# Ecological Impacts of *Pteridium aquililium* and *Chromolaena odorata* Invasions in Rangelands of the Bamenda Highlands

Harry Wirngo Mairomi[1]; Stephen Koghan Ndzeidze[2]

[1]Department of Geography, Higher Teacher Training College, HTTC, University of Bamenda, North West Region, Cameroon.
[2]Department of Animal and Rangeland Sciences, Oregon State University, 222 Withycombe Hall, Corvallis, USA

Publication Date: 2025/05/10

**Abstract: Weeds are a growing threat to livestock rearing in the grazing lands of the Bamenda highlands. The ecology of grazing lands in the Bamenda highlands is in a convergent evolution with increasing weed invasion. The recent dynamics has seen the increasing invasion of two notable weeds notably *Pteridium aquililium* and *Chromolaena odorata* in the region with different ecological repercussions. The study set out to study the ecological implications of these two species of weed in the grazing landscape. A total of 64 cross section transects were studied in different topographic units across the region both in high plateau areas and lowland areas. Quadrats of 1x1m were laid in foot hills, slopes and top of hill. Information relating to grass species composition, relative abundance, weed species and ground cover was obtained through this field evaluation. Soil analysis from different samples collected across the area was also performed. Results revealed change in vegetation composition with an increase in weeds in composition, reduction in relative abundance for palatable species and shifts in species. There is a significant reduction in native species in densely infested *C. odorata* sites in the area. Moreover, most native species are absent where *C. odorata* is abundant, and species richness declines by nearly 72% from the margin to the center of the infestation. In Bracken infested areas where its canopies are quite closed, other weed are associated to its invasion in the undergrowth notably *Emilia pratemisa, Taraxacum sp and Alchemilla Cryptantha.* Species reductions in fern infested pastures are not as great as *C. odorata* stands although *Pteridium aquililium* creates more continuous extensive patch sizes of monospecific stands than *C. odorata* discontinuous dense stands. Shifts and species reduction due to invasions reached 61%. Species shifts mostly concern *Setaria sp. (S. sphacelata), Loudetia and Panicums* on the better soils and with *Andropogon, Paspalum* and *Imperata* of medium size on the poorer soils. Fuel loads increase and modify fire regimes creating post fire succession species. Management require concerted actions among actors to curb invasions.**

***Keywords:*** *Pteridium Aquililium, Chromolaena Odorata, Ecological Impacts, Grazing Land, Bamenda Highlands.*

**How to Cite:** Harry Wirngo Mairomi; Stephen Koghan Ndzeidze. (2025). Ecological Impacts of Pteridium aquililium and Chromolaena odorata Invasions in Rangelands of the Bamenda Highlands. *International Journal of Innovative Science and Research Technology*, 10(4), 3034-3047. https://doi.org/10.38124/ijisrt/25apr869.

## I. INTRODUCTION

The ecology of rangelands is often in convergent evolution particularly the interactions and relationships animating the life of rangelands (Mairomi, 2018). Rangeland use has glaring outcomes with landscape evolution as consequences of land use practices. The North West Region of Cameroon is covered at close to 60% by savanna vegetation. Weeds have increasingly spread in these rangelands in the Bamenda highlands over the years but their ecological repercussions has hardly been characterized. *Pteridium aquililium* an altitudinal invader and *Chromolaena odorata* an exotic introduced in the regions from the 1970s, are two key species invading grazing areas. Graziers in their daily routine of activities constantly encounter this outstanding threat of weeds but are limited in their actions, ideas, technologies, finances and management strategies (Mairomi et al., 2022). This is owing to land ownership and rangeland tenure in Cameroon. This institutional related aspect includes organization and management, land tenure, use of local institutions, management capacities of exploiters, government policies and policies of concerned structures (Ndambi, 2005).

Letouzey (1968, 85), Hawkings and Brunt (1965), Boutrais (1974, 78) described the vegetation composition of the Grass fields of Cameroon dominated by *Hyparrhenias* grass with a mix of *Sporobolus*, *Loudetia* and other grasses in

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

herbaceous and shrub savanna with *Terminalia* species and a host of ligneous species. They noted the change in response to cultural practices like grazing and fire. Letouzey (1968) qualified savannas derived from burnt down forest as 'peri-forest savannas' and the subsequent upsurge of *Sporobolus* in high plateau areas (Hawkings and Brunt, 1965). Awason (1984), Macleod (1987), Ndzeidze (2001), Lambi (2010), Ndenecho (2006), Akodeng (2002) noted inherent practices; grazing, fire and cultivation as major variables of landscape degradation which continuously animate change in grazing areas in the Bamenda highlands. Heavy grazing and anarchical exploitation changes vegetation composition in case of persistence Walker (1995), De Leew (1996). Research has focus on how cultural practices like fire and grazing alter the grassland landscape without much focus on the ecological impacts of these weeds on the pastoral landscape. Ehrlich (1971) and Arther (1994) pose questions about the ecological implications of land use practices on weeds and highlighted that socio-economic actions account for range fragmentation, loss and degradation with greater ecological repercussions on the rangeland habitat. Nevertheless, weed invasions in rangelands in North West Cameroon seem to have remarkable effects pending investigation. Empirical evidences ascertain that nefarious resource extraction and weed invasions portend great threats to pasture degradation and scarcity but there exist little on ecological implications of weeds on rangelands especially the Bamenda highlands. Essentially, the apparent destructive role of weeds in rangelands is worrisome to pastoralist and other stakeholders. This study is confronted with the question – what are the ecological impacts of *Pteridium aquililium* and *Chromolaena odorata* in rangelands of the Bamenda highlands as well as understanding whether land use is related to weed spread. The impulse of weed spread in vulnerability corridors, establishment and consequences is therefore regarded with empirical considerations on plant composition and soil changes.

The Bamenda highlands is endowed with extensive grazing lands that constitute a bastion for livestock production. It presently host over 5.5 million heads of cattle and other small ruminants like sheep and goats. Unfortunately, the grazing areas of recent are increasingly experiencing invasion of weeds. While the land use histories have been characterized (Ndzeidze, 2012, Ndenecho, 2009), the ecological implication of invasions beacons for scientific clarification. The Bamenda highlands thus provides a good setting to explore ecological implications of two species of weeds ravaging the grazing landscape. This research seeks to answer the question on the ecological implications of these two species of weed *Pteridium aquilinium* and *Chromolaena odorata* in the grazing landscape.

