

**EFFECT OF RANGELAND USE ON HERBACEOUS SPECIES COMPOSITION AND
DIVERSITY OF NATURAL PASTURES IN PADER DISTRICT**

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DECLARATION

I, Waiswa Caleb, declare that this is my original work, and all contents herein represent my findings and investigation. Any additional information from other sources has been duly acknowledged. This work has never been submitted by any other individual or institution for the award of any academic qualification.

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APPROVAL

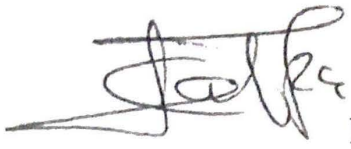
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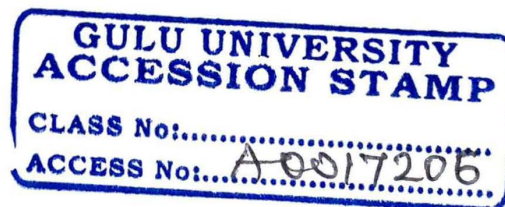
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ABBREVIATIONS AND ACRONYMS

TEK	Traditional Ecological Knowledge
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GLM	Generalised Linear Model
IVI	Importance Value Index
CP	Crude Protein

ABSTRACT

This study investigated the diversity of herbaceous pastures under different grazing and burning intensities, and herders' perceptions of pasture composition and utility value in Aswa Ranch, Pader district. Data were collected through a cross-sectional vegetation survey between November and December 2022 using 1m x 1 m quadrats along transects placed in areas with different grazing and burning intensities. Diversity was assessed using indices such as richness (S), Shannon-Wiener (H'), Gini-Simpson (G), and Importance Value Index (IVI). Focus group discussions were also conducted to record local ecological knowledge and perceptions. IVI analysis revealed *Hyparrhenia species* and *Digitaria abyssinica* as dominant in minimally grazed plots and *Brachiaria decumbens*, *Sporobolus pyramidalis*, *Paspalum spp.*, and *Cenchrus ciliaris* as dominant in regularly grazed areas. Herders similarly identified *Hyparrhenia spp.*, *Brachiaria decumbens*, *Imperata cylindrica*, *Panicum maximum*, *Sporobolus pyramidalis*, and *Cynodon dactylon* as abundant, but highlighted *Sporobolus pyramidalis* and *Cymbopogon afronardus* as undesirable for livestock production. Minimally grazed areas had higher Shannon-Weiner, species richness, evenness and Gini-index values. In contrast, regular burning was associated with higher species diversity. Generally, Aswa Main was more diverse than Aswa Zebu. Herdsmen's perceptions revealed high grazing intensity, indiscriminate bush burning, proximity of kraals and animal watering areas as factors affecting pasture composition. While the general state of the pastures was considered favourable for livestock production by the herdsmen, pastures are experiencing a downward trend in pasture quality, as depicted by the increasing trend of undesirable species such as *Sporobolus pyramidalis* and *Cymbopogon afronardus*, especially in the overgrazed areas. Therefore, to ensure a more uniform distribution of palatable species across the grazing areas, the ranch management should adopt an incremental restoration strategy involving phased oversowing combined with rest periods and proper rotational grazing management to facilitate natural pasture regeneration and increase species richness and evenness. They should also incorporate legume species as part of the restoration strategy to improve the nutritive value of pastures.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

About 40% of the earth's surface area is occupied by rangelands, 70% of which is agricultural land (Abdalla *et al.*, 2018; Conant, 2012; Wang & Fang, 2009). These not only support the functioning of natural systems but also play a vital role in the survival and well-being of numerous individuals worldwide (Godde *et al.*, 2020). They provide grazing resources for livestock production and other ecosystem services (Bailey *et al.*, 2019; Kazungu *et al.*, 2020; Olsson *et al.*, 2019; Reda *et al.*, 2020). As highlighted by Eldridge *et al.* (2016) and Golodets *et al.* (2010), livestock production stands out as the predominant land-use practice within the rangelands. It is estimated that about 50% of global livestock animals rely on rangeland resources for their dietary needs and survival (Briske *et al.*, 2020; Thornton, 2010). Notably, pastoral livestock farming, a prevalent practice in natural grasslands, covers one-third of Africa's total land area (Egeru *et al.*, 2015). Grazing animals are efficient at utilising resources for food production in these largely dry rangelands, where traditional crop cultivation is limited (Philipsson *et al.*, 2011; Treydte *et al.*, 2017). This underscores the significance of rangelands in driving the economies of African countries through the livestock sector.

