Soils formed on basalt are similar. On steep slopes, profiles are shallow with abundant gravel and stone, some even of boulder size. On gentle slopes, they are deeper with less rock fragments. All the soils have a high organic matter content favoured by the moist cool climate. Consequently, they tend to be well drained and their permeability is fairly rapid. There is a very high clay content (45 to 70%) with gibbsite being the predominant clay material. Most of the soils are acid and low in nutrient status indicating that heavy leaching takes place and due in part to their ferrallitic nature. All the main plant nutrients, such as nitrogen and phosphorus, are low and the balance between them is particularly delicate (Yamoah et al., 1984). Unless manipulated with care, acute deficiencies could be induced.

It is generally believed that the whole of the Bamenda Highlands were once covered in forest (Nkwi and Warnier, 1982). Evidence to suggest this comes from the Shum–Laka Rock shelter where gorilla teeth have been found (De Maret,1982). Evidence to suggest this also comes from regolith stratigraphic studies of late

Quarternary environmental history in the west Cameroon Highlands (Tamura, 1986). The highlands possess a unique flora and fauna, with numerous endemics, particularly among the birds and vascular plants. The high and often very localized degree of endemism is believed to have arisen during the Pleistocene age when climatic changes forced the forest to retreat to the wetter mountainous areas (Macleod, 1986).

Moist montane forest is the climax community of the wetter mountains. It is characterized by a low canopy at 10-20m, with occasional trees up to 30m tall. There are rather few lianas, but the epiphyte load is very heavy with many bryophytes, ferns and epiphytic orchids. Species – richness increases with elevation. The understorey is dominated by small trees and tall woody herbs, particularly Rubiaceae and Acanthaccae, while in damp places which have not been burnt, ferns are abundant.

The first settlers in the highlands were probably nomadic iron smelters or blacksmiths (Jeffreys, 1961). Nkwi and Warnier (1982) conclude that some six to nine millennia in the past, perhaps earlier, the region was almost entirely covered with forest, and was inhabited. The first major change that affected the lives of the people was the introduction of new food crops from South East Asia some 2000 years ago. This caused a dramatic transformation of the environment. Slash – and – burn shifting cultivation slowly cleared the trees and turned the land into Savanna. During the later half of the 19th Century the highlands witnessed the migration of the pastoralist Mbororo tribe from the north as well as the movement of the agrarian Bantu tribe from the South East. The movement of pastoralist and agriculturalist led to drastic transformation of the environment (Tamura, 1986). Today, the forest refugia are still being degraded. The livelihood activities dependent on these forests and the biophysical role these forests play on natural resource availability are already imposing stresses on local communities.

METHODS

The study focused on the Ijim-Oku tropical montane cloud forest refugia which is considered the climax vegetation community of the area. Based on an inventory list of floristic elements established by Hawkins and Brunt (1965) and by Thomas (1986), the plant elements of the complex mosaic of montane woodland, tree/shrub Savanna and grassland Savanna was studied with the objective of determining the floristic links or affinities with the moist montane forest. Field observations involved a study of the Ijim and Oku montane forest refugia, the woodlands south of Simonkov village and northwest of Verkovi village, the tree/shrub Savanna north of Lang village and northeast of Ibal-Oku and the grassland Savanna on the southern slopes of Mount Oku and between Verkovi, Wvem and Tadu. The mosaic of farmlands and fallow fields was also investigated in terms of floristic elements and successions. The dynamics of various members of these ecosystems and how they change from the moist montane forest was then established in quantitative terms and the major influences causing changes in floristic structure and composition identified. The floristic parameters used are based on life form: large trees, small trees, shrubs, herbs, epiphytes, ferns, sedges and grasses.

RESULTS

The lower limits of the forest are presently mapped between 1500 and 2100m above sea level. Below this zone, the vegetation is a complex mosaic of moist montane forest, degraded montane forest (montane woodland), scrublands and tree savanna and grasslands. The lower limits of the forest are dominated by *Schefflera*

Table 1: Comparison of plant species per life form in montane forest and montane woodland ecosystems.

Life form	No. of species		Percentage change in species
	Montane forest	Tree/shrub Savanna	(%)
Large trees	63	0	-100.0
Small trees	10	9	0.0
Shrubs	25	26	+4.0
Herbs *	24	104	+76.4
Epiphytes	9	5	-44.4
Ferns	2	0	-100
Sedges	0	0	0.0
Grasses*	0	53	+100

Table 2: Comparison of plant species per life form in Montane forest and tree/shrub Savanna ecosystems.