*A. Introduction, Establishment and Ecology of Weeds*

The perennial shrub *Chromolaena odorata* (King and Robinson, 1997) was first introduced into West Africa in the late 1930s. It has since spread rapidly throughout West and Central Africa, from Guinea to northern Angola and central Zaire. *C. odorata* has become a troublesome weed in open spaces, clearings around human settlements, in early secondary succession, crop and pasture lands, and in young tree crop plantations. Interviews with Mbororo pastoralist reveal it was first noticed in the 1970s in the North West introduced from Nigeria (Mairomi, 2018). It had become a common weed of road and railway sidings, young tree crop plantations, crop and pasture lands and clearings around villages. It was also being found in southern and central parts of Cameroon. Nowadays, it is thus integrated in the vegetal landscape where it is experiencing a strong territorial expansion and is qualified as a vegetal "pest" by agronomist and ecologists in the inter-tropical region in general. According to Youta (1998), in the center of Cameroon, the names given by local populations are "Benjamin", "arracheur de champs" showing proof and witness at the same time of its recent introduction in the milieu, of its high capacity of dissemination, of its rapid growth and its invading character that singularises it or distinguishes it. by 1990s it was already well established as in weed in cropland. Today it is a major dilemma in rangelands, a nightmare and a dreaded obstacle to grazing. *C. odorata* is a typical pioneer species of secondary forest succession with a strong heliophilic character and vigorous vegetative development. Also, some allelopathic effects are reported from Nigeria. Initially *C. odorata* spreads by seed, but after establishment it may also reproduce vegetatively from lateral branches; regrowth occurs after slashing and burning. According to Mbororo pastoralist, the name given to these outstanding invaders; "Agogo" for Bracken fern and "Bukaser" for *Chromolaena odorata* signify their power to colonise and produce a lot of progeny. Even the native names in Aghem in Mechum or Lamnso in Bui area tell their capacity to suffocate (Mairomi, 2018). Known in the Dumbo-Mayo kela vicinities as "Naira" stresses its origin and introduction into the territory from neighboring Nigeria. It is highly distributed in warmer lowlands up to about 1400m of altitude taking up very dense concentrations especially along road sites below 1200m. The most remarkable invasions are in the Misaje lowlands passing through Dumbo to Mayor Kela, the Wum area around Waindodown and Mechum valley with road network playing a great part in its distribution. Over the years, infestations have passed from light, moderate to dense infestations and continue to extend to clean areas with huge ecological implication.

The invasion of *Pteridium aquililium* in the Bamenda highlands has been highly tagged with irrational land use related to the complex- grazing, fire and fragmentation. It is noted to have originated from forest edges and is now distributed almost everywhere-grazed forest lands, mid altitude shrub savanna and high plateau herbaceous savanna. Bracken fern or "Agogo" as it is called by Mbororo graziers spreads rapidly through rhizomes and pores. Extensive invasions are located in Dzeng Mbiame plateau especially in Berlem, Sabga-Ndawara hills, Fungom and the Kukube hills in the Nkambe plateau (Mairomi, 2018). It is highly invasive between 1200m-2400m in the area. In a greater part 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. Following dry season bush fires, it reveals to a large extent that it is a fire-

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

resistant species as underground rhizomes send out new shoots after clearance of old rank vegetation by fire. In the Bamenda highlands, it is a postfire successional species (Mairomi, 2021) and after fire may form so-called 'bracken savannas'. It is one of the few seasonal sub-montane native species to increase in burned compared to unburned areas (D'Antonio et al., 2000). Though ubiquitous, it is largely located and invasive betwee 1500-2000m in the Bamenda highlands (Mairomi, 2016).

*B. Land use, Disturbance and vulnerability*

Natural path ways do exist and there are introductions of particularly exotic species. Native invasive species are equally expanding in extent and area cover. Obviously intrinsic are the associated changes that are brought within the different landscapes but an aspect that is worthy of note is the fact that change is either facilitated by the existing land use practices or ushered in by the established weeds. The composition and structure of grasslands or rangelands are literally the main associated changes in what concerns implications. But change, axed on land use and land management involves the increasing grazing pressure and altering fire regimes that occur in different intensities bringing unlike vulnerabilities within the different grazing areas located in the ecological sites embedded in the upland or high lava plateau and low land grazing areas.

Management options are either deterrent or enhance rangeland ecosystem sustainability. Traditional range use practices (traditional open free ranging and fragmentation) represent disturbances for the rangelands. In addition to grazing, vegetation dynamics represent change along several axes including existing fire regimes, climate variability and particularly the traditional range use practices. Poor management or land use practices constitute significant instability but the timing and intensities of disturbances lead to variable states. Within the context of potential natural condition, natural disturbances lead to change in composition but above and beyond, are range use practices-disturbances that can lead to replacement of seral species with weedier species. Vegetation dynamics in North West Cameroon is therefore axed on shifts in species composition linked to linear succession of plant communities sequentially changing in orderly response to control of variables like grazing (defoliation), fire, competition and climate variability.

Changes in rangelands in the Bamenda highlands is therefore articulated around the variable states induced by disturbances i.e. change related to grazing, prevailing fire regimes or the traditional range use practices and natural factors like climate variability. These, are therefore the various cultural and physical processes that continuously interact in different intensities and induce susceptibility to weed invasion or enhance range amelioration. Succession in plant communities in Grass field grasslands and change or shifts in species composition are in response to the afore-mention variables. Moreover, dynamism is also noticed in the diverse array of management options (including alternatives sought with development agencies) retained by resource users in response to challenges facing the rangeland resource.

## II. METHODOLOGY

*A. Study Site*

The Bamenda highlands or North west region of Cameroon is located between latitudes 5°20' - 6°40' N and longitudes 9°35' - 11°20' E with a surface area of 17,836 km2 (figure 1). Diverse ecological zones is presented with varied relief through flood plains and valleys in inter montane basins to plateaus and mountains. Most Soils are derived from basalts, granites and trachytes, with a great variation in weathered material and are acidic and poor in nutrient content with high phosphorus requirements. 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. The climate of the area is a tropical montane climate with 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 Moby (1979). 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). Grass composition include *Hyperrhenia diplandra, Hyperrhenia rufa, 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.* The main adventitious plant species (Hawkins and Brunt, 1965) are Sporobolus and bracken ferns. Grazed species are significantly affected by bush overgrazing and bush fires. The extensive grass vegetation shows variations with climatic zonation, edaphic influences, grazing intensity and frequency of dry season burning.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