In Uganda, rangelands which are commonly natural grasslands, are the mainstay sources of feed for ruminant livestock (Egeru *et al.*, 2015) and account for more than 90% of beef production in the country (Zziwa *et al.*, 2015). However, the composition and biomass of forages within the grasslands are subject to spatial and temporal changes. Such changes can greatly influence rangeland productivity through their effect on its biomass production and total nutrient status, which in turn has a large bearing on utility for livestock production in terms of nutrient intake. According to Tolera *et al.* (2000), the orientation of species composition towards low-nutritional pastures is associated with reduced livestock reproductive performance and production, slower growth rates, poor body condition, and higher vulnerability to parasites and diseases. Nantongo *et al.* (202) demonstrated a decline in average daily growth (ADG) among animals on natural pastures due to reduced dry matter intake (DMI) based on seasonal variations in pasture composition. As highlighted by Savadogo *et al.* (2009), the primary causes of rangeland degradation are climatic conditions, anthropogenic activities (deforestation, burning, and grazing), and/or their interactions. For instance, overgrazing creates bare soil surfaces, which reduces the soil's ability to support

pasture establishment and growth and replenishment of palatable soil pasture seed banks. Consequently, undesirable, ungrazed plants thrive and set seed, lowering the pastureland's grazing value. Additionally, the soil seed bank for most palatable species in overgrazed sites may be depleted to a point that relieving it of livestock activity and fertilisation does not restore native species. Warth *et al.* (2020) mentioned that land cultivation, intense grazing, and shortened fallow periods can also curtail flowering/seed setting to replenish soil seed bank sinks. Also, frequent and intense burning can destroy vegetation regenerative capacity through sprouting or recruitment from soil seed banks (Balch *et al.*, 2013).

In the Acholi sub-region, there has been a resurgence of agriculture-related activities following recovery from the disruptive 2-decade-long insurgency due to civil strife. From the natural laws of ecology, it is expected that significant changes in vegetation structure through succession processes occurred during the period of insurrection since a large portion of the land was left unused or minimally used for farming or grazing. However, this vegetation now faces increasing development pressure, as evidenced by the ten-year agricultural production data from UBOS (2010–2019), which show a systematic increase in land use intensity associated with increased expansion of farmlands, livestock density, and extraction of both herbaceous and woody biomass. As highlighted by Thornton (2010), the intensity and scale of these land use practices is projected to increase owing to the increasing human population and demand for rangeland resources. Unfortunately, the impact of these land-use practices on the composition and diversity of natural pastures in Acholi sub-region has not been extensively explored. Yet, designing management options that maintain grazing lands in good condition or restore degraded pasturelands requires knowledge on how vegetation responds to varying kinds and levels of land-use intensity (Angassa *et al.*, 2006; Asner *et al.*, 2004).

Against this background, the current study sought to investigate the impact of differential utilisation of grazing land on the composition and diversity of pastures. To achieve this, pastures under minimally and regularly grazed plots and minimally and regularly burned plots were evaluated for their phytosociological attributes. This assessment was integrated with the herders' perception of the composition and utility value of pastures similar to Angassa *et al.* (2012) & Roba (2008). According to Grice and Hodgkinson (2002), this approach is effective in informing viable management systems for both the conservation and sustainable use of semi-arid rangelands. This

research provides valuable information relevant to the development of appropriate management practices that will sustain livestock production without further degrading pasture resources.

