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Invasive Weeds *(Pteridium aquililium* -Agogo) and Land Use: A Growing 'Nightmare' to Graziers in Rangelands of the Savanna Grasslands of the Western Highlands of Cameroon

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Abstract:- Weeds are growing threats on rangelands. *Pteridium aquililium* is one species that is rapidly spreading in tropical Africa. A litany of literature exists on its spread but land use implications on its spread has not been sufficiently characterize in savanna grasslands of Cameroon. It is this complementary evidence that the paper unpacks with the changing vegetation composition. Using 64 cross sectional transects in 5 different topographic units in the western highlands of Cameroon, this paper seeks to 1) map the extent of Bracken fern invasion 2) discuss land use practices and implications on weed spread and 3) analyze the changes on vegetation composition with related impacts for grazing. From field evaluation, the study revealed that 1) more than 65% of rangeland are invaded by Bracken fern with 48% dense patches, 32% moderate and 20% light patches 2) land use involving overgrazing, suppression of palatable species and use of fire are facilitating factors for weed spread 3) the change in vegetation composition is sustaining annual self-perpetuating weed communities that impair the weed-free areas causing reduction in carrying capacity creating vulnerable conditions that facilitate invasiveness 4) larger patch densities are found in plateau summits between 1800-2000m causing shifts in species and pasture scarcity. The results enhance our understanding of the dynamics of rangeland vegetation and the need for a jelled policy on weed management as a future study avenue.

I. INTRODUCTION

Invasive weeds are spreading across rangelands with far reaching impacts on grazing (Norgrove, 2010, Ndzeidze, 2012). Rangelands represent more than 60% of the surface area and is one of the major land use types in North West Cameroon (Mairomi, 2016). Bracken fern is considered one of the most successful invasive plant species (Taylor, 1990). Infestations of *Pteridium aquililium* are growing in extent and area cover without a formal survey. Grass floristic formations in the region are dominated by two species *Hyparrhenia rufa* and *Sporobulus spiramidalis* (Hawkings and Brunt, 1965) in the Sudan savanna that vary according to topographic setting in species composition with other grasses. Land use in grazing management is intensive though reliant on traditional pastoral methods (Ndenecho 2005, Lambi and Ndenecho, 2010). Like elsewhere in Cameroon, rangelands are considered as no man's land and classified as state lands that are formally recognized as communal lands meant for use by all and to which different individuals, groups or communities attribute variable more or less appreciative perceptions (Mairomi, 2012). In this context, open free ranging prevails as the dominant pastoral strategy with some informal communal control movements as pastoralism has change from the nomadic type to sedentary pastoralism. Undefined boundaries, unsecure pastoral tenure and grazing rights, land grabbing, trespassing, land use conflicts (farmer-grazier conflicts), degradation, poor range products and more recently challenges of weed management, climate variability are the major challenges. The dreadful weed invasions leave socio-economic and ecological implications that warrants some institutional aspects for redress.

Disturbances is a major issue of rangeland ecosystem dynamics (IRRC,2011), however, human alteration of such disturbance regimes results in the introduction of novel disturbances that produce changes in the system settings (e.g. resource availability), and that more often increase the opportunities for invasion (Vitousek et al, 1997). Land-use change has clearly exacerbated the adverse effects of invasive species on native biodiversity by creating suitable habitats for such species, from which they can either permanently or temporarily invade remaining indigenous habitats (Schneider, 2004). In response to increasing population densities, there are pressures on resources and increasing processes of landscape change that alter the surface, thus presenting a continuously changing base for subsequent interactions (Pokshishevskii, 1970, Zenlinski et al, 1970). Thus landscape evolution has been shaped by land use practices that create different vulnerabilities for weed spread. Land use and weed spread is given a close view in this study.

Much less attention has been given to assessing the human-environment interactions in which plant invasions is explicitly linked to social, economic, and cultural causes of land transformation (Schneider, 2004). This work discuses land use, Bracken invasion and implications. Bracken fern invasions appear to be a critical component of the

landscapes resulting from these processes (Turner et al, 2003; Schneider 2004). But the spatial distribution of bracken fern and its relationship to land use suggests a more complex process involving land-use strategies, land degradation, and fire regimes (Schneider 2004).

II. METHODOLOGY

2.1 Location

The North West Region of Cameroon has a surface area of 17,836 km^2 and the area lies between latitudes 5°20' - 6°40' N and longitudes 9°35' - 11°20' E. There is a varied relief stretching from flood plains and valleys in intermontane basins to plateaus and mountains thus presenting diverse ecological zones. Most soils are acidic and poor in nutrient content with huge demands in phosphorus. These soils are derived from trachytes, basalts and granites with a great variation in weathered material. 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 varied topography influences climate from its lowest points of 300m in the Mbembe area to the closing heights of Mt Oku at 3011m. Moby (1979) describes it 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).

Existing grasses in the area include *Hyperrhenia rufa, Hyperrhenia diplandra, Hyperhenia bracteata, Hyperrhenia mutica, Pennisetum purpereum, Bracharia mutica, Bracharia ruziziensis, Andropogon gayanus, Andropogon festaccitoris, Sporobulus pyramidalis* or Giant rat's tail grass, *Sporobulus africanus, Imperata cylindrica, Loudetia phragmitoides (Gramineae)*. Other herbs *include Biophytum petersianum, Borrrenia scabra, Eulophia impatiens, Pteridium aquilinum, Tephrosia pedicellata, Mellilnis minutiflora, Setaria sphacelata, Paspalum commersonii.* These grazed species are highly affected by bush fires and overgrazing. The grasses which grow extensively show many variations with climatic zonation, edaphic influences, grazing intensity and frequency of dry season burning. The main adventitious plant species (Hawkins and Brunt, 1965) are *Sporobolus* and bracken ferns.

2.2 Population

The third General Housing and Population Census of Cameroon (RGPH),2005 puts the population of the North West Region at about 1 728 953 representing 9.9% of the national total on about 17836km^2 being 3.7% of the country's total surface area giving a density of about 100 persons per square kilometer far above 37.5/km^2 national average for the country. High plateau areas (1500-2200m) host very high population densities of more than 200persons/km^2 like Belo, Kumbo, Njinikom, Oku and other areas with more than 100persons per km^2 like Jakiri and Santa. These high plateau areas hold the most extensive and densest Bracken weed patches. Cattle stocking density are also moderate to high. Cattle population in the North West was about 467817heads in 2015 (Regional Service of Survey and Statistics, MINEPIA, NWR)

The North West is dominated by a Tikar population; the Aghem people to the west, Bum to the north, Nkwen and Kom to the center, Moghamo to the south, Banso to the east, and the Wibum to the north east that constitute the main groups classified as the natives. They mostly practice agricultural activities. The Fulani population spread over the hills in the rangelands almost everywhere constitutes a minority and dominates grazing activities and represents about 4-9% of the population. Most of these groups securely settled in their localities in the 19th century but waves of the Fulani only came in the early 20th century from Nigeria and north Cameroon. The Jafun sub group of the Fulani are greatly present with the Aku's that came in later during the second half of the 20th century. Due to population growth and resource scarcity, pastoralism has changed from the pastoral normadic type to sedentary pastoralism. Scattered spontaneously within the hills, they adhere and pay allegiance to their spiritual leaders-the Ardos that head communal structures known as Ardorates. Most grazing zones are organize by council areas according to this social disposition. The Fulani still seem incapacitated and lack the genuine will to trigger off the required fight against weeds. An important drawback towards this improvement is the land tenure system and the communal nature of range exploitation that thus warrants communal approaches.