Life form	No. of species		Percentage change in species
	Montane forest	Tree/shrub Savanna	(%)
Large trees	63	0	-100.0
Small trees	10	9	0.0
Shrubs	25	26	+4.0
Herbs *	24	104	+76.4
Epiphytes	9	5	-44.4
Ferns	2	0	-100
Sedges	0	0	0.0
Grasses*	0	53	+100

* Immigrants

abyssinica and *Carapa grandiflora*. Other common trees are *Szygium staudtii schefflera mannii, Pygeum africanum, Rapanea neurophylla*, and *Bersama abyssinica*. Smaller trees include *Nuxia congesta, Ixora foliosa, Pittosporum mannii, Clausena anisata, Alophyllus bullatus* and *Xymalos monospora*. In places, particularly under *Schefflera abyssinica*, there are dense stands of *Mimulopsis solmsii*. Tree ferns *Cyathea manniana* also occur but are uncommon. At higher elevations the canopy is dominated by *Szygium staudtic, Rapanea newrophylla*, and *Podocarpus milanjianus*. The forest edge community at higher elevations, which is subject to attack by fire, contains some small montane trees such as *Philippia manic, Rhamus prinoides, Peddiea fischeri, Cassine aethiopica, Myrica arborea* and *Agauria salicifolia*.

Table 1 is based on an inventory of plant species in the moist montane forest and degraded montane forest or montane woodlands found at the lower limits of the climax forest community. In each of the two ecosystems, plants were counted according to life form and a comparison of the ecosystems established. The conversion of moist montane forest to montane woodland revealed that these sampled plots lost all the large tree species, 10% of the small tree species, 80% of the shrubs, 54% of herbs and all the epiphytes. The montane woodland is derived from moist montane forest through extensive fire damage. The understorey, has many forest edge species such as *Pteridium aquilinum, Hypericum Lanceolatum;* and *Crassocephalum mannii*. Epiphytes tend to be impoverished and the rich terrestrial fern communities are absent. Livestock grazing prevents much regeneration but where regeneration occurs, a tall herb community develops with second growth species such as *Crassocephalum mannii; Polyscia fulva, Croton macrostachyas* and *Neoboutonia grabrescens*.

Table 2 compares the plant species in the moist montane forest with those in the tree/shrub Savanna ecosystems. The conversion of moist montane forest to tree/shrub Savanna has the following outcome: all large trees are lost, small trees dominate (almost all small trees survive), almost all shrubs survive, a dramatic arrival of immigrant herbs, a 44% reduction in the total number of epiphytes and a total degradation of ferns except *Pteridium*. There is also a dramatic arrival, in the area of 53 immigrant species of grasses. Tree/shrub Savanna is often dominated by *Lasiosiphon glancus*, *Hypericum lanceslatum* and *Pteriduim aquilinum* and contains numerous forest edge species. The Lasiosiphon often

Table 3: Comparison of plant species per life form in montane forest and grassland ecosystems.

Life form	No of species		Percentage change in species
	Montane forest	Grass Savanna	(%)
Large trees	63	0	-100.0
Small trees	10	9	-100.0
Shrubs	25	0	-100.0
Herbs*	24	104	+76.4
Epiphytes	9	0	-100.0
Ferns*	2	4	+50.0
Sedges*	0	13	+100
Grasses*	0	53	+100

* Immigrants

surports epiphytic orchids and parasitic Loranthaceae. In the Verkovi area of Oku, many *Lasiosiphon* trees were seen to contain *Schefflera abyssinica* stranglers, which suggests that the tree/shrub Savanna could change into forest if the trees were allowed to develop. The *Pteridium aquilinum* is able to withstand burning because of its rhizophourous growth and therefore dominates fire-burned areas.

Table 3 compares the floristic elements of grassland plots with those of the climax montane forest vegetation. In the grassland plots there was a total degradation of large trees, small trees, shrubs and epiphytes. The proliferation of invading herbs and bracken fern (Pteriduim aquilinum) is typical. Thirteen sedge species and 53 grass species combine with the above characteristics to create a "grassfield landscape". The grasslands were originally dominated by *Hyparrhenia* spp. and had a rich ground flora. In a few decades the whole community had changed to be dominated by *Sporobolus* grass, which forms coarse, fibrous tufts and species – poor communities (Hawkins and Brunt, 1965). Being unpalatable when over 35cm tall, *Sporobolus* could withstand the heavy grazing pressure and trampling of livestock. This change in dominance combined with intensive grazing pressure, annual burning of grasslands and overall loss of vegetation has now led to serious erosion problems on most sites.