1.2 Problem Statement

There is a paucity of scientific information on how different land use practices affect the composition and diversity of natural pastures in the Acholi rangelands, even though national data (UBOS 2010–2019) indicate increasing land use intensity driven by agricultural expansion, rising livestock numbers, and herbaceous and woody biomass extraction. As indicated by Zerbo *et al.* (2016), such land use practices and their interaction with climatic and edaphic conditions influence the composition of natural pastures within the rangelands. The magnitude and direction of the change in species composition depend on the nature, duration, and intensity of the intervening factors. Moreover, these changes are said to affect biomass production and the total nutrient status of pastures (Bell *et al.*, 2021), which in turn has a large bearing on utility for livestock production in terms of nutrient intake, thereby affecting farmers who heavily depend on livestock for their livelihoods.

Although the response of pasture species to land use practices and other factors has been investigated in Uganda's rangelands, for instance, distance from piospheres (Egeru *et al.*, 2015), climate and non-climatic transformations (Atuhaire *et al.*, 2018), pasture use and management strategies (Roschinsky *et al.*, 2012), and production systems, land cover, and soil factors (Egeru *et al.*, 2019; Kyoshabire *et al.*, 2018; Zziwa *et al.*, 2012), issues on the intensity of use, which affects pasture composition, are still largely unknown, especially in the Acholi subregion. Additionally, much of the existing research primarily examines the impact of grazing on rangeland vegetation in the Karamoja subregion and Western Uganda, resulting in a void in knowledge specifically related to the rangelands in Acholi despite the increasing ranching activities in the subregion.

Therefore, this study examined the impact of uneven utilisation of natural pastures on the composition and diversity of herbaceous species. The study sought to provide information on the composition of herbaceous pasture species, which is valuable for assessing the ecological conditions of grazing areas and their capacity to meet the dietary needs of grazing livestock (Gurevitch *et al.*, 2010; Heitschmidt *et al.*, 1995).

1.3 Objectives of the Study

1.3.1 Main objective

The main objective of this study was to investigate the effect of differential utilisation of natural pastures on their composition and diversity in Aswa Ranch.

1.3.2 Specific objectives

- i) To determine the phytosociological parameters of herbaceous pastures under different grazing intensities in Aswa Ranch.
- ii) To determine the diversity of herbaceous pastures under different burning intensities in Aswa Ranch.
- iii) To assess the herders' perceptions of the composition and utility value of herbaceous pastures in Aswa Ranch.

1.4 Hypotheses and Research Questions

1.4.1 Hypotheses/Research question.

- i) The phytosociological parameters of herbaceous species do not differ across different grazing intensities.
- ii) Herbaceous species diversity is the same across different burning intensities.
- iii) What are the herders' perceptions of the composition and utility value of herbaceous pastures in Aswa Ranch?

1.5 Significance of the Study

According to Heitschmidt *et al.* (1995) and Gurevitch *et al.* (2010), species composition is the primary determinant of the ecological condition of grasslands, with the kinds, size, and density of plants, influencing ecosystem quality and quantity. Riding on the above, the current study investigated the composition of the natural pastures within the research area using field surveys and herders' perceptions to offer valuable insights into the condition of rangelands. Consequently, the results of this research will guide rangeland managers and researchers in formulating and implementing sustainable grazing management practices aimed at conserving nutritious pasture species, ensuring a long-term ecological balance and livestock activity. This research also provides invaluable information that will aid policymakers in designing policies that enforce sustainable land use practices and protect the integrity of rangelands. Additionally, the study findings

underscore the significance of integrating field-based studies and local herders' knowledge in understanding rangeland pasture dynamics.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Natural grasslands support more than 40% of the world's livestock production (Briske *et al.*, 2020; Thornton, 2010), and serve as essential grazing grounds and a primary dietary source for livestock in the tropics (Egeru *et al.*, 2015; Khuliso *et al.*, 2020). In Uganda, the livestock sector is a significant contributor to the economy, accounting for approximately 17 percent of the agricultural Gross Domestic Product (GDP) and 4.3 percent of the overall GDP (FAO, 2019). Overall, this sector (80% of animal herds and 90% of cattle) is sustained by natural pastures (Government of Uganda, 2014). Unfortunately, these natural grasslands are constantly impacted by suboptimal management, rendering them vulnerable to ongoing degradation. Studies indicate that this degradation is a consequence of both human and natural factors, which significantly affect the grazing resources (Zerga, 2015). Therefore, in the absence of sustainable management practices, the capacity of natural grasslands to support the nutritional requirements of livestock is compromised, thereby constraining the livelihoods of livestock-dependent communities.