2.3 Methods

A mix method was used for the study. Research instruments were prepared in the month of November 2016 and field work between March and April 2017. Key informant interviews were used and over 44KIIs of the 68 communities covering the various pastoral communities in North West Cameroon were covered. It covered Donga Mantung, Ngoketunjia, Bui, Mechum and Boyo divisions of the North west region. It targeted key persons like heads of grazing units and some elderly pastoralist. It concerned 13 open questions on major themes related to weed distribution, spread, density, land use practices, grazing, implications for pastoralism and livelihood. Interview was treated according to thematic relating to land use, grazing management and weed spread. Mobile mapping using GPS loggers was used. It was facilitated by communal grazing heads 'Ardors' that provided cattle care takers "Gainakos" to participate in mapping. In fact, information gotten from Key informant interviews was used in participatory mobile mapping as pastoralist provided information on weed location that eased mapping and made it faster for each unit. The points collected were classified in situ as dense, moderate or light. Also, 64 transects were laid out in a cross section manner cutting through hill summits, slopes, valleys and plateau

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summits with quadrats that gave us information on relative abundance of *Pteridium a.* on grass composition for different sites.

III. ECOLOGY

Pteridium aquililium is well known for its invasiveness. It is referred to as pasture brake; and locally as "Agogo" by Mbororo graziers; names that are all indicative of its power to colonise environments as well as its impacts on pastures. In much of the tropics, *Pteridium spp.* is common in some mountain areas and will become more dominant where fire occurs (D'Antonio et al., 2000; Wesche et al., 2000). *P. aquilinum* is found in a variety of sites in sun to partial shade and on soils that range from deep and rich to hard-packed or sandy. It is one of the first plants to colonize logged or cleared areas though it seldom persists in cultivated areas. In most of its habitat in the area, it is either present as a pest or weed or invasive. Though ubiquitous, it an altitudinal plant in North West Cameroon. Most of these are terrestrial managed habitat and include; cultivated or agricultural land, managed grasslands or grazing systems, disturbed areas and roadsides, managed forests and plantations. Others are natural forests and grasslands. The species is regarded by pastoralist as a harmful invading rangeland weed.

Fronds tend to grow mostly after fires and as a geophyte it turns to grow better under unshaded areas or habitats. Due to land use histories of the Grass fields characterised by dry season bush fires, *Pteridium aquililium* illustrates that it is to a large extent a fire-resistant species as underground rhizomes send out new shoots after clearance of old rank vegetation by fire. In fact, bracken fern is fire responsive. In tropical regions the species is often referred to as a typical postfire successional species (Wesche et al., 2000) and after fire may form so-called 'bracken savannas' (Beard, 1953). It is one of the few seasonal sub-montane native species to increase in burned compared to unburned areas (D'Antonio et al., 2000).

Spores are wind-dispersed. Viable spores are often found in abundance within a soil profile and spores may remain viable for up to 10 years. Natural regeneration from spores may occur and is mainly restricted to areas of disturbed or burnt ground. Expansion of established clones will be chiefly vegetative (Grime et al., 1988). The latter is quite true for the growing tickets of bracken patches over the area gradually increasing in extension after establishment with underground rhizomes.

IV. ELEVATION AND ENVIRONMENTAL REQUIREMENTS/SOIL TOLERANCES

Bracken fern is commonly found at varying altitudes in the area. From the lowest altitudes around the Ako Mbembe forest (300 m) to the closing high points of Mt Oku (3011m), *Pteridium aquililium* can be located. In low altitude areas below 1200m, it is found in association with *C. odorata* in the edges of some degraded forest and tree shrub savanna. It is more abundant in uplands or the high plateau and dominates altitudinal ranges in the study area of 1600-2400m above sea level. Its greatest weed location habitats, patch sizes and densities fall within this range (Mairomi, 2016). A diverse topographic setting marks the North West with different ecological zonation. There is tropical deciduous forest and wet meadows below 1000m, mid altitude tree-shrub savanna 1000-1600m and high plateau herbaceous savanna. With varied edaphic conditions in the area, soils are largely derived from basalt and trachyte basement but Bracken fern is implanted in all of these condition being altitudinal. The largest invasions are however establishing in basalt derived soils in plateau areas in the 1800-2200m range.

It prefers acid soil, tolerating soil pH of 3.0-7.6. Nevertheless, in the North West Region of Cameroon, it is most frequent and abundant below pH 4.5 and particularly on deep soils. Soils in the area are acidic with pH values ranging from 4.2-5 quite common in the mid altitude and high plateau areas offering very suitable conditions for its establishment and proliferation. It is found on a range of shaded and unshaded habitats but grows best on productive brown-earths and more open habitats. These are the conditions on which you find the largest patch sizes and heavy dense infestations in the Berlem, Sabga, Ndawara and Binka rangelands. Young shoots are very sensitive to cold and trampling by large mammals.

P. aquilinium is a cosmopolitan weed that readily spreads into pasture and marginal areas and is favoured by fire and soil acidity. Its presence reduces land productivity and adversely affects biodiversity (www.cabi.org/isc). The plant is little affected by animals because of its toxicity. *P. aquilinum* is difficult to control particularly because of its ability to sprout from an extensive network of underground rhizomes and has large reserves of carbohydrate. During the growing season the fronds are dark green and may reach a height of up to 2 m. The fronds usually turn yellow before becoming dark reddish-brown. In marginal grazing land bracken produces monotypic clumps. In extreme cases it may dominate all the ground vegetation. Bracken takes months to break up during the dormant season when the fronds have dried. Under some climatic conditions it becomes a fire hazard.

V. INVASIVENESS AND SPREAD

Bracken fern is considered one of the most successful invasive plant species (Taylor, 1990). Except in desert regions, it occurs around the world. It is found in various types of habitats, from woodlands to grasslands, and becomes a difficult weed to eradicate because of its persistent underground rhizome (Fletcher and Kirkwood, 1979). It establishes itself in areas dominated by fires, deforestation, and agricultural activities (Page, 1986), causing severe problems to both farmers and conservationists (Pakeman and Marrs, 1992). The increase of bracken fern in homogeneous areas is correlated with human activities (Rymer, 1976). The high success of bracken fern invasions in tropical regions is due in part to its dispersion mechanisms: Spores are dispersed all through the

year, and once individuals are established, deep rhizomes allow their local persistence. Bracken fern's success in establishing itself is also due to its high resistance to diseases and pests (Cooper-Driver, 1990), to the presence of allelopathic substances (chemicals that inhibit the growth of nearby plants) (Gliessman, 1976), to its prolific vegetative reproduction (Page, 1986), to the high density of the frond canopy and litter suppressing the ground flora, and to tolerance of a broad range of climatic and edaphic conditions (Gliessman 1976; Page, 1986). Another factor that contributes to bracken fern invasion is the resistance of the rhizome to fire and adverse weather conditions, allowing the colony to spread vegetatively (Fletcher and Kirkwood, 1979). After dry season fires set by graziers for regeneration and clearance of old dry grass from December to February, shoots of Bracken spring up from ground rhizomes. Nevertheless, the dynamics of invasion in rangelands in has been minimally addressed. Research on this invasive in Cameroon is modest, although its disruption of land uses is well known. In the stretch from Shukai to Belem in Kumbo sub-division, for example, bracken fern covers huge areas, disrupting both agricultural and cattle grazing activities. It is also a successful invader in rangelands in Tadu and has greatly expanded in extent in Ntunir (Jakiri) and Binka (Nkambe). Characteristics such as resistance to fire, tolerance to long dry periods, low susceptibility to diseases, carcinogenic effects on potential predators (for example, cattle), and high rates of dispersion make bracken fern very difficult to eradicate. Bracken fern plots tend to be quite large and homogeneous, due mainly to a frequent fire regime (annual dry season fires) that eliminates other vegetation. Bracken fern rhizomes run deeply into the soil and are the main reason for colony expansion. Areas covered by the fern are structurally distinct from forest and other disturbed land covers in the region.