Slash-and-burn shifting cultivation with short fallow durations of 1 to 5 years accelerate the savannization process. Fallow fields were surveyed with the objective of establishing the successions of fallow grasses and weeds. The following succession stages were identified. During the first year, there is rank weed growth dominated by members of the compositae. *Erigeron floribundus* dominates together with *Ageratium conyzoides, Anisopapus africanus, Guizotial scabra, Laggera alata* and *Laggera pterodonta*. The annual grass *Rynchelytrum repens* is often also abundant on first year fallows. During the second year of fallow, there is invasion by *Imperate cylinduia* which may become dominant towards, the end of the wet season. Third year invasion is by grasses such as *Hyparrhenia, Digitaria* spp. and *Melinis minuntiflora*. Fourth and fifth year fallows are rare. However, in areas where population pressure on land is low, fourth and fifth year fallows show a gradual decline in *Imperate cylinduia* and *Hyparrhenia* dominance. *Imperata cylinduica* tends to persist on land which is under permanent cultivation or is being fallowed from a year to two because it is capable of growing on soils of poor fertility. It is a light demanding species and is shaded out later in the succession by the taller *Hyparrhenia* grasses.

Hawkins and Burnt (1965) report that germination rates of *Hyparrhenia* are very low. This may partly account for the time it takes before it re-establishes itself in old farmlands. Ten *Hyparrhenia* species dominate grass Savanna sites. When left uncultivated for several years, there is the dramatic invasion by several other grasses, sedges and herbs.

Over-grazing, trampling and burning have caused the once *Hyparrhenia* dominated grasslands to be replaced by *Sporobolus* grassland and their subsequent invasion by more resistant disturbance climax species such as weeds, bracken, *Setaria sphacelata, Arthraxon quartinicus, Pennisetum clandestinum* and *Panicum maximum* (Table 3). The consequence is short, clipped tufted ineffective grass cover and complete loss of vegetation in some areas resulting in gully and sheet erosion. Most of these slopes are prone to landslides.

Table 4 shows the long-term changes in the Montane cloud forest. New species arrive and overlap native species in montane woodland and tree/shrub Savanna sites. Seeds ride wind and water currents for great distances and may be carried by birds. All together 53 species of montane forest birds are found in the area. There are also 83 species of birds excluding montane forest species (Macleod, 1983); Large mammals that can effect the propagation of new species are not abundant due to indiscriminate hunting and forest clearance which continue to threaten many species and have reduced them to small populations. Increase in human mobility might have contributed in the occurrence of immigrant species. The immigrants alter the ecosystem very often on a permant basis. The influx of new and permanent organisms in degraded forest sites results in renewed succession and a new climax (see table 4).

In order to establish the fact that the Savannas of the Bamenda Highlands are derived from montane cloud forests, the survey identified the species native to moist montane forest but now found in the woodland, tree/shrub, Savanna and grassland sites. Table 4 presents the results. Six montane forest trees and shrubs dominated montane woodlands together with eight species of immigrants and 80 immigrant herbs. On the other hand, 10 montane forest native species dominate the tree/shrub Savanna sites together with 21 species of immigrant trees/shrubs, 80 herb species and 53 grass species. The grassland Savanna sites have no trees native to moist montane forest and no immigrant trees. Main immigrants are grasses (53 species), herbs (80 species) and sedges (13 species). The study concludes that the grassland is a plagiosere.

Table 4: Tree and shrub species found in montane forest and represented in different ecosystems.