2.2 Phytosociological Parameters of Pastures under Different Grazing Intensities

Phytosociology delves into the composition, development, and interrelationships of plant species within communities (Ismail & Elawad, 2015). It examines how populations of plant species coexist and interact (Mishra *et al.*, 2012), and observes changes in vegetation cover influenced by human activity, climate change, and growth-impacting factors. Key phytosociological attributes include species richness, species evenness, relative abundance, and importance value index, which collectively define the composition of grasslands. These attributes are said to be majorly influenced by grazing intensity (Eldridge *et al.*, 2016). Previous studies that have examined phytosociological parameters of natural pastures at different grazing intensities report results at varying depths.

For instance, Haarmeyer *et al.* (2010) reported a higher abundance of annual species on heavily grazed sites in their study, which was attributed to increased precipitation during the study period. Additionally, Odadi *et al.* (2017) and Selemani *et al.* (2013) observed that annual species and weeds, which are often undesirable for grazing, were prevalent under heavy grazing. Likewise, desirable grass species (perennials) have been observed in moderately grazed areas

(Pfeiffer *et al.*, 2019; Tefera *et al.*, 2007). Rutherford & Powrie (2013) mentioned that heavy grazing changes composition by affecting quality, favouring annual species.

Jawuoro *et al.* (2017) observed low species richness in areas near piospheres due to heavy grazing. They argued that the higher animal concentration near piospheres hampered seed germination and slowed plant regeneration upon grazing due to defoliation and soil trampling. Declining species richness has also been observed under continuous grazing systems (Desta *et al.*, 2024; Atsbha *et al.*, 2020). The authors attributed the findings to increased indirect pressure on seedling germination and plant establishment patterns under those systems. Likewise, Desta *et al.* (2024) demonstrated higher species richness under grazing exclusion and controlled grazing. The authors argued that controlled or no grazing improves seedling germination and pasture establishment.

According to Rahmanian *et al.* (2020), overgrazing exerts a negative effect on species diversity. The authors argued that intense grazing reduced species diversity by eliminating palatable species. However, Rutherford and Powrie (2010) reported from their fence-line studies that intense grazing may even increase species diversity of the grazed communities by increasing evenness. Moreover, Rutherford *et al.* (2012) reported an increase in evenness due to the suppression of dominant species that resulted in higher species diversity of heavily grazed communities. (Shu *et al.*, 2022) also reported an increase in species evenness and Shannon-Weiner indices under high grazing intensity. The high evenness was caused by the occurrence of small weeds with no clear dominant species because of the loss of the large dominant species, e.g., Gramineae and Cyperaceae plants, due to intense grazing. However, some studies reported no significant association between grazing intensity and plant diversity (Eldridge *et al.*, 2016; Jordan *et al.*, 2022). In their study, in southern Tunisia, Gamoun, (2014) reported higher significant results of Shannon-Weiner on ungrazed sites and weaker significance on heavily grazed sites. Hao *et al.* (2022) reported the highest Shannon-Weiner and evenness in heavily grazed sites in their study in the Alpine Steppe on the Qinghai–Tibetan Plateau.

Grazing regimes are said to affect the dominance of pasture species in the rangelands by altering its composition. The effect of grazing regimes on the dominance of pasture species is demonstrated by Hao *et al.* (2022). The authors reported a shift in species dominance from grasses and sedges to forbs. Heavily grazed areas negatively affected the importance value of

sedge species. However, the importance values of sedges and grasses were highest under low grazing intensity. The findings were partly attributed to the fact that browsers preferred grasses and, therefore, forbs had a competitive advantage to grow and set seed. Similarly, Yang *et al.* (2016) observed a shift in the dominant species of the plant community from palatable grasses (Gramineae and Cyperaceae) to unpalatable grasses (Compositae and Ranunculaceae).