In the analysis of survey data, field points suggest that bracken fern invasion is negatively correlated with land availability. Bracken fern density is low in land-sparse or less tax with pressure of grazing. Low stocking densities are their characteristics that distinguish them from neighbouring lands. In contrast, bracken fern density is high in land highly grazed or characterized by high land pressures. This trend of events corresponds to what Schneider (2004) characterised in Calakmul region in Mexico on the speculation that bracken fern prevalence is associated with longer-term land use and repeated burning of the landscape. This pattern appears to be consistent with observations over the study area particularly in the high plateau areas.

Field data attributes greater risks of *Pteridium* invasion to land use practices such as overgrazing and uncontrolled livestock movement as the dominant causal factors of spread at 89%. This is noticed in the competitive suppression of graminea and growth allowance that grazing allows to the weed. Moreover, burning is one of the key variable regularly characterizing rangelands in the area. The removal of old rank vegetation during the dry season propels *Pteridium aquililium* to vegetative spread through underground rhizomes with new shoots in the following rainy season. Most pastoralist identify burning and range fragmentation with weed spread.

Combining biophysical, socioeconomic, and spatial data relevant to Bracken fern prevalence provides a different understanding. Analysis of topographic characteristics indicates that steep and moderate slopes and areas facing the sun from a northeasterly direction are more susceptible to the establishment of bracken fern than are other areas in the region. Repeated burning of fern-dominated areas also favors retention of the species. These factors are the subject of ongoing research. Socioeconomic and spatial data also indicate, however, that pastoralists' willingness to combat bracken fern invasion is related to the land, labor, and capital conditions of the household. In open rangeland conditions, as among the pastoral communities of the NWR, lack of security of tenure with open range grazing system, the high labour and other costs involved in controlling bracken fern lead to a common response: Leave or avoid the invaded land, and graze the non-invaded land or areas free of infestation. Also, it is to avoid Bracken poisoning. Therefore, Bracken fern invasion reduces available pastures and decreases carrying capacity. This has been the trend of events and attitudes marking pastoralist in relation to weed infestation in the study area. This option is no longer viable especially in grazing zones that are not really large in extent coupled with dwindling rangelands as a result of encroaching human activities notably agriculture and settlement. In cattle ranches like in Tadu and Jakiri where Bracken is really taking its turn, the situation becomes more demanding due to the ranch size and the quest for pasture improvement and animal fattening. Land-use intensity, therefore, appears to play a fundamental role in decisions about bracken fern management, consistent with various induced intensification theses (for example, Turner and Shajaat Ali 1996).

Bracken fern is seen as a night mare, a pertubation and probably now one of the worst limiting factors to livestock production by graziers. This is consistent with the responses describing the local circumstances by every single pastoralist in the high plateau zone. The apparent rewards for combating Bracken fern is not really evident in the near future given the high cost of labour involved and lack of security of tenure. Open rangeland extensions have the largest increase and highest densities of *Pteridium aquililium* invasion. They are followed by private lands that are mostly ranches (Tadu, SODEPA Jakiri, Elba Ndawara, Yang Philemon ranch; Tadu&Ijim). Bracken is almost absent in forest extensions but is found in grazed forest lands towards the summit of mount Oku where mostly goats and sheep are reared. In this area, it is found with *Emilia Pratemisa* invading *Pennisetum clandestinum* (refer to photo plate 1). In agro-forestry units dominated by Eucalyptus plantations, the extent of Bracken fern invasion in such grazed forest lands is also increasing in extent and at times very dense. This result is expected because the invasive species is favoured by disturbance to establish itself and there is a human disturbance that might not be regular but is usually taking place-fire. It is used to clear brush or undergrowth but at times is incidental from neighbouring

grazing fields, farms or rangelands. In this situation, two allelopathic species; Bracken and Eucalyptus are found in association (refer photo no 2). Private ranchers are delineated with considerable land but do not necessarily invest the labour to keep up the pasture that they have created. In turn, due to management and mobilisation of finances, some of the paddocks are relegated to the background awaiting improvement and are susceptible for bracken fern to invade, which is then promoted by intended burning to combat brush and incidental burns from fires that usually burn around the ranches. This is noticed in the few ranches in the area.

VI. LAND USE HISTORIES AND SPATIAL DISTRIBUTION OF BRACKEN FERN

Plant invasions, which affect ecosystem recovery are an important part of land-use change in the region and are closely related to ecosystem function and landscapes. Bracken fern has increased enormously in the area, impeding regular succession of the vegetation. The general assumption in the literature is that this invasion is linked to land degradation, but the spatial distribution of bracken fern and its relationship to land use suggests a more complex process involving land-use strategies, land degradation, and fire regimes. Bracken fern identified as an invasive is an important element of land use dynamics in the area.

During the colonial days before the 1960s and early post-independence period, resource depletion and degradation warranted movements by pastoralists to search for better areas. At the time, it served as some form of rotatory movements that permitted rest and restoration in depleted areas under pressure (pastoral nomadism). With the low pressure (stocking density) and abundant rangelands, this land use practice was sustainable. Nowadays, population increase, land grabbing, settlement expansion and accompanying agricultural extension on rangelands causing dwindling rangelands and increase in livestock numbers have enormously increased the stocking density. The problem has been worsened in the recent past by the problem of weed infestation. Restricted to the same grazing areas and only limited to seasonal transhumance movements, the present range practices-open ranging in communal grazing reserves with common pool tragedies leave more to be desired. With the current unprecedented Bracken fern infestation and the reduced nature of grazing, more range areas are vulnerable with high susceptibility of weed establishment and the situation demands more than ever, efforts to salvage the situation from ruin.

Bush fire is an important strategy and major variable of rangeland management in the western highlands. Land disturbed by events such as bush fires also creates exposure to weeds. Bush fires are set during the dry season (December to March) especially in the months of January and February. Primarily, it is to clear off dry biomass or old rank grass and facilitate vegetation (grass) regeneration through re-shoots. Animal preference for young growing grass is higher this early stage when leaves are not yet too tender. Moreover, bush fires are aimed at clearing disease pest especially in Tse tse fly infested zones. Bush fires remove vegetation and disrupt plant canopies especially their aerial parts, thus, exposing the soil. Such disturbed rangelands do have exposed soil that provides easy access for exotic seeds or plant parts to grow. It is worthwhile noting that Fulani pastoralist retain fires as the major way of clearing bushes, regenerating pastures and controlling the problematic cattle ticks. But overall, post-fire situations facilitates Bracken fern invasions . It marks a great transitional element from one rainy season to another. Following a fire, the blackened soil has a lower albedo and absorbs heat more readily and without its protective vegetation cover, the soil is more vulnerable to erosion. Ash initially increases considerably the quantity of nutrients in the soil and bacterial activity is accelerated with warmer soils. Any seedlings left in the soil will grow rapidly as there is now plenty of light, no smothering layer of leaf litter, plenty of nutrients, a warmer soil and, at first, less competition from other species. Bracken fern and other weeds that have pass through dry season fires are noticeable at the beginning of the rainy season by their more vigorous growth. The plant communities in the study area associated to annual fires do have a proportion of species that can sprout quickly after the fire and which have accumulated reserved water in underground tubers or rhizomes insulated by the soil. Bracken fern disposes such underground rhizomes that sustain its transitions during the dry season without much difficulty.