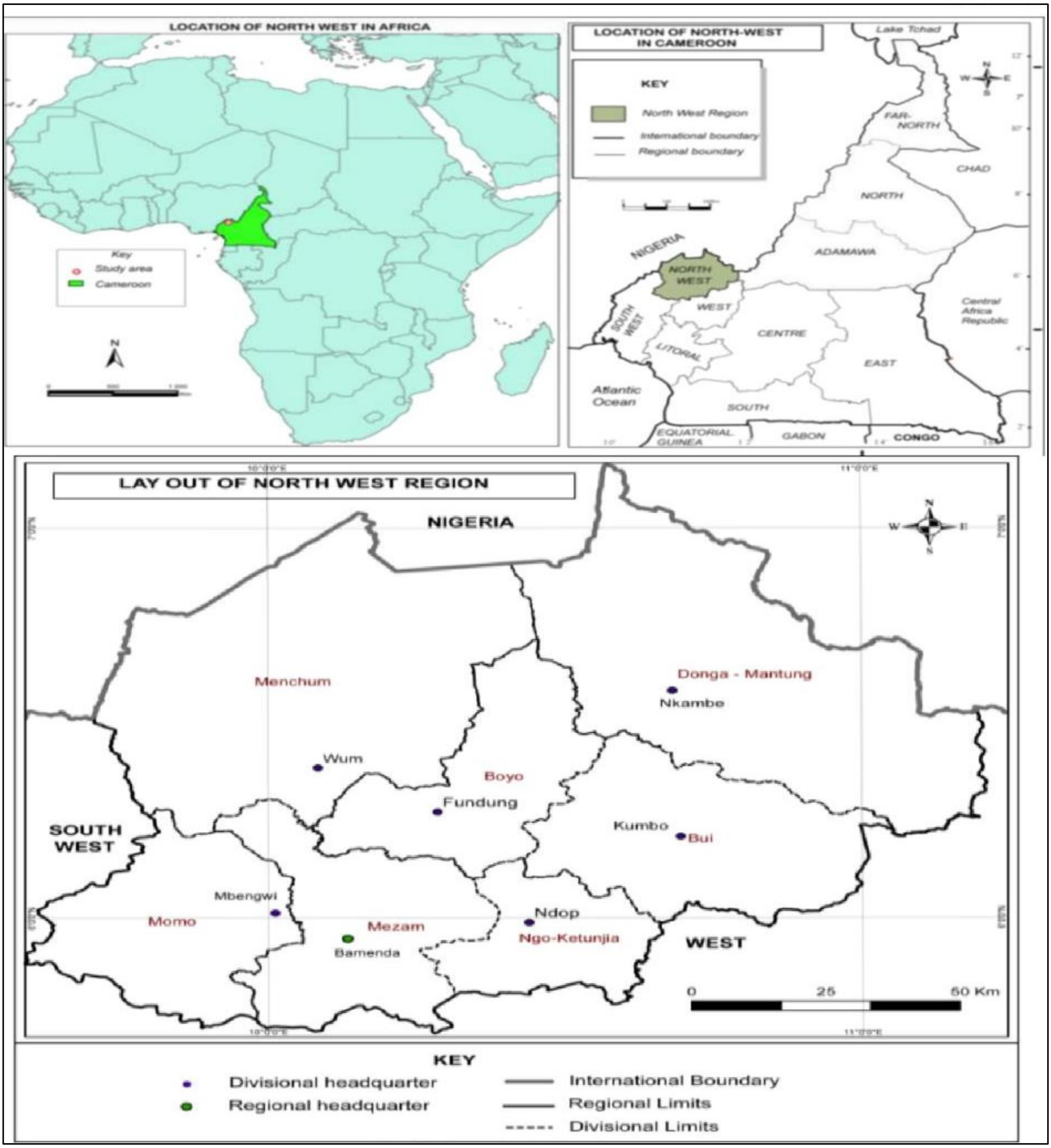


Fig 1: Location of Study Site

*B. Methods*

To highlight the changes noticed in grasslands relating to the invasion of Bracken fern and *Chromolaena odorata*, transects and quadrats were used. A total of 64 cross section transects were studied in different topographic units across the region both in high plateau areas and lowland areas. Quadrats of 1x1m were laid in foot hills, slopes and top of hill. Information relating to grass species composition, relative abundance, weed species and ground cover was obtained through this field evaluation. Plants with a full flowering head and other vegetative parts were collected and identified either by a botanist in the field or at the National Herbarium, Yaounde. According to the Range health book of the USDA, for each dominant soil type, 25 soil samples were taken to ensure spatial representability and a mixture was examined in the IRAD laboratory, Yaounde. Therefore, soils on basalts, trachyte derived soils and granitic soils were considered in both *Sporobulus* and *Hyparrhenia* grasslands locally. Samples were considered for the horizons 0-14 and 15-40 centimeters. Chemical and granulometric analysis of

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

soils was done to examine the mineral constituents with the texture (silts, clays, sands) contained in the soil. In this light, soil samples on weed infested sites for the two main weeds studied *Chromolaena odorata and Pteridium aquililium* were examined with adjacent grassland soils with a particular interest of understanding possible changes in soil components. Moreover, soil analysis evaluated soil pH value, nitrogen, Carbon, bases, organic content and residual humidity in view of comparison with the adjacent weed infested sites. Photos were also taken to compliment field data.

## III. RESULTS AND DISCUSSION

### *A. Environmental and Ecological Impacts*

➢ *System Dynamism, Shifts in Composition and Changes in Vegetation States/Transitions*

Weed invasion was noted to reduce plant diversity, species richness and community productivity for infested area. Management efforts often contribute to an increase in plant diversity. In the area, the trend of dynamics for vegetation states have been generally aligned from pure highly dominant *Hyparrhenia* grasslands to a mixture of reduced *Hyparrhenia* and *Sporobolus, Pennisetum clandestinum* and to weedier situations. This is especially noted for the high plateau areas. Transitions from *Hyparrhenias* to weed status are more conspicuous for lowland areas with more warm climates. The processes noticed to cause states to alter/change in the area or the transitions are grazing and overgrazing, fires, trampling and erosion as well as climate variability. The displacements and shifts of species and subsequent changes resulting from interspecific competition is also associated to the fact that gramineae species are heliophile and when competition rarefies light, displacement becomes obvious. In fact, the herbaceous cover in the area assimilates better and produces their best outputs or growth in plane light. Reduction in the light-period with shade simply witnesses the gradual dwindling of pasture in the understorey in favour of weeds.

There is a significant reduction in native species in densely infested *C. odorata* sites in the area. Moreover, most native species are absent where *C. odorata* is abundant, and species richness declines by nearly 72% from the margin to the center of the infestation. In the Dumbo and Wum rangelands where *C. odorata* is the dominant weed, the pastures are mostly *Hyparrhenia* grass. Quadrats in light, moderate and dense infestation areas showed a species reduction of 9%, 38% and 71%, respectively along transect lines in Dumbo. In Wum, species reduction was in the order of 13%, 34% and 62%. In weed free sites, the percentage of *Hyparrhenia* grass reaches over 73% of ground cover. The aerial ramification of the weed creates a thick monospecific canopy that captures a greater part of sunlight and, therefore, huge shades are created that suffocate other species. Shifts in species composition are noticed as well as great reduction in species diversity to less than five species. In the Nyos-Bum stretch where its intensities are dominantly light to moderate, diversity is reduced but it is found in association with Bracken fern in shrub savanna that marked the area. Nevertheless, in terms of species shifts, dense *C. odorata* infestations present an uderstorey with almost complete exclusion of *Hyparrhenia* in some extreme circumstances unlike *Pteridium* sites that always retain some *Sporobolus* grass. Concerning species-poor savannas areas in the area, *C. odorata* invasion have no significant effect on plant species richness, although it causes species shifts. A glaring outcome is, therefore, shifts in weed infested sites. Thus savannahs are rendered less useful for grazing and this negatively affects pastoralism and pastoralist's livelihoods. Several noxious range weeds have been shown to reduce species richness, plant diversity, and community productivity in a number of areas (Belcher and Wilson 1989; Parmenter and MacMahon 1983; Rikard and Cline 1980; Wallace et al. 1992 cited by DiThomaso 2000).

In Bracken infested areas in the high plateau zone, the pastures are a combination of *Sporobolus pyramidalis* and *Pennisetum clandestinum*. *Pteridium aquililium* infested pastures are more glaring and conspicuous in their monospecific stands due to more extensive spread. Where its canopies are quite closed, the undergrowth is mostly characterized by *Emilia pratemisa, Taraxacum sp and Alchemilla Cryptantha.* Species reductions in fern infested pastures are not as great as *C. odorata* stands although *Pteridium aquililium* creates more continuous extensive patch sizes of monotypic stands than *C. odorata* discontinuous dense stands. Shifts and species reduction due to invasions were 5%, 27% and 52%, respectively for light, moderate and dense infestation in Sabga and 7%,31% and 61% in Berlem grazing zone. It is noticed that inherent diet preferences among livestock species are a major force in shifting species composition of native plant communities. Livestock in the area (Cattle, goats, sheep, horses) overgraze preferred pastures precluding grass growth thereby suppressing competition and giving unwanted invaders the tolerance to complete their vegetative cycles reproducing asexually with dense root networks like Bracken fern or producing a lot of progeny more than most grasses like *C. odorata* that are distributed further afield from the invading colony. In some circumstances, dense extensive infestations like in the Mechum valley and Waindo-up forces pastoralist to avoid grazing infested areas and this increases infestation. Some Aku pastoralists stated they had moved their settlement from the Mechum valley towards Waindo due to severe *C. odorata* invasions.