Based on the conclusions of Eldridge *et al.* (2016) and Titcomb *et al.* (2021), a synthesis of the previous research indicates that the impact of grazing intensities on phytosociological attributes is dependent on factors such as the ecosystem type, site characteristics and grazing history, plant traits and their adaptive capacity to grazing, and herbivore type. This explains the differences in how plant communities respond to grazing pressure, which is important in determining the grazing value of a given grazing land. Therefore, the current study sought to understand the grazing value of natural pastures within the research area by examining their phytosociological attributes under site-specific grazing intensities.

2.3 Herbaceous Species Diversity under Different Burning Intensities

According to Boakye *et al.* (2013), fire frequency has an overriding effect on plant species diversity. Depending on the management decisions implemented, unnaturally frequent fires can have detrimental impacts on plant diversity (Collins & Calabrese 2012). Pyke *et al.* (2010) argued that that fire can change plant communities by reducing the dominance of some plants while enhancing the dominance of others. Studies have attempted to investigate the effects of fire intensity and frequency on species diversity. For instance, in their study, Munyai *et al.* (2023) found a greater prevalence of palatable *T. triandra* in the burned sites and the unburned areas were characterised by unpalatable species with high moribund material. Similarly, Collins & Calabrese (2012) found higher species diversity in areas infrequently burned and grazed and the lowest diversity in frequently burned and ungrazed sites. Morrison (2002) reported a reduction in herbaceous species richness in one of the most species-rich savannas in North America after a reduction in fire frequency and drought, signifying the role of fire in shaping vegetation structure. Morrison (2002) concluded that species richness of native grasses and exotic forbs did not significantly differ between burned and unburned treatments. However, they concluded that burning during the drought period increased forb species richness.

In his study on the Effects of fire intensity on plant species composition of sandstone communities in the Sydney region, Morrison (2002) found that monocotyledon and Fabaceae species were more abundant at higher than lower intensities, the Proteaceae and Rutaceae at intermediate intensities, and the Epacridaceae at lower rather than higher intensities. Additionally, fire-tolerant species increased with fire intensity and were higher in areas with medium intensity. Fire-sensitive species were higher in burnt areas with low intensity. The overall richness of the species increased with increasing fire intensity, this being mainly due to the increasing richness of the fire-tolerant species. The evenness of the fire-sensitive species was greater in the burnt areas than in the unburnt areas. Similarly, Twidwell *et al.* (2012) reported that Native forb species richness was greater in burned than in unburned areas. The available literature shows a difference in the effect of fire on species composition and diversity based on the location, grassland type and frequency/severity of fire. The current study investigated the effect of different burning intensities on the diversity of herbaceous species.

2.4 Herders' Perceptions on the Composition and Utility Value of Dominant Herbaceous Species

2.4.1 Abundance and utility value of dominant herbaceous species

The application of herders' perceptions in ecological research is grounded in their intrinsic ability to discern key aspects of grassland ecology. Herders possess a nuanced understanding of pasture quality, carrying capacity of livestock, ideal grazing periods, palatability of diverse plant species for animals, and seasonal distribution and accessibility of pastures, among other dynamics of grasslands (Ghorbani *et al.*, 2013; Egeru *et al.*, 2015). This traditional ecological knowledge (TEK) emerges from herders' continuous interaction with the environment, coupled with their acute observational abilities. It not only informs their strategies for the optimal use of natural pastures for grazing but also enriches ecological studies, offering a practical perspective on the sustainable management of grassland ecosystems.