Ecosystem	Montane woodland	Tree/shrub Savanna	Grassland
Native Species	<u>Native trees/shrubs</u> *Adenocarpus mannii* *Agauria salicifolia* *Maesa lanceolata* *Rapanea neurophylla* *Crassocephalum mannii* *Hypericum riparium*	<u>Native trees/shrubs:</u> *Croton macrostachyus* *Dombeya ladermannii* *Garcinia polyantha* *Rauvolfia vomitoria* *Trema spp.* *Adenocarpus mannii* *Bridelia stenocarpa* *Maesa lanceolata* *Psorospermum aurantiacum* *Psychotria succulenta*	No trees All native trees degraded
Immigrants species	<u>Immigrants: tree/shrubs</u> *Hypericum revolution* *Hypericum lanceolatum* *Lasiosiphon glaucus* *Myrica arborea* *Phillipea mannii* *Crotalaria sp* *Eriosema chrysadenium* *Nepeta robusta*	<u>Immigrants: trees/shrubs</u> *Canthium subcordatum* *Etanda abyssinica* *Hypericum revolutum* *Lasiosiphon glancus* *Hypericum lanceolatum* *Tricalysia okelensis* *Annona chrysophylla* *Crotalaria sp.* *Mussaenda arcuata* *Piper sp.* *Protea sp.* *Protea madiensis* *Pseudarthria hookeri* *Psorospermum densipunctatum* *Psorospermum fabrifugum* *Rubus sp.* *Satureja robusta* *Solanum sp.* *Stephania lactificata* *Terminalia glaucus* *Vernonia auriculifera*	No immigrant trees 53 species of immigrant grasses
Total	Native species = 6 trees Immigrants = 8 trees Immigrants herbs = 80 herbs	Native species = 10 trees/shrubs Immigrants = 21 trees/shrubs Immigrant herbs = 80 herbs	No trees

DISCUSSION AND CONCLUSION

The montane woodlands, tree/shrub Savanna and grassland Savanna of the Bamenda Highlands are ex-moist montane forests, that is, derived from montane forest. Pyrogenic and anthropogenic influences have acted together to contribute to the origin and maintenance of these ecosystems. The succession pattern towards the development of grassland is however not very clear and studies are needed to clarify how past land use intensity influences the various pathways in the dynamics of the vegetation. The population density exceeds 75 persons/km2. Most inhabitants are farmers who have cultivated the land very intensively. Figure 1 shows that as a result of continued human impact on the landscape, natural moist montane forest has been transformed into woodlands and grassland. The resulting derivatives reflect the character and intensity of anthropogenic agents. Figure 1 reflects the influence of agricultural encroachment, fire damage to forests and the grazing and burning of resulting fallow fields. On the other hand, Figure 2 demonstrates savannization and land degradation due to an increasing impact of pastoralism on the montane forests during the dry season when forage is scarce and both cattle, goats and sheep are obliged to browse the shrubs and small trees. They range fully in the forest. Goats and sheep are voravious feeders and inhibit natural regeneration of forest species. Accompanied by trampling by cattle and fire damage almost no regeneration takes place, leaving a moribund vegetation. The impact of