Quadrat evaluation in Dumbo and Wum for *C. odorata* infested sites and Sabga and Berlem for *Pteridium aquililium* infested sites as examined above is presented in figure's 3 and 4. System change with variables such as grazing and fire to change in state, succession and change in plant composition is a focus in figure 2. With constant uncontrolled grazing and plant invasiveness, according to site suitability more vulnerability is created for weed establishment. With annual fires set to regenerate pastures and clear old rank grass and spread over the years, succession turn to replace pastures with weeds. There is thus a change in plant composition with shifts in species, reductions in species diversity with the dominance of weeds.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

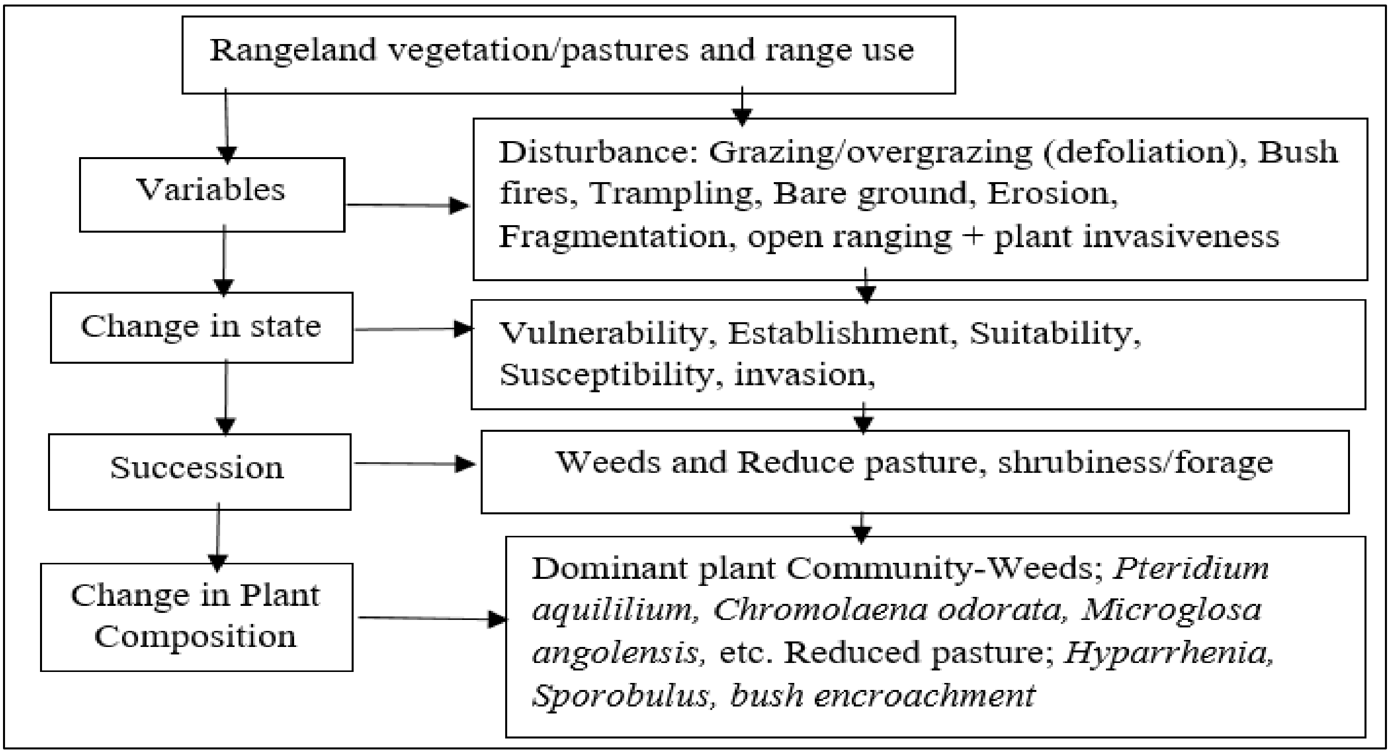


Fig 2: System Change in Plant Composition in Weed Infested Areas
Source: Author's Conception

Grazing, fire, plant invasiveness with range fragmentation are key variables in rangeland that trigger change in state nurturing vulnerability, invasion and establishment of weeds. Mutations are thus noticed through succession and change in plant composition and relative abundance. According to bioclimatic factors, site suitability varies with diverse landscapes of the area.

- *Plate 1: Change in Vegetation States/Composition and Shifts in Species*

Photo 1: *Hyparrhenia* in High Plateau (Bihjeng, Nkambe)

Photo 2: *Hyparrhenia* in Lowlands (Dumbo)

Photo 3: *Hyparrhenia & Sporobolus*

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

Photo 4: *Hyparrhenia* invaded by *C. odorata*

Photo 5: *Pteridium aquililium* Infested Pastures

Photo 6: *Chromolaena odorata* infested rangelands
Photos by Mairomi H. W.

From a Hyparrrhenia vegetated (Photos 1-6) surface, intervening variables like grazing, fire, plant invasiveness ushers change in state with vulnerability, site suitability, invasion and establishment. There is thus succession and change in plant composition leading to weediness, shrubiness, reduced pasture.