Numerous studies have leveraged TEK to explore variations in the abundance, seasonal changes, and utility value of rangeland pastures. For instance, Keba *et al.* (2013) found that in Ethiopia's Borana rangelands, pastoralists favoured grasses like *Cenchrus ciliaris* and *Pennisetum maximum*, which also exhibited higher crude protein (CP) levels, while the less preferred and less palatable species like *Digitaria naghellensis* and *C. dactylon* had higher

structural fibre content. Their study confirmed a strong correlation between pastoralists' ranking of common grass species and chemical composition values derived from laboratory analyses. Similarly, Roschinsky *et al.* (2012) reported that in western Uganda's Ankole pastoral system, *Hyparrhenia rufa* and *Brachiaria spp.* were preferred, contrasting with the least desirable yet prevalent *Sporobolus pyramidalis* and *Cymbopogon afronardus*. In Karamoja sub-region, Atuhaire *et al.* (2018) identified *Hyparrhenia spp.*, *Brachiaria spp.*, *Pennisetum spp.*, and *Chloris spp.* as dominant, with *B. decumbens* standing out for its competitiveness and nutritional value. For pastoral and agropastoral production systems in northern Uganda, Anyait *et al.* (2023) noted the dominance of *Hyparrhenia rufa* and *Imperata cylindrica* during the wet season in the pastoral system, while *Brachiaria species* and *Themeda triandra* prevailed within agropastoral systems. Likewise, *Imperata cylindrica* and *Cynodon dactylon* were the only available species during the dry season for the pastoral system, with *Cynodon dactylon* and *Panicum maximum* dominating in the agropastoral system.

A synthesis of these previous studies confirms that pastoralists have enormous knowledge of plant diversity and are therefore reliable sources of information for ecological studies. These studies also show that pasture composition and utility value differ across locations due to spatial variation in topography, soil characteristics, and management practices. Considering the above, this study sought to determine the abundance and utility value of dominant pastures in the study area based on the experience and knowledge of local herders regarding the pastures in their grazing lands.

2.4.2 Land use practices influencing herbaceous species composition and diversity

A combination of dominant herbaceous perennial grasses (Morris & Kotze, 2006) and a mix of legumes describes a healthy grazing area. Perennial grasses have extensive root systems and are thus better adapted to preventing soil erosion than annual species (Zerga, 2015). In addition, the presence of legume pasture species improves the utility value of grazing areas since they are high in crude protein content. However, the occurrence of these species (in terms of composition, diversity, and distribution) in natural grasslands is majorly influenced by anthropogenic (human) activities (Alcamo *et al.*, 2011), such as grazing, use of fire, and selected cutting practices. For instance, grazing on natural grasslands, which is one of the primary ways in which land is utilised, influences the makeup of species within the community, the traits of

the vegetation, and the amount of plant matter present (Klein *et al.*, 2007; Post & Pedersen, 2008). Grazing has both short- and long-term impacts on plant communities (Jacobo *et al.*, 2006; Teague *et al.*, 2004).

In the short term, grazing can alter the plant community structure by removing plant matter, and over time, botanical composition and species diversity changes. Under appropriate grazing, there is an improvement in both species diversity and plant productivity. Appropriate grazing may be characterized by regulation of the number of livestock allowed to graze, as well as their placement, time spent foraging, and frequency of visits to the grazing land (Ruvuga, 2021). This is to maintain grazing areas with desirable perennial grass species, adequate plant coverage, and abundant forage growth (Pfeiffer *et al.*, 2019; Tefera *et al.*, 2007). Also, Selemani *et al.* (2013) and Verdoodt *et al.* (2010) revealed that practices such as rotational grazing allow for the areas rested from grazing to recuperate, bring in new plant varieties, and revive biodiversity. Often, the rotational grazing system is employed where there is no alternative grazing land to permit the migration of livestock.

On the other hand, prolonged intensive grazing results in weakened growth of desirable plant species, a rise in undesirable vegetation, decreased forage production, decreased biodiversity, and increased soil and water erosion (Odadi *et al.*, 2017; Selemani *et al.*, 2013). In addition, continuous grazing leads to a substantial decrease in plant ground cover, significant alterations in the mix of herbaceous species, and hindrance of herbaceous regrowth (Hawkins, 2017; Jordaan *et al.*, 2019; Jordaan & Rooyen, 2020). This is because heavy grazing interferes with the growth and spreading of seeds for herbaceous species (Bhasin, 2011). In such conditions, undesirable plant species (such as weeds) that are not grazed have ample opportunities to flourish and produce seeds (Egeru *et al.*, 2015).