- *Selectivity*

Through invariable or inflexible movements of different herds of cattle on rangelands, the most palatable plants are eaten and in due course overexploited. They are subsequently unable to complete their vegetative cycle and to reproduce. This reduces their vigor. The dissemination of seed-reproducing seasonal and perennial species is thus compromised and their density on pasture land decreases. If the species concerned is a tree desired by animals, young plants might not be able to establish. On the other hand, less appreciated species will increase and eventually invade the land. Overgrazing reduces the competitive ability of palatable plants but on the contrary less palatable plants or weeds are given a good opportunity to proliferate. In areas highly noted with Bracken fern, their proliferation did not only retain the plants ability to expand through seed and vegetatively by rhizomes but one of the greatest factor was the outstanding consistent suppression of palatable species (*Hyparrhenia, Loudetia, Sporobolus*) by grazing. As such, grazing clears competition for *Pteridium aquililium* and makes way for the creation of extensive monocultures that occupy particularly the high plateau.

VII. PROLIFERATION OF WEEDS AND LESS DESIRED PLANTS

Unpalatable species are either less desired or rejected by cattle. They have time to complete their vegetative cycles and disseminate their seed. Moreover, the reduction of the palatable species most desired by cattle encourages their proliferation. Bracken fern tend to meet less root and aerial competition. Overall, this is caused by livestock selectivity

and overgrazing preferred grasses annually. This thus favours the rapid shift from the existing native preferred species within the plant communities. With suppression of preferred annuals and perennials, less palatable plants and weeds proliferate and expand to the neighbouring vulnerable ground gradually extending the monotype culture being put in place. Open extensive grazing or normadism with little or nonexistent communal rules to pasture harvest leaves much to be desired. Stocking was not regulated but is now managed to control animal movement. Periods of deferrement (rest or postponement of grazing) and fallow did not exist to allow for pasture to regrow and regain vigour owing to weak or nonexistent communal grazing institutions and regulations. But informal control has been reinforced over the years. Therefore, in the course of the year, pasture harvest (palatables) is continuous with no restrain with graziers moving their herds in all directions avoiding only areas recently vacated by others- a practice by the Fulani. Unwanted plants particularly *Pteridium aquililium, C. odorata, Microglossa angolensis and Vernonia auriculifera* thus strive to blossoming especially during the rainy season attaining maturity and reproducing a lot of progeny. Moreover, overgrazing together with hoof action is noted in the area to reduce ground cover thus exposing the soil. This increases vulnerability to Bracken invasion and even exotic species particularly *Chromolaena odorata* and facilitates their establishment.

Continuous grazing often leads to overgrazing and this reduces the production of regrowth because less opportunity is allowed for pastures to reconstitute. The grasses are unable to reconstitute their underground reserves, leading to the root system being weakened and depleted by the loosing mass. Subsequently, production reduces the following year. However, if deferrement or rest periods are introduced, the grazing potential could be restored. The gradual reduction and disappearance of the grass cover and extreme events like trampling leads to erosion. In some areas like in the Mbokam hills, Sabga hills, Ngie hills in Tabenkeng, Nkuv hills these manifestations are quite phenomenal. Photo 1&2 demonstrate extensive bracken invasions.

Photo 1:*Pteridium aquililium* infestation in Berlem (2200m) Dzeng-Mbiame plateau, Kumbo

Photo 2: Dense extensive Bracken fern invasion in Ntunir, (1960m) Jakiri
Source: Mairomi (2016)

Bracken fern infested areas are large and conspicuous. Mairomi (2016) characterizes the weed spatial distribution in the area. In highly infested areas like Berlem (Kumbo sub-division), heavy invasions abound. Within this grazing area, a high density infestation stretches over an area of more than $3km^2$; one of heaviest weed patch in the study area. This stretch of rangeland is located in the Dzeng Mbiami plateau. Thick densities of bracken have rendered the rangelands almost worthless and some of the areas are completely out of use with total avoidance by graziers. These dense patches are also noted in Bamdzeng grazing area. In other areas in the region with dense monocultures of Bracken, average weed patches are about $100m^2$. Weed patch sizes of $100\text{-}500m^2$ are quite dominant in Jakiri sub-division. Patch sizes of this nature are very remarkable in Ntunir, Vekovi and Tadu grazing zones of the sub-division. The situation in Mbiame sub-division is not really different with moderate to dense patches. Grazing areas around Kovki, Mbohtsem and Rifem were quite characteristic. Dense patches that are similar to that of Berlem are located in Binka, Bihjeng, Nkonchep and Bishua grazing areas in Donga Mantung division. The Njeuma and Bih grazing zones are relatively free with light infestations. Bongi, Sah and Kukube hills are dominated by moderate densities with spontaneous spatial distribution of patch sizes of $50\text{-}200m^2$. In Mentang, Achain, Ijim and Bainjong grazing areas in Boyo division, bracken patches remain modest and not too extensive. Modest patches that hardly exceed $200m^2$ are also characteristic in the Zhoa council area and Bum sub-division in Boyo division. Bafmen, Fungom and Nyos sites are the leading sites here. Moderate to dense infestation abound from the Sabga hills to grazing zones in Zhong-Santa, Awing and Pinyin. Bracken is spotted in certain slopes in mid altitude zones 1100-1400m in association with light *Chromolaena odorata* invasions in tree shrub savanna extending from Nyos to the Kimbi area. This association is observed in forest edges in Momo division and in Ako.

Field mapping of the extent of infestation is presented in table 1. More than 65% of rangeland are invaded by Bracken fern with 48% dense patches, 32% moderate and

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20% light patches. It shows that satellite fronts are advancing very fast in rangelands. Donga mantung, Menchum and Bui divisions present very large areas infested by weeds and in dense patches. The effects on grazing are unprecedented as well as the changes in species composition.

Table 1: Weed infestation in rangelands of the North west region

Division	Grass Land (area in km^2)	Weed infested area in km^2	% Rangeland infested by weeds	Dense infestation in km^2	Moderate infestation in km^2	Light infestation in km^2
Boyo	401.30	156.39	39%	62.40	53.04	40.56
Bui	526.41	299.82	57%	158.47	83.72	56.81
Donga Mantung	1067.18	544.17	51%	239.36	146.88	157.76
Menchum	1374.77	769.44	56%	299.91	238.39	230.70
Ngoketunjia	1050.5	525	50%	141.75	231	152.25

Source: GPS field mapping, Mairomi, 2016

VIII. ALTERED FIRE REGIMES AND PERSISTENCE ANNUAL COMMUNITIES.

Communal rangelands in the area are riddled with common pool degradations and provide an ideal condition for invasion of bracken fern. With open uncontrolled range grazing that often tends to lead to overgrazing and reduced competition, appropriate conditions are set for bracken. There is minimal competition for light particularly in the high plateau savanna areas dominated by *Sporobolus piramidalis*. Moreover, the large amount of dry biomass created by bracken fern or dry vegetation readily provides fuel loads during the dry season that are receptive to seasonal dry season bush fires. It increases the need for dry season bush fires that are hotter and more destructive to the environment due huge fuel loads created. Fire is no longer set to clear old rank grass, renew pastures and eliminate disease pest but for extensive huge patches. These fires are ignited by pastoralist or are incidental burnings. As such, the fern fire ecology ensures its persistence and subsequent expansion. There are thus annual self-sustained perpetuating Bracken fern communities. This is reason why some bracken stands have existed over long periods and remain resilient to seasonal fires that clear the areal biomass but rhizomes sustain the transition to the next rainy season. Burning however remains problematic due to poor fire mastery as there is indiscriminate burning but in some grazing units, some informal norms are implemented.