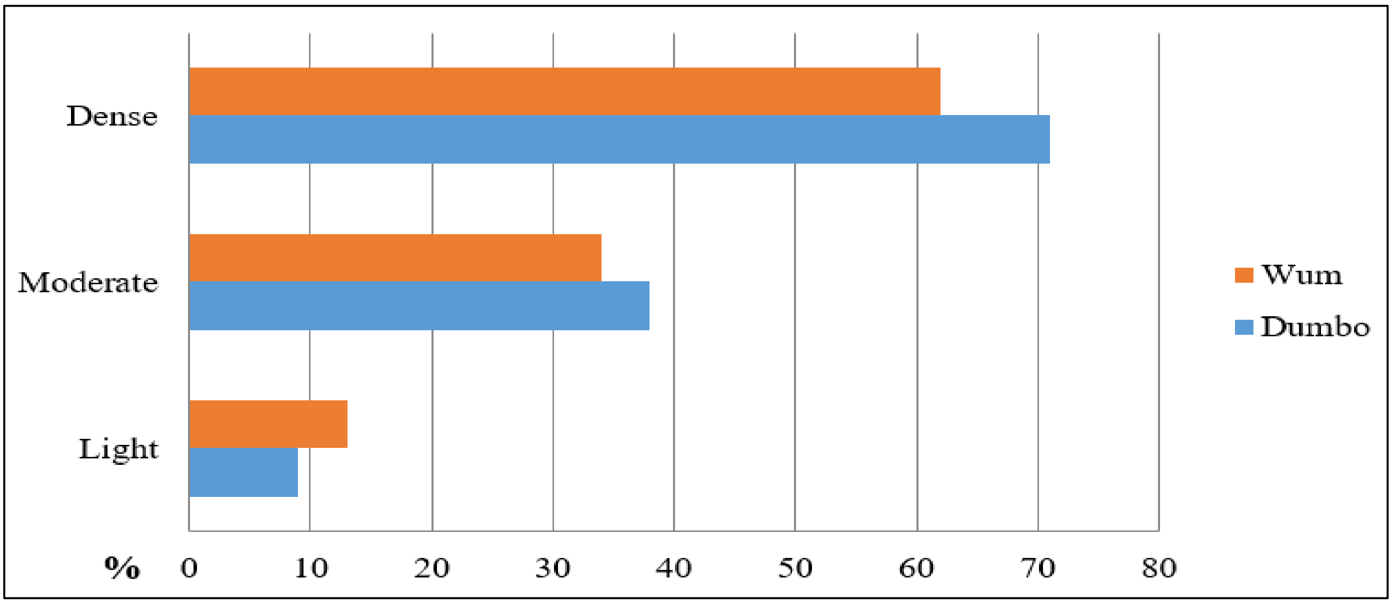


Fig 3: Percentage Species Shifts in *Chromolaena odorata* Infested Sites

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

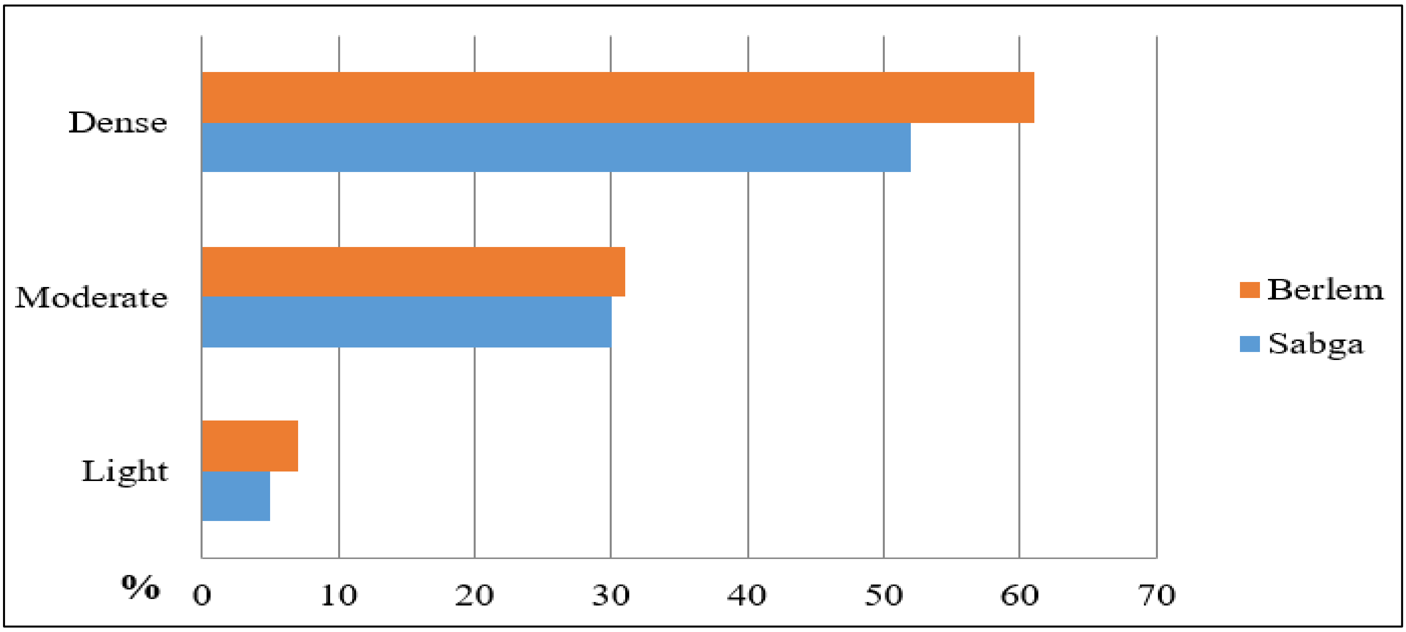

Fig 4: Percentage Species Shifts in *Pteridium aquililium* Infested Sites

The inter-specific competition in the area displaces valuable genetic resources or grass species thus limiting grazing by greatly reducing preferred species. The competition has resulted in displacement and creation of hectares of weed dominant areas like in Berlem grazing site in Kumbo sub-division. The resulting loss of genetic diversity is important to the functional dynamics of the rangeland ecosystem and as an indicator of rangeland health. In other words, the loss or shifts in diversity causes ecosystem instability in portions and affects even the annual fires that are subsequently discussed. There is direct competition of exotic *C. odorata* and natives for space and light. Species richness and shifts are more altered in *C. odorata* infested sites than *Pteridium* invaded sites. Dense infestation providing huge shades of monospecific stands demonstrated the greatest effects in species richness in terms of reductions and shifts. It is worthy to note here that species shifts mostly concern *Setaria sp. (S. sphacelata), Loudetia and Panicums* on the better soils and with *Andropogon*, *Paspalum* and *Imperata* of medium size on the poorer soils. Nevertheless, in all cases, a mixture can still be found, *with Mellinis Mutiflora, Digitaria (spp.) Eragrostis (spp.),* and others. The situation described especially for high lands illustrates that various legumes were abundant, depending on the light the taller grasses would allow. *Trifolium baccarini, T. simense* and *T. usambarense* existed as clover and numerous *Crotalarias* of less interesting value and *Desmodium ascendens* but have enormously reduced. With *P. aquililium* stands limiting light and animal species preferences with suppression, these shorter grasses are easily outsted and shifts are likely. In general, legumes appeared to be more sensitive to changes in the present environmental conditions than grasses, they were not found growing naturally over such wide ranges of habitat. Inasmuch as these grasses are affected, shifts in the main pastures (*Hyparrhenia* and *Sporobolus*) are significantly noticed as they are enormously reduced in terms of their relative abundance.

Nevertheless, in areas like the Zhoa-Nyos-Bum stretch and in Dumbo where there is woody encroachment, structural diversity is however revived. In fact, this corroborates the findings of Youta (1996) of the role of *C. odorata* in forest savanna dynamics, i.e. suppressing graminea and facilitating establishment of ligneous species in transition. Bush encroachment was particularly noticed with *Annona senegalensis* around the Dumbo landscapes and *Terminalia brownis* in the Bum area. According to graziers these two species are greatly expanding within the rangelands. Shrubs increase abiotic microsite variability by providing shade, reducing wind and capturing rain (Roger, 1994). But shrubiness was notice to be a great cause of graminea suppression by reducing light as well as the photo period of graminea. *C. odorata* infestations in the understorey and its areal ramification in shrubs causes enormous reduction in relative abundance of *Hyparrhenia rufa* grass thereby reducing pastures and causing tremendous shifts in species.

*B. Threats on Endemic Species in the Oku Mountain Area*

The pasture composition of the second highest peak in Cameroon-mount Oku (3011m) is a little different especially above 2200m and presents stages of plant succession in terms of altitudinal zonation. Five groups of vegetation are identified; montane forest, degraded montane forest (as a result of anthropogenic activities) Arundinaria Bamboo forest, Scrublands and tree savannah. Grazing takes place in the upper montane grassland of 2000-3000m of altitude. Vegetation here is dominated by *Sporobolus africanus*, a species of grass which occur mostly in few swamps at 2100m and around Lake Oku (Binla, 2005). The original grass is dominated by *Hyparrhenia* but has significantly reduced due to grazing, repeated burning and trampling by cattle. Species of plants in this altitude are confined to a subset of three grassland types where *Sporobolus africanus* is rare or completely absent. They are; basalt pavements grassland dominated by *Loudetia simplex* and threatened species include *Eriocaulon parvulum* and *E. asteroids*, rocky grassland on thinner soils found on the top and ridges and on

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

steep slopes characterized by an absence of *Sporobolus*. Threatened species on this height are *Bafutia tenuicaulis, Helichrysum camerunenses, and Crotolaric lamnedae*. Summit grassland and scrub at 2900-3011m highest grassland vegetation and most grass species are endemic to this region. Grazing pressure exerted by cattle, goats and sheep has degraded the grassland resulting to threats of *Alchemilla fischeri, Agrostis mannii, Habenaria obovata*, and *H microceras, Anthospermum aspermuliodes* and *veronica mannii*. Goat and sheep rearing in this area are degrading the area inducing Bracken fern invasion though still at infant colonies just above the montane forest edges but could really be a great threat in the future.