As for grazing exclusion, there is an increase in the growth of previously suppressed species and their diversity in the natural grasslands (Shang *et al.*, 2008). Regarding the use of fire, Mapiye *et al.* (2008) argued that prescribed burning aids in controlling and removing undesirable vegetation in grazing lands, resulting in increased livestock productivity. Additionally, fire enhances the palatability and nutritional value of rangeland pastures (Sabiiti *et al.*, 1992). However, unprescribed fires can destroy valuable vegetation, exposing soils to erosion, and alter plant composition towards fire-tolerant species with low nutritional value

(Mapiye *et al.*, 2008; Waiswa *et al.*, 2019). For instance, bushfires in Karamoja sub-region have promoted the prevalence of less desirable fire-resistant species, such as *Themeda triandra*, *Lanea humilis*, and *Dichrostachys cinerea* (Aleper *et al.*, 2017).

The influence of other human-induced factors on herbaceous species composition has also been highlighted, such as charcoal production (Aleper Daniel & Namaganda, 2017), road construction, construction of watering points and kraals (Egeru, Bernard, *et al.*, 2015; Jawuoro *et al.*, 2017; Shahriary *et al.*, 2012), and expansion of human settlement. Generally, effective grazing management is crucial for achieving economic benefits while safeguarding the health of grasslands and livestock (Alemu *et al.*, 2019). Sustainable grazing practices enhance livestock productivity and ensure natural grasslands continue to provide other ecological benefits (Godde *et al.*, 2018; Teague & Barnes, 2017). This research addresses the previously unexplored aspects of the human activities influencing the diversity and composition of pastures in the study area from the herders' perspective.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study Area

The study was conducted in Pader District at Aswa Ranch since it is characterised by land use activities which presented suitable ground for the study. The Ranch is situated in Northern Uganda within the Acholi sub-region (Figure 3.1). The district's boundaries are defined by Lamwo District to the northwest, Kitgum District to the northeast, Agago District to the east, Otuke District to the southeast, Gulu District to the west, Oyam District to the southwest, and Lira District to the south. Aswa ranch is approximately 35km off the Gulu-Kitgum highway and covers areas within Angagura, Laguti and Atanga sub-counties. The ranch is located along river Aswa and comprises several seasonal streams that tend to dry up during the dry season. The river and streams serve as the main drinking water sources for livestock on the ranch throughout the year.

The area typically experiences two wet seasons (from March to May and September to November) and two dry seasons (from December to February and June to August). The average annual rainfall is approximately 1,330 mm, with monthly maximum temperatures around 29°C and minimum temperatures around 17°C. However, it is noteworthy that recent climate change dynamics have caused greater variability in rainfall and temperatures in this area.

The area is dominated by native tropical grasses such as *Brachiaria spp.*, *Panicum maximum*, *Hyparrhenia spp.*, *Pennisetum spp.*, *Andropogon spp.*, *Heteropogon spp.*, *Setaria spp.*, *Themeda triandra*, *Cenchrus ciliaris*, and *Cynodon spp.* Conversely, the overstorey is primarily composed of Combretum and Acacia species.

Originally established in 1967 by the Uganda Livestock Industry Limited, the ranch purposed to breed beef animals, train farmers and livestock technicians, and provide semen for breed improvement in the local community. However, after its collapse during a wave of insecurities in the region, it was revived in 2014 by the National Animal Genetic Resources Centre and Data Bank (NAGRIC & DB) under the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) (Aswa Ranch records). The ranch was restocked with over 1000 heads of cattle and has since grown to a capacity of more than 1800 heads of cattle. These animals are managed under separate farms: “Aswa main” in Angagura, comprising cattle of mixed breeds and “Aswa zebu” in Laguti, comprising pure zebu breeds. In each location, animals are managed in separate herds/kraals, with kraals typically located 5 km apart. Currently, the ranch has over 2500 heads

of cattle with an average of 80 heads of cattle per herd/kraal. The herdsmen in the ranch practice open continuous cattle grazing, a practice which does not allow sufficient time for grazed areas to fully recover. In recent years, the ranch has experienced an influx of activities such as charcoal production, expansion of crop cultivation, and settlements by squatters within the ranch, increasing pressure on the available grazing grounds. Additionally, due to insecurity caused by land wrangles within the ranch, a large area of land meant for grazing is not utilised by the herdsmen.