As such, there are long standing stands in rangelands that have long been invaded and are gradually expanding. Persistence and further invasion is ensured. The communal or public rangelands that are invaded by weed are under no specific grazier's control. No attempts have been made in combating bracken at the communal level in grazing zones except for the traditional mechanical method; burning. In view of the foregoing, the temporal and spatial aspects of invasion are thus brought to light. Bracken fern have persisted over decades invading the common property resource. The invaded acreage is increasing and pastures are deteriorating. Weed patch sizes are increasing over time as well as densities emphasizing the increasing cost and labour that could be engaged in combating it. Infestations are best managed when they are light and mild thereby reducing risk of weed establishment.

The main change in rangelands in the North West Region has been the increase in Bracken fern invasion and reduction in good pastures. Bracken infestation are expanding and in some grazing areas, they are overriding the weed free pastures. Bracken fern tends to be dominant in large open areas that are invaded and has become a major weed in high plateau. It appears it has the potential to invade virtually any piece of open land. The scarcity of cheap and successful herbicides, high labour cost and overall lack of security of tenure or the open nature of communal areas limits investment to combat bracken invasion by graziers in the study area. Grazing still unfolds when patches are still dominated by light and moderate density infestations. When intensities become dense with close frond canopies, these areas are almost ruined and are avoided and gradually abandoned by graziers. Penetration by cattle is done with a lot of difficulty and often meets with skin injuries and allergies.

The extent and density of Bracken fern in rangelands imply a more complex relation involving size and distribution of grazing area. The general trend is that the larger the grazing area, the larger the amount of land under bracken fern invasion especially in grazing areas situated in the high plateau areas. The stretch of land from the Wainamah hills, Jakiri to Tadu through Berlem to Mbiame and Binka to Nkambe occupies more than 50% of the total cover of Bracken in the study area. This part of the region is the most affected. The Sabga hills extending to Ndawara is also heavily invaded. Infestation densities around the Nyos hills are moderate to dense but comparatively not too large in extent or area cover. There is a similar situation around Bum and Misaje areas with small weed patches that hardly go beyond $100m^2$ but highly spread in the grazing fields. In these areas the area under bracken fern is modest. All these areas have a perculiar land use history; having been introduced to pastoral nomadism in the first half of the 20th century, and today experiencing more settled pastoralism with seasonal migratory movements or transhumance during the dry season. Given the fact that, bracken vegetative reproduction is very rapid particularly with its rhizomes, its weed patches after establishment tends to grow expansively and increase in density. Long periods of disturbance and resource depletion through grazing or fire regimes are linked to large weed invasion patches. Nevertheless, the amount and density of bracken fern weed patches could be

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independent and not necessarily linked to long periods of disturbance. Moreover, spread could be by spores and after establishment ensured by rhizomes. Land use history and current land management practices remains an asset for invasion of the Bracken fern because they promote and do not deter invasion. This thus establishes a relation between land management practices within rangelands of the region and persistence of bracken fern. Photos 1 and 2 shows dense invasions in Berlem.

IX. RELATIVE ABUNDANCE OF WEEDS ON GRASS COMPOSITION

However, species composition and percentage of weed presence in highland plateau depends on patch density; dense, moderate or light (sparse). Dense patches show weed presence on plant composition at over 35-60% with relative abundance over of >71individuals or more per quadrat. Moderate patches stood at 20-34% of weed presence, 41-70 individuals per quadrat and less than 24% of palatable species. Light patches portrayed less than 20% of weed presence on grass composition and less than 40 individual bracken fern plants in a quadrat but the relative presence of palatable species was higher at over 35%. Table 1 derives the average percentage of weed presence according to patch density in the study area obtained and characterized from field evaluation. Spatial distribution of weed density is presented in figures 1.

Table 1: Patch density and percentage of weeds in grass composition

Patch density (Pteridium aquililium)	% of weed presence on grass composition	Relative abundance per quadrat $1m^2$	Relative presence of palatable species
Dense	35-60 (+)%	71+	less than 15%
Moderate	20-34	41-70	less than 24%
Light or sparse	less than 20%	1-40	less than 35%

Source: Field evaluation 2014

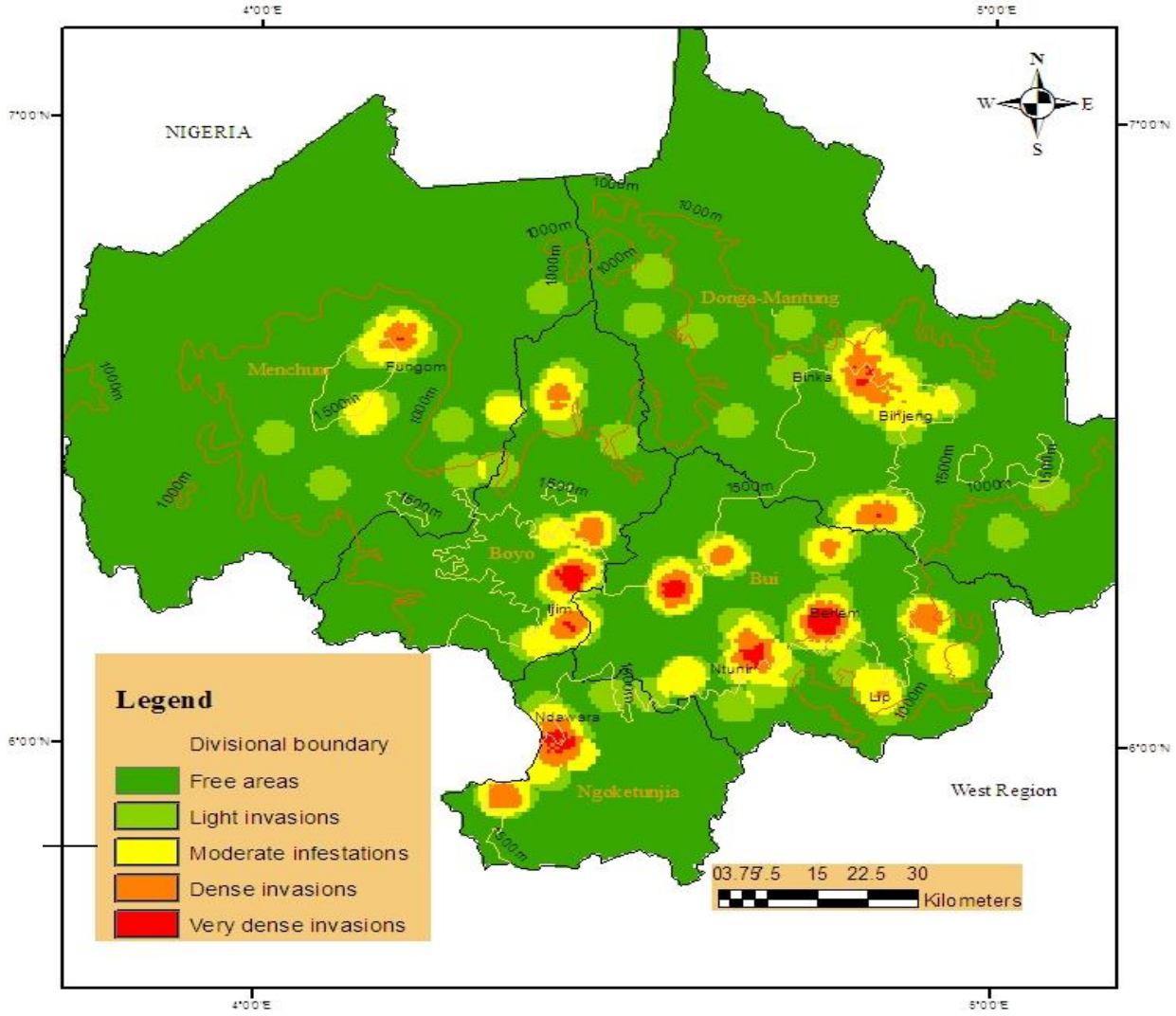

Figure 1: Density and distribution of *Pteridium aquililium* invasions in the study areas

Source: Field inventory and mapping of weeds, 2014, point density and interpolation Kriging of ArcGIS

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Amongst the points mapped for *P. aquililium*, classification had the following distribution amongst the existing mapped patches; 48% dense, 32% moderate, 20% light. Concentrations are above 1500m depicting it is more altitudinal (fig 1). Table 2 portrayed weed species presence and relative abundance on different weed patches.