- *Altered Fire Regime and Change in Fuel Load Characteristics.*

Loss in structural diversity can cause ecosystem instability, and the introduction of some species can increase fire frequency (Rosentreter 1994; Whisenant 1990). Even in tropical areas of Hawaii the invasion of non-native warmand cool-season grasses has provided an abundance of fine fuels and increased fire frequencies (D'Antonio and Vitousek 1992 cited by DiThomaso, 2000). This has subsequently led to dominance by more fire-tolerant non-native species. In the Bamenda highlands, a native invasive species-*Pteridium aquililium* is fire-tolerant and its dominance is evidently pursued in the rangelands with fire disturbance. The enormous above ground biomass created by *Chromolaena odorata, Pteridium aquililium* and to a lesser extent *Microglossa angolensis* and *Vernonia auriculifera* generate massive fuel loads. The dense and extensive nature of these weeds in some locations has altered the fire frequency and more importantly the intensities of fires. *C. odorata* was remarked with dense weed patches causing more intense fires in rangelands in Mayo Kela. Bracken fern expanses in Berlem, Ntunir, and Binka were observed with huge fuel loads.

As weed patches or infestations pass from moderate to dense, livestock movements and grazing tends to avoid these dense weed infested sites. Moreover, the infested pastures in the mist of weeds are grazed and suppressed by livestock. Huge dense mono-specific stands of weeds during the drought period in the dry season therefore create more fuel loads for intense fire. Graziers reportedly confirmed that in weed infested areas, more biomass is created and fire becomes more intense or hot and becomes more obvious. Fire therefore is more needed not just for regeneration of pasture- the primodial role of fire in rangelands in the area, but now a necessary tool to clear the standing bunches of weeds. As such, graziers consequently seek more recourse to the use of fire in grazing management and in managing their environment. Even in the ranches where fire tracing, caution and timing are applied with more rigour, weed invasions call for more attention and use of fire to its huge above ground biomass.

Again, the period of burning during the dry season is a little altered in weed infested areas unlike the weed free zones in the area. According to graziers infested areas require more intense hot fire to burn the standing weed patches compared to the pastures. Due to open free ranging practiced in most of the community grazing zones, pastures are continuous grazed without any period of rest during the rainy season. Therefore, pastures are continuously suppressed and therefore do not grow much above ground biomass by the dry season like the standing patches of weed avoided by livestock and chanced to flourish to good heights to blossoming during the long eight months of the rain fed vegetal proliferation. Graziers prefer to burn these areas in the month of February when weed moisture levels are least. During this period atmospheric humidity is low and with the dry Harmattan winds, fire is hotter and burning likely clears the dry fuel loads put in place by weeds. Given that fire intensity itself is dependent on environmental factors; fuel moisture content, fuel load, fuel height and slope of the land, an outstanding situation is therefore created for hot fires meant for bush clearance. A site effect of this method is seed dispersal in the course of the dry season. Contracdictory to this supposition is that of burning at the beginning of the dry season to limit seed maturity and spread but with less intense fires.

Photo 7: Increased Dry Fuel Loads/Biomass Generated by *Chromolaena odorata* in Tan-Mbokam site, Jakiri
Photo by Mairomi H. W.

- *Microclimatic Conditions and Litter Decomposition*

Within the weed infested sites, small micro conditions are altered depending on the infestations. This particularly holds so for rangelands especially when the infestations are dense and extensive. In the context of land users in the Grassfields, *C. odorata* invasion in savannahs has had both negative and positive effects of varying intensities relating to the density and extent of infestations. A comparative examination was made for *Hyparrhenia* savannah and adjacent *Chromolaena odorata* invaded savannah in Mayo kela in the Dumbo neighborhood and Waindodown in Wum.

*C. odorata*-invaded areas have higher Nitrogen status yet lower available Phosphorus than savannah or grass-invaded sites. Despite the difficulties involved within the infested sites, some farmers either by error or by design still prefer working in the infested farms after fallow saying they are fertile. This tendency was demonstrated with the field sample soil analysis showing the change in soil constituents for weed infested sites and adjacent weed free zones. Table 1 demonstrates the comparative tendencies for weed infested

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

sites and adjacent weed free savanna areas. The findings go in line with the perception of farmers especially in the forest fringes in the area whom after fallow come back to cultivate confirming that areas cleared off the *C. odorata* are relatively more fertile compared to their adjacent grasslands. Cropland encroachment into rangelands by farmers has been reputed for this fact for which farmers are inclined to it and therefore continue to pursue farming objectives.

Microclimatic conditions are altered by *C. odorata* invasion. This results is higher decomposition rates. In fact, with huge extensive invasions, micro conditions are created by the shades of *C. odorata* aerial ramifications limiting light reaching the soil. This corresponds to what Norgrove (2007) notes that there is a general reduction in either soil or air temperature was noticed for *C. odorata* invaded sites. Litter decomposition is essentially composed of *C. odorata* leaves and this is due to the high litter input (Photo 8).

- *Plate 18: Micro Conditions under C. odorata dense Shades*

Photo 8: Shifts in species composition

Photo 9: Clear undergrowth or understorey due to *C. odorata* Shades

- *Clear Understorey*

Photo 10: Litter decomposition in *C. odorata* micro conditions

Photo 11: Soil in *C. odorata site*

Huge extensive shades in dense infested sites of *Chromolaena odorata* create different microconditions compared to adjacent uninfested savannas. A perculiar aspect is what takes in the understory (photos 8&9) of the dense shades. First, there is reduction of light that reaches the ground and secondly, a reduction in plant composition and relative abundance causing shifts and reduction in species diversity. Litter is dominantly death leaves of *C. odorata* and soil humus layer is not deep (photos 10&11).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