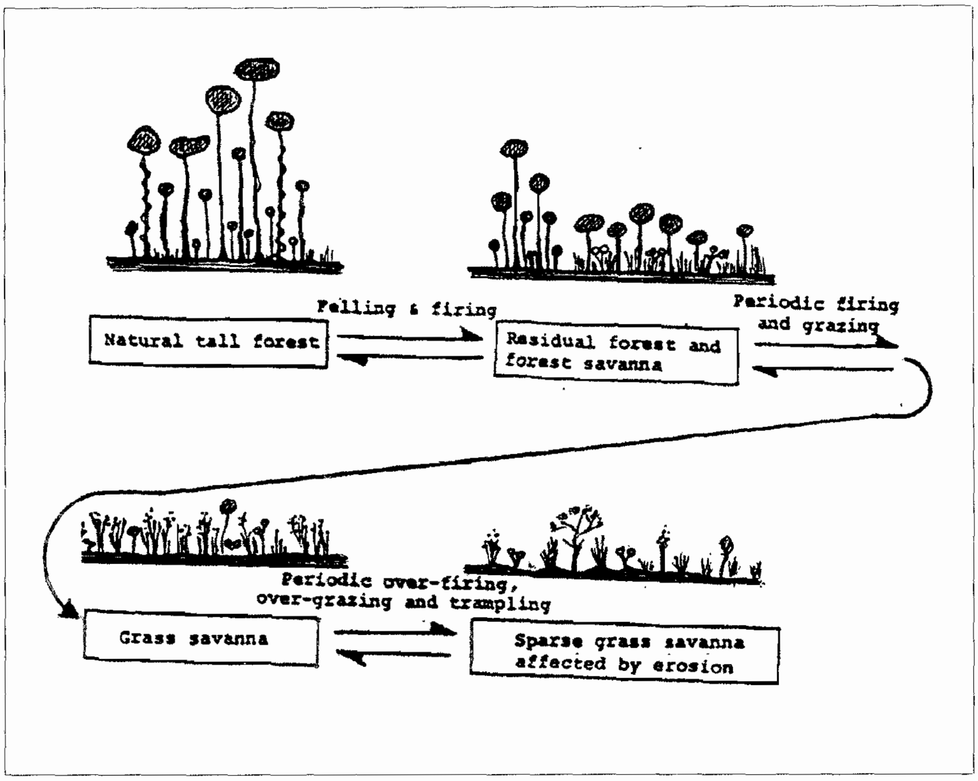

Figure 1: Dynamic relationship between human impact and process of savannization in the Bamenda Highlands (modified after Haruki, 1984).

grazing and annual burning on the surrounding forest has caused degradation in the terrestrial environment. This is mainly the result of biodiversity erosion and soil erosion.

From available literature, it will be clear that there is no simple and no conclusive answer to the problem of the origin of savannas. The evidence is, indeed, often conflicting and confusing and the explanation of what has happened in one area, even if we are relatively sure about it, does not necessarily apply in the case of another. In fact, it will seem likely that climatic, edaphic, biotic, pyrogenic and anthropogenic influences, individually or severally, may have contributed to the origin and maintenance of the savanna grasslands.

Whatever the cause, savannization is an environmental management problem. It is a desertification process which impoverishes climatic climax ecosystems (habitat loss and extinction of species). The mountain forests are rich in biodiversity. These are centres of endemism where large numbers of endemic animals and plants occur. The present use of mountain land is having a number of deleterious effects: forest and range degradation, decrease in dry season water flow and socio-economic conflicts. On global scale potential climate change particularly threatens these ecosystems. Mountain plants and animals are among the most vulnerable to climate change. Priority resource management initiatives should include:

- Changes in forest resources, with potential implications for agriculture, livelihoods dependent on cloud forests, rates of erosion, slope stability, magnitude of floods, and biodiversity;
- Intensification and/or extensification of agriculture and grazing, with potential implications for food security, rates of erosion and magnitude of floods, and biodiversity; and
- Changes in water resources due to factors such as changing agricultural practices, changing seasonal or permanent population size, with implications for downstream water supplies, energy availability, flooding and sediment transfer.

An understanding of these interactions provides an important foundation for development of sustainable management schemes for the future. With the current concern about the global change and mountain regions urgent action is needed in rehabilitation, conservation, sustainable management and monitoring of mountain regions.

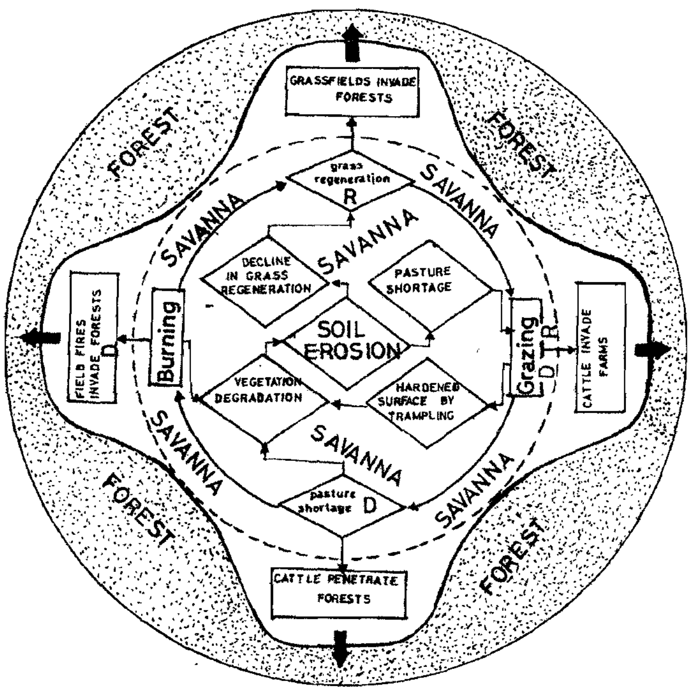

Figure 2: Grazing impact on forest-savanna contact zones and the process of savannization in Bamenda Plateau: D = dry season, R = wet season (modified after Hori, 1986).

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