X. SITE SPECIFIC ANALYSIS

- *Slopes*

Slopes are amongst the most affected areas with the change in floral composition and soil cover. Being a hilly terrain, grazing along slopes that has created terraces of 40-60cm with bare ground and sporobolus at the edges are now invaded by Bracken with different implications. Desired species were found to be greatly diminished and vegetation is a dominant stand of *Sporobolus* of over 63% of grassland composition with terraces on slopes. Vegetation change is axed on an increase in weeds among the floral composition. *Pteridium aquililium, Microglossa angolensis, Dissortis minutiflora* and *Sida rhombifolia* constitute over 20%. Soil cover is 17-30%, worst compared to other areas and more glaring along transhumant areas. On slopes at elevations between 1000m and 1300m around Esu, Nyos and Kimbi with shrub savannas, *Pteridium aquililium* in found in association of *Chromolaena odorata* at the understory of shrubs. Slopes are generally sensitive and poor in range condition and require much attention.

- *Plateau summits*

The most extensive Bracken invasions are in plateau summits cutting across Sabga, Ndawara, Jakiri, Berlem to Nkambe (refer photo 1&2). With gently undulation terrain holding high cattle densities over 5TLU/ha, land use has effective taxed pastures causing deterioration and the climate and soils have provided suitable conditions for its spread. *Loudetia, Setaria, Andropogon, Paspalium and Hyparrhenia* are greatly diminished and almost absent, *Sporobolus* is in steady dominance over 63%. It is the most affected zone especially the high lava plateau areas of 1800m and above. It constitutes the greater part of the rainy season grazing area and supports grazing over 240days from April to November all the wet long season. *Pteridium aquililium* is relatively increased among the floral composition. It is found with a mix of *Microglossa angolensis* in Kukube, with *Dissortis multiflora* in Ndawara and Binka, with *Emilia pratemisa* in Tadu, Berlem and Oku. In fact, over 21% of the floral composition in these areas is weeds. Exceptional cases for most affected plateau areas of Tadu, Dzeng-Mbiami i.e. Berlem sites registered cases of over 40% of *Pteridium aquililium* with dense monospecific stands. This area requires urgent attention in terms of weed management with areas that already in avoidance.

- *Foothills*

The relative abundance of *Hyparrhenia rufa* grass, *Pennisetum purpureum* and *Loudetia simplex* are still high at over 70% of grass composition like the managed rangelands of Dumbo ranch and Kimbi reserves though weeds are taking their turn in road sites and inland valleys. The mix of Bracken and Chromolaena O. on forest edges is remarkable, also with dense patches. Lowlands like Misaje, NjiniKimbi valley showed dense infestations of *P. aquililium* (8%)and *C. odorata* in a grass composition. *Adropogon, Melinis, imperata, Crotalarias Setaria sp. (S. sphacelata), Loudetia Panicums* and legumes such as *Trifolium* constituted over 20% of grass composition.

- *Kikuyu patches*

Sporobolus is highly intermingled with *Pennisetum clandestinum*. It presented more than 65% Kikuyu in grass composition with less than 8% in Bracken invaions. *Sporobolus pyramidalis* have grown in kikuyu patches and now represent well over 22% while *Trifolium* and *Solanum* in association stands at over 12%. Found in plateau areas and gentle slopes, it is sensitive to trampling when grazing becomes intense with the presence of terraces, *Pteridium aquililium* invasion is likely. Invasions are mostly light to moderate with spotted satellite fronts. However, for *Pennisetum clandestinum* areas, ground cover here remains highest for the study area at over 70-95% like Taashem in Jakiri and Mbamdzeng in Kumbo. Nevertheless, they keep a good range condition and trend but remain sensitive to misuse. More so, Kikuyu patches that are not under very intense pressure and with little appreciable management were mostly invaded by short seasonal ephemeral herbs like the case of *Crassocephalum sp* noticed in the Ndawara area.

XI. IMPAIRMENT OF WEED FREE AREAS

Over 65% of rangeland have been infested by Bracken fern in the North west region of Cameroon. Close to 50% of it is dense, implying that a huge areas of rangelands in the western highlands are already avoided by pastoralist and livestock. The direct implication is that cattle concentrate on the weed-free areas increasing the stocking density. Concentration on non-infested areas leads to overgrazing and degradation of the commons. In Ntunir in Jakiri for instance, the grazing acreage and livestock units stood at 2Tropical livestock unit per ha but due to weed invasion (70% of the area), the weed free area is now grazed at 5TLU/ha. Again in Fungom, the grazing density stood at 1.7% for the grazing unit but due to weed invasions, the weed free areas now support 4TLU/ha. This is when risk of overstocking and overgrazing sets in, with grazing right to tussock removal creating bare ground, with hoof action accentuating it leading to formation of rills and gullies. Thus resource degradation sets in creating more vulnerable conditions for weed spread.

XII. THREATS AND CHALLENGES

Weeds have left a good number of challenges to the pastoral community

- In open rangeland conditions, as among the pastoral communities of the NWR, lack of security of tenure with open range grazing system, the high labour and other costs involved in controlling bracken fern lead to a common response: Leave or avoid the invaded land, and graze the non-invaded land or areas free of infestation.
- Avoid Bracken poisoning

- Bracken fern invasion reduces available pastures and decreases carrying capacity.
- Pastoral institutions are weak and poorly organized
- Land use change, Undefined boundaries, unsecure pastoral tenure and grazing rights, land grabbing, trespassing, land use conflicts (farmer-grazier conflicts), degradation undermine resource base
- Grazing strategies, common pool perception, open ranging
- Poor range products (cattle, milk)
- The impacts of this growing condition in rangelands is quite significant and ranges from impacts on livestock, graziers and even livelihoods or the local economy to changes in ecological status of rangelands. Infestations impact livestock and rangeland by interfering with grazing, lowering yield and quality of forage, poisoning animals, increasing costs of managing and producing livestock, and reducing value. It increases land erosion, reduce plant diversity and alter fire frequency.

12.1Translating local action into policy reforms

Only when the numerous graziers that fend for their livelihoods in the rangelands of the area are coordinated with some minimal institutional framework that efforts can be harnessed for rangeland management and improvement (Mairomi, 2012). Eliminating weeds from rangelands is a costly community initiative that requires the little efforts of every small or individual grazier making use of the range. Institutional mechanisms are necessary for good resource governance and sustainable rangeland development. These include an appropriate sharing of responsibility and coordination across stakeholder groups: wide participation in strategic planning and networking among practitioners (Graziers, farmers) and stakeholders (authorities). This type of organization bringing together actors in a common platform can create both the impetus and opportunity for innovation. Such prospects could include environmental zoning. With such a platform, shared values can provide good capacities for mitigation and response in participative approaches in range management. The commonality of interests makes collective action possible either to solve or tackle problems internally or to obtain what is needed from other parties (e.g. government authorities, NGOs). Achieving sustained rangeland development requires forward looking institutions that sense emerging problems and commit to effective execution of agreed solutions. A handful of institutions are engaged in the pastoral landscape in the North West Region; MIDENO, CIDENO, SNV, APESS, EU, UNDP, TDCS, MINEPIA, MINADER, etc.