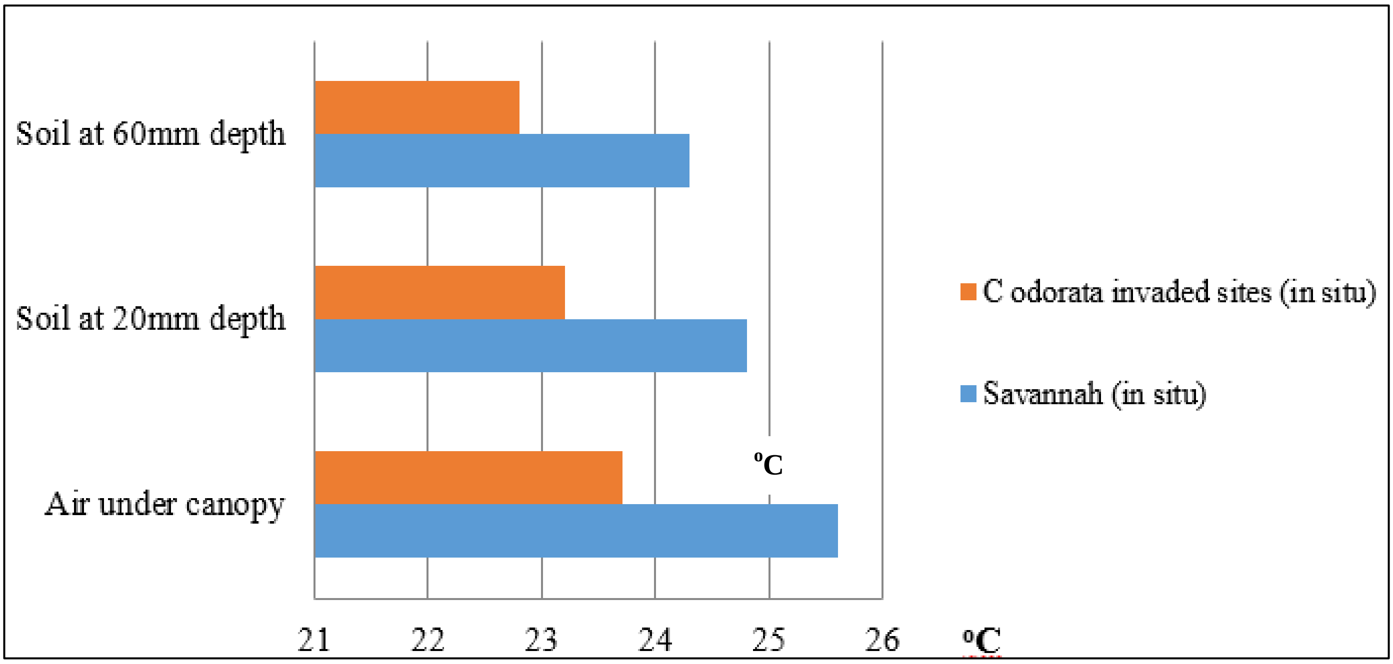


Fig 5: Air and soil temperature (ºC) under Savannah and *C. odorata* Invaded Savannah (Morning)
Adapted from Norgrove, 2007

*C. odorata*-invaded areas can have higher soil faunal densities and activity, higher soil enzyme activity than savannah, probably due to the rich litter input, although both are lower than adjacent forest. Hence, farmers prefer this land for agricultural purposes. Earthworms sampled by expulsion method in three 0.25 $m^2$ internal reps per area by Norgrove (2007) indicate higher earthworm densities under *C. odorata* invaded site than savannah in North West Cameroon explaining the reason behind litter decomposition.

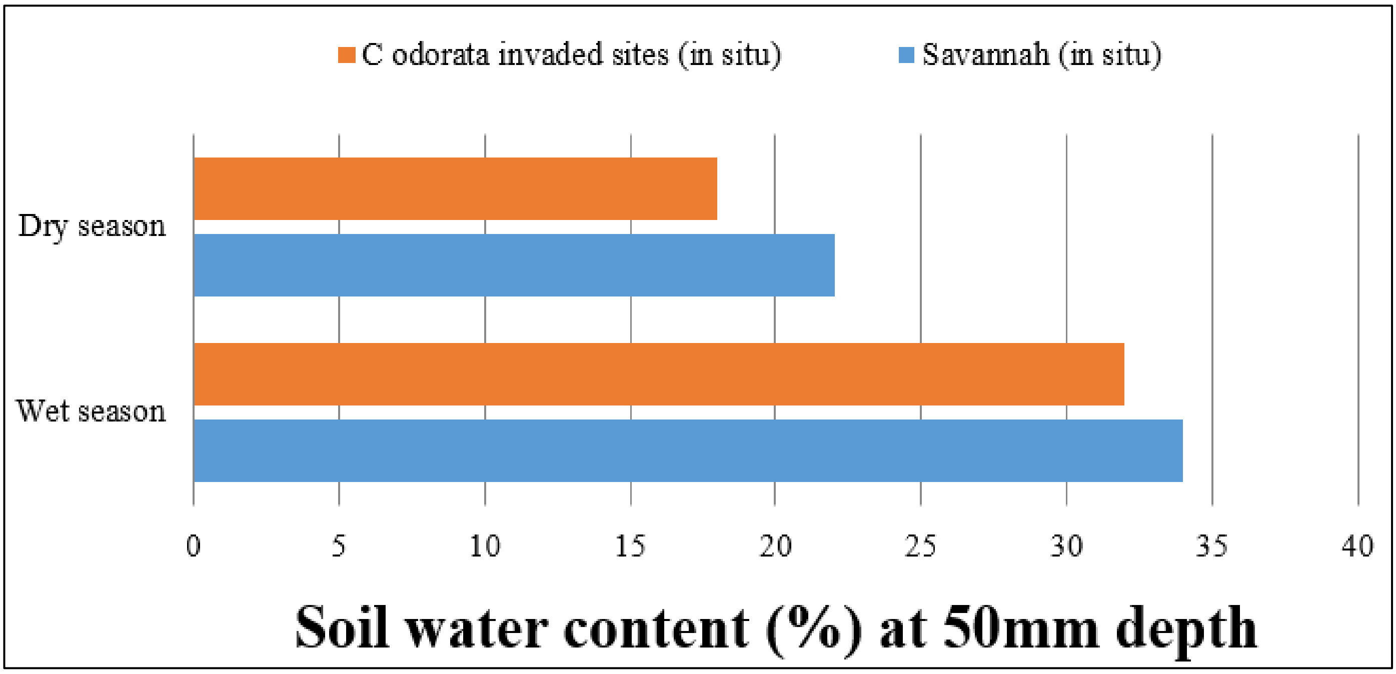


Fig 6: Soil Water Content (%) Under Savannah & C. odorata-Invaded Savannah
Source: Field Derive Soil Samples

- *Change in Soil Constituents in Weed Infested Sites*

Soil examination was realised from field samples from weed infested sites and adjacent weed free sites or savannah areas to examine change in soil content with weed infestation. Sampling was done at Mayo kela-Dumbo and Waindodown in Wum for *Chromolaena odorata* infested and adjacent sites on *Hyparrhenia rufa* landscapes. Soils on *Pteridium aquililium* infested sites were taken at the Dzeng Mbiami plateau at Berlem, Sporobolus grassland. Table 1 potrays this.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

Table 1: Soil Laboratory Analysis on Weed Infested and Adjacent Savanna Grassland

| Sampled element | *Pteridium* infested site. CA | *Sporobolus* savanna CA' | *C.odorata* infested site CB | *Hyparrhenia* grassland CB' | *C.odorata* savanna CC | *Hyparrhenia* grassland CC' |
|---|---|---|---|---|---|---|
| **Sampling site** | Berlem, Dzeng plateau | | Mayo kela, Dumbo | | Waindodown, Wum | |
| **Depth (cm)** | 30 | 30 | 30 | 30 | 30 | 25 |
| **Residual humidity %** | 17.5 | 16.68 | 4.058 | 4.167 | 7.991 | 6.724 |
| **Nitrogen(g/kg)** | 8.406 | 7.646 | 1.720 | 1.619 | 3.810 | 2.480 |
| | **Organic Matter Content** | | | | | |
| **Organic Matter (g/kg)** | 72,242 | 60.357 | 21.406 | 27.271 | 20.414 | 17.065 |
| **Organic Carborns (g/kg)** | 41.904 | 35.010 | 12.417 | 15.818 | 11.841 | 9.899 |
| | **Interchangeable Bases** | | | | | |
| **$Ca^{2+}$ (cmol/kg)** | 0.281 | 0.643 | 0.535 | 0.382 | 1.645 | 0.261 |
| **$Mg^{2+}$ (cmol/kg)** | 0.141 | 0.690 | 0.381 | 0.012 | 1.536 | 0.000 |
| **$K^+$ (cmol/kg)** | 1.197 | 1.057 | 0.441 | 0.398 | 5.493 | 0.218 |
| **$NA^+$ (cmol/kg)** | 0.404 | 0.163 | 0.042 | 0.146 | 0.188 | 0.189 |
| **S (somme)(cmol/kg)** | | | | | | |
| **T (CEC) (cmol/kg)** | 30.068 | 30.390 | 7.313 | 8.104 | 17.232 | 12.206 |
| | **Acidity /Alkalinity** | | | | | |
| **pH ($H_2O$) – 1 :5** | 4.98 | 5.57 | 5.37 | 5.40 | 5.67 | 5.33 |
| **pH(KCI) – 1 :5** | 4.18 | 4.43 | 4.22 | 4.11 | 4.57 | 4.03 |
| **Phosphoric Acid** | | | | | | |
| **P Ass (mg/kg) Bray 2** | 3.018 | 3.262 | 1.136 | 1.018 | 74.815 | 2.862 |
| **Level of fertility** | High | low | low | low | Moderate | Moderate |