When social and environmental issues are systematically neglected for long periods, economic growth will be affected. Some problems of sustainability are already urgent and require immediate action; examples are local ecosystems where population is pressing on deeply degraded rangelands that have been heavily infested by weeds. In such cases, productivity is already on the decline and opportunities for correction and mitigation may even be lost; abandonment of existing practices and out migration may be necessary. The urgency of some of these problems has been overlooked because the people most affected are physically remote from centers of power, or because their voices are not heard, or both. Rangelands seem marginalize by state development policies in terms of policy prioritization. Most importantly in this case, is the inability of livestock rearers to organize and instill community organizations that can handle common problems faced by every pastoralist in the area.

An analysis of the problems resulting from the various categories of cattle and livestock breeders who are less well integrated into specific development programs in the area, but who constitute one major group of land users in the area results that an integrated weed program can best be realised at the level of the Ardorates. This can be possible if graziers grouped in the umbrella of the ardorate are defined with a specific grazing area with grazing rights and some security of tenure in the nearest future and if developments agents channel their efforts towards such platforms with graziers. As such, integrated weed management and rangeland improvement schemes can therefore be orchestrated and run with feedback if stakeholders are committed. The Fulani having been practicing communal life is a sure proof of a background of historical experience, well located in space and time, and providing a solid basis for present-day investigation and possible rejuvenation of activities through conceived strategies[1]. Through a careful study of the prevailing situation in different grazing zones, an efficient undertaking can be made.

Some issues call for immediate action because there are good prospects for reversing the damage to the environment at relatively low cost, as in taking measures against weed invasion. Even then undoing some of the damage to the affected areas may not be fully possible. But knowing the health impacts does create a moral imperative to protect those affected from further exposure and prevent others from becoming victims.

Another category of issues unfolds over a longer time horizon. The problems may not yet be urgent, but the direction of change is unmistakable. For these, it is essential to get ahead of the curve and prevent a worsening crisis before it is too costly. There is already a need to adapt to the consequences of past and current behavior, but there is also still scope for mitigation, though not for complacency. Weed infestations that are still at an infant or early stage stand a better chance of being managed than when such areas become established. Satellite infestation are easily identified and located by the range user through his daily routine of activities. Most of these grazing communities lack the firm basis for which action towards one of their greatest environmental threat can be taken. In a good number of areas like Berlem grazing zone in Kumbo, Binka in Nkambe or Fungom and Sabga, weed infestations have passed from

[1] **Ngwa Nebasina E. 1990**
Land use dynamics and restructuring on some sectors of the Grass Field Plateau (Cameroon), In the Geographical Journal, Vol 20. Nº 3, Kluwer Academic publishers, Yaoundé, 203-208p

light to dense with huge acreage but these communities remain passive and weak without strong community structures to take concrete action.

Environmental and social stresses reflect the failure of institutions to manage and stay put with the current problems plaguing rangelands in the North West Region particularly weed infestation. What is more important for sustainability is how to manage risks by retaining options. There is considerable uncertainty about the consequence of population activities on complex range ecosystems. Small changes can sometimes accumulate and translate into range loss and degradation. In such areas where the cost of human action is uncertain, with potential for large and irreversible damage, there is a need for proceeding with greater caution in maintaining environmental and social assets.

Today, the challenges are those of securing more a communal land right or grazing rights, barbe wire to extend and reinforce fences and to provide dips for ticks control. Moreover, developments in technology infusion or hybridization/cross breeding have been in a halt for some time after some trials and need to be rejuvenated. This will give more voice and opportunity to women and increase milk production. The weaknesses of this grazing project should serve as lessons learnt or fallouts that can be extended in other areas in the region.

12.2 Community Base Management Systems (CBMS)

Community base management underlines the concept of participation which stresses the equitable and active involvement of all stakeholders in the formulation of development to increase their level of knowledge, influence and control over their own policies and strategies and in the analysis, planning and implementation, monitoring and evaluation of development activities. Participation and community development are key concepts that are inter-woven in the grassroots in matters of development. Principle 22 of Rio 1992 declaration on environment and development stressed that Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. More so, considering the failure of top-bottom approaches pursued up to the 1980s, Community development in Cameroon was nevertheless revived and is associated with the 1990s common initiative law that paved the way for the creation of NGOs as well as decentralization (Ngwa,1997).

Community based management systems formed around Ardorates could take the form of small dairy cooperative and be registered in accordance with Law No 92/006 of 14 August 1992 authorizing the creation and functioning of cooperatives and common initiative groups promulgated by the president of the Republic and with decree No 92/455/PM of 23 November 1992 laying down the procedure for implementing this law. This can create a platform and attract support from organizations requiring fulfillment of some administrative procedures for any aid to be offered them. Range management can be reached in this light with integrated weed management plans.

The integrated strategy for rural development in the Growth and Employment Strategy Paper GESP (2003) provides for the sustainable management of natural resources through preservation and restoration of the production potentials with community initiatives. Communal rangeland management especially its improvement is largely to be achieved through this approach. In fact, the PNDP's target has been to put in place mechanisms for communities and decentralise structures of the state to be proper actors of their development in the framework of the progressive process of decentralisation. This is the basis for which CBMS can be bestowed with existing social institutions in the rangeland landscape around Ardorates in harmony with state policy through the councils.

12.3 Integrated weed management

Integrated weed management embodies aspects around community grazing areas with state and non-state actors. These could include:

- Enhanced pastoral code elaboration and promulgation (already in progress by the Ministry of livestock, fisheries and animal industries and the Netherlands development organization SNV)
- Improving pastoral land tenure laws that are workable, inclusive and adapted to local values, In fact, legislative dispositions that are acceptable and can be adopted in function of cultural and socio-economic context.
- Strengthening institutional weaknesses by harnessing CBMS through grazing zones (Ardorates) with pastoralists and development partners with grazing rights and security
- Developing institutional frameworks and Integrating CBMS in the overall development plan of decentralized councils (participation, collective action. Capacity building and evaluation)
- Integrated weed management involving
- Inventory and mapping (determine and record weed species present, area infested, infestation density, field surveys, GPS loggers, GIS)
- Prioritizing weed problems, choosing and strategically implementing control technics for weed management units. (preventing expansion, detecting and eradicating new introductions, containing and controlling large infestation)
- Adopting proper range management practices (minimizing soil disturbance by livestock and control livestock movements, deferrement, herd splitting, limiting weed seed dispersal, early detection and eradication of satellite fronts, proper grazing rotation, monitoring and evaluation, environmental zoning, reseeding).

12.4Ranching, private enclosures and weed management.

Public and private ranches exist as well as small individual enclosures that show more commitment in weed management. These can be spotted in the SODEPA ranch in Jakiri and Tadu, IRAD Bambui, the Elba ranch Ndawara, the Tadu Dairy ranch, Philemon Yang ranch (Tadu &Ijim), Achidi Achu ranch and some few cattle owners around

Wum and Jakiri with some petit ranches calved out and ploughed and seeded with improved grass species. In these circumstances, tilling and revegetation or the replacement control is engaged, replacing weed infested grounds with more desirable improved pastures such as *Brachiaria ruziziensis.* It is often possible to rehabilitate it and thus restore it to a level of utility possibly not as good as its original state but better than was in its damaged state. Given satisfactory perception of the threat, funding, technology, and organization are key to reverse tendencies of degradation.

Sequence grazing is therefore set as the management tool where different paddocks are graze in succession that differ in forage species composition and combination. This extends the grazing seasons and enhances quantity and quality forage. Rotational stocking with deferment therefore increases management tools by providing the time for plant reproduction and restoration of plant vigour, a return to environmental conditions that are appropriate for grazing and the accumulation of forage for later use (Mairomi, 2012).

In 1994, a herbicide Asulame was experimented upon by the Institute of Zootechnical Research (I.R.S) as a product to deal with the problematic *Pteridium aquililium* with less success. Research and trials continue in reseach intitutes like IRAD Bambui. MINEPIA is currently carrying out trials with another herbicide that is a glysolphate i.e. Zooma. The site effects on the environments or its residual effects are still to be ascertain but the herbicides have been noticed to be causing pollution of water but associated biodiversity in the area of application has been ascertained.

In relation to pasture improvement, *Pennisetum clandestinum* (kikuyu) grass was introduced during the colonial days in 1944 through the Livestock Investigation center in Jakiri to stabilize erosion and improve pasture. It is well established in the high plateau often in association with *Sporobolus spiramidalis.* It now spreads slower than hitherto but since then very little has been done in terms of pasture improvement. *Brachiaria ruziziensis, Alfafa grass, Trypsacum laxum* have since then been introduced but not well established like *Pennisetum Clandestinum*. Another important land stewardship strategy that is a rangeland improvement prospect is agroforestry. *Leucaena leucocephala, Calliandra calothyrsus, Stylosanthes guianensis* are multipurpose trees gradually being integrated in the range landscape.

XIII. CONCLUSION

Pteridium aquililium infestation is a growing night mare to graziers in rangelands in North West Cameroon with diverse consequences. It is and “ecological terrorist” causing shifts in plant composition and scarcity in pastures. Land use practices like open ranging and the use of fire are facilitating factors that require caution in use. Moreover, Bracken fern in a successful invader that has establish across rangelands in the western highlands of Cameroon. It is highly invasive in plateaus especially between 1500-2200m with very dense patches that are fast advancing. Annual self-perpetuating communities continue to grow with different implications for grazing management, impairing the weed free areas adding degradation to vulnerable communities. This adds to problems of land grabbing, dwindling range from crop encroachment and tenure problems. The area infested continues to grow in area cover and density. Urgent action is required to salvage the situation from ruin. Integrated weed management can be incorporated through a platform-grazing Ardorates. Community base management institutions can harness the socio-economic context into a market oriented well organize coordinated structure to manage weeds and improve rangelands as well as the livelihoods of graziers.

REFERENCES

[1]. Cooper-Driver, G. (1990): Defense Strategies in Bracken *(Pteridium aquilinum* (L.) Kuhn). *Annals of the Missouri Botanical Garden 77* (2): 281-286**.**

[2]. D'Antonio, C.M., N.E. Jackson, C.C. Horvitz, and R. Hedberg. (2004): Invasive plants in wildland ecosystems: merging the study of invasion processes with management needs. *Frontiers in Ecology and the Environment* 2: 513-521.

[3]. Fletcher, W. W., R. C. Kirkwood. (1979): The Bracken Fern *(Pteridium aquilinum* L. (Kuhn)): Its Biology and Control. In *The Experimental Biology of Ferns*, edited by A. F. Dyer. London: Academic Press. 591-635.

[4]. Gliessman, S. R. (1976): Allelopathy in a Broad Spectrum of Environments as Illustrated by Bracken.*Botanical Journal of the Linnean Society* 73: 95-104.

[5]. Hawkins, P. and BRUNT M. (1965). *Soils and ecology of West Cameroon.* Vols. I & II, FAO Expanded Programme of Technical Assistance No. 2038, FAO, Rome.473p

[6]. Lambi, C., M. and Ndenecho, E., N. (2010). Ecology and Natural Resource Development in the Western Highlands of Cameroon. Issues in Natural Resource Development. Langaa Research and Publishing Common Initiative Group; PO Box 902 Bamenda.135p

[7]. Mairomi, H. W. (2012): Human Encroachment into Grazing and Rangelands; A Case Study of Rangeland Improvements in Jakiri Sub-Division. Masters dissertation, Department of Geography, University of Yaounde I, 179p

[8]. Mairomi H. W. (2017) : Weed Infestation in Rangelands of the Grassfields, Tracking System Dynamism in the North West Region of Cameroon. PhD thesis, Department of Geography, University of Yaounde I, 374p.

[9]. MINEPAT, Ministry of Economy, Planning and Regional Development (2003): *Poverty Reduction Strategy Paper for Cameroon*, Final Report. Yaounde, 203p.

[10]. Norgrove, L., Dux, J. and Fuambeng, P. (2007). Changes in ecosystem function in savannahs and fields invaded by *Chromolaena odorata* in Cameroon
[11]. Moby, E. (1979): Climate. In; Atlas of the United Republic of Cameroon. J — F Loung (ed) Edition Jeune Afrique, Paris. p. 16— 19.
[12]. Ndenecho, E. N. (2005): Biological Resource Exploitation in Cameroon; From Crisis to Sustainable Management. Unique Printers Bamenda pp101-130
[13]. Page, C. N. (1986): The Strategies of Bracken as Permanent Ecological Opportunist. In *Bracken: Ecology, Land Use and Control Technology*, edited by R. T. Smith and J. A. Taylor,. Carnforth, England: Parthenon Publishing Group. Pp 173-180
[14]. Pakeman, R. J., and R. H. Marrs. (1992): The Conservation Value of Bracken *Pteridium aquilinum* (L.Kuhn-Dominated Communities in the UK, and an Assessment of the Ecological Impact of Bracken Expansion or Its Removal. *Biological Conservation* 62 (2): 101-114.
[15]. Pamo, E. T., Youkeu, S., Onana, J., and Rippstein, G. (1998). Evaluation de quelques espèces fourragères locales du domaine soudanien Camerounais. *Sceince. Agronome. & Developpement* ., 1 : 19-25
[16]. Pokshishevskii, V.V.(1970): World population and resources: The larger historical context of the problem pp 40 – 53
[17]. Rymer, L. (1976): The History and Ethnobotany of Bracken. *Botanical Journal of the Linnean Society 73:*151-176.
[18]. Schneider, C. L. (2004): Bracken fern invasion in Southern Yucatan: A case for Land-Change Science, *Geographical Review* 94 no2 Ap 2004WN: 0409403133008, pp229-242.
[19]. Taylor, J. A. 199o. The Bracken Problem: A Global Perspective. In Bracken Biology and Management, edited by J. Thompson and R. T. Smith, 3-9. Sydney: Australian Institute of Agricultural Science
[20]. Turner, B. L., II, and A.M. Shajaat Ali. 1996. Induced Intensification: Agricultural Change in Bangladesh with Implications for Malthus and Boserup. Proceedings of the National Academy of Sciences 93: 14984-14991.
[21]. Turner, B. L., II, P. Klepeis, and L. Schneider. 2003. Three Millennia in the Southern Yucat6n Peninsular Region: Implications for Occupancy, Use, and "Carrying Capacity." In The Lowland Maya Area: Three Millennia at the Human-Wildland Interface, edited by A. G6mez-Pompa, M. F. Allen, S. L. Fedick, and J. Jimenez-Osornio, 361-387. Binghamton, N.Y.: Food Products Press, an imprint of Haworth Press.
[22]. Vitousek, P. M., H. A. Mooney, J. Lubchenco, and J. M. Melillo. 1997. Human Domination of Earth's Ecosystems. Science 277 (5325): 494-499.
[23]. Zelinsky, W., Kosinski, ., R. Mansell p. (1970) Geography and a crowding world. A symposium on population pressure upon physical and social resources in the developing lands 601p