Source: Field Soil Samples Analysed at Laboratory of Soil, Plants, Water and Fertilizers Analyses IRAD, Yaounde

➢ *Soil Organic Matter Content*

The organic matter and carbonic constituent was established for the site locations and like the reflection of the study area varied. Soil characteristics vary over very short distances in the area. Soil analysis revealed 72.2g/kg for organic matter and 41.9g/kg for carbonic content for the Berlem Pteridium infested site much higher than *C. odorata* sites. This is typical of high plateau basaltic humic soils with *Sporobolus spiramidalis* as the dominant grass. *Pteridium aquililium* invasion here is heavy with very dense infestations. The adjacent weed free Sporobolus grassland showed 60.3g/kg and 35.0g/kg respectively for organic and carbonic content. As such a significant difference was established for the samples. Organic matter determines soil fertility by providing humus which is important in maintaining soil structure, in slightly increasing the soil's water holding capacity and holding a small store of N, P, S and trace elements in organic forms. These cannot be taken up directly by plant roots but have first to be converted by soil microbes to inorganic (ionic) forms identical to those supplied in fertilisers, Johnny (2011). Organic matter content is therefore one major soil component playing a significant role in the soil. In *C. odorata* infested sites it showed a slight comparative increase; 27.271g/kg and 20.414g/kg for Mayo kela and Wum respectively as against 21.406g/kg and 17.065g/kg for adjacent sites.

➢ *Cation Exchange Capacity. (CEC)*

The total capacity of a soil to hold exchangeable cations is expressed as Cation exchange capacity is (CEC). Cation exchange capacity was estimated following the method used by the University of Arizona College of Agriculture and Life Sciences by summing the major exchangeable cations (K, Ca, Mg, and Na) using units of centimoles of charge per kilogram of soil (cmol/kg). CEC is an inherent soil characteristic that influences soil fertility. The humic and red ferraliltic soils in the high plateau area (30.390cmol/kg) did not show any difference in exchangeable cations with the *Pteridium* infestation. Even the *C. odorata* invaded sites didn't show any significant difference in CEC with adjacent *Hyparrhenia* grassland in soils on granite (8.104cmol/kg) Mayo kela but did in black ash brown basaltic soils (12.206 cmol/kg) Wum

*C. The Soil pH (Percentage of Hydrogen Irons) Presence of Alkalinity/Acidity.*

The pH value indicates the degree of acidity or alkalinity of soil. The pH value ranging from 1 to 6 indicates that the soil is acidic; meanwhile pH value from 8 to 14 indicates that the soil is Alkaline in nature. Soils can be infertile whether acidic or alkaline. As such, the ideal soils are those with pHs around 7 where soils are neither acidic nor alkaline, the value 7 being a neutral value.

Two methods were used to determine the pH of the samples obtained from the field. The pH values obtained using water pH ($H_2O$) and calcium chloride solution (0.01 M CaCl2) pH (kcl). The soils were mostly acidic and their fertility sustains agriculture and grass growth because of the organic matter content. The result obtained corroborates the findings of Ndenecho (2006). In fact, the humic ferralitic soils in the high plateau area of Berlem had a pH value of 4.98 and 4.18 for the *Pteridium aquililium* infested site and 5.57 and 4.43 for the adjacent grassland. *C. odorata* infested sites are not indifferent. In Mayo kela it reveals a value of 5.40 and 4.11 for the *Hyparrhenia* grassland and 5.37 and 4.22 for the adjacent *C. odorata* infested site. The situation for the

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

samples of Wum revealed a 5.33 and 4.03 for *Hyparrhenia* and 5.67 and 4.57 for *C. odorata* infested site.

Overall, soils in the study area are strongly acidic as their average values fall between 4.0-5.7. With strong acidity, exchangeable cations or nutrients are reduced thereby reducing soil fertility. Moreover, there is low moisture retention capacity that facilitates fast scorching of pastures with the coming of the dry season. The organic matter content of soils in the Berlem plateau was relatively higher with medium acidity making the soils to be a little fertile compared to those in the lowlands of Mayo kela. The most significant difference on soils in relation to weeds was the noticeable increase in nitrogen content in the soil in *Chromolaena odorata* infested sites. The situation for Mayo kela gave a difference as the *C.odorata* sites obtained a value of 1.823cmolc/kg compared to the adjacent *Hyparrhenia* savanna with 0.892cmolc/kg. In the case of Wum, similar results were analysed, 1.512 cmolc/kg for *C. odorata* infested site compared to adjacent savanna with 1.013 cmolc/kg. However, a significant difference is observed in phosphorus content (74.815) in *C. odorata* sites in Wum compared to adjacent (2.862) *Hyparrhenia* sites.

## IV. CONCLUSION

Weed infestation is a problem that reduces herbage yields and production of rangelands. Its rapid spread to previously clean areas is a stern management concern because it greatly reduces grazing capacity. Weed infestations notably *Pteridium aquilinium* and *Chromolaena odorata* were negatively correlated with grass availability and density. Shifts in species, reduction in species composition and preferred grass, altered fire regimes and change in soil composition are some of the ecological changes. Other socio-economic implications are interference with grazing, lowering yield and quality of forage, poisoning animals, increasing costs of managing and producing livestock, and reducing land value. Moreover, wildlife habitat and forage, soil and water resources, increase erosion, reduce plant diversity and altered fire frequency are other aspects affected. These glaring outcomes continue to grow with increasing extent of weeds in spatial cover and density with no earmarked efforts to counter these weeds due to institutional challenges. More focus should be on the institutional challenges and opportunities affecting pastoral production in the area.

## 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
[10]. Mairomi, H. W. (2021): 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. International Journal of Innovative Science and Research Technology, Vol, 6, 1495-1507.
[11]. Norgrove, L., Dux, J. and Fuambeng, P. (2007). Changes in ecosystem function in savannahs and fields invaded by Chromolaena odorata in Cameroon
[12]. Moby, E. (1979): Climate. In; Atlas of the United Republic of Cameroon. J — F Loung (ed) Edition Jeune Afrique, Paris. p. 16— 19.
[13]. Ndenecho, E. N. (2005): Biological Resource Exploitation in Cameroon; From Crisis to Sustainable Management. Unique Printers Bamenda pp101-130
[14]. 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
[15]. 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
[16]. 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
[17]. Pokshishevskii, V.V.(1970): World population and resources: The larger historical context of the problem pp 40 – 53

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr869

[18]. Rymer, L. (1976): The History and Ethnobotany of Bracken. Botanical Journal of the Linnean Society 73:151-176.
[19]. 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.
[20]. Taylor, J. A. (1990): 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
[21]. 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.
[22]. 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.
[23]. Vitousek, P. M., H. A. Mooney, J. Lubchenco, and J. M. Melillo. 1997. Human Domination of Earth's Ecosystems. Science 277 (5325): 494-499.