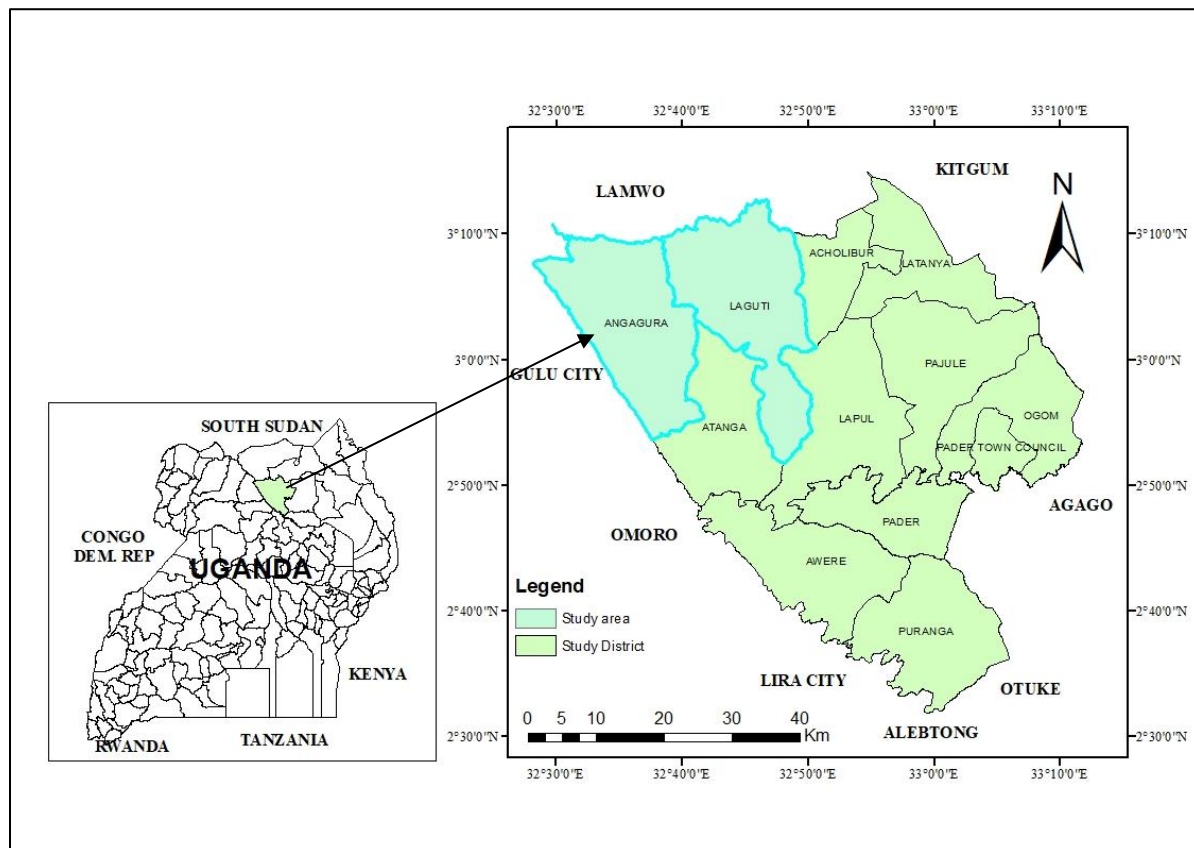


Figure 3. 1: Map of Pader district showing the location of the study area

3.2 Study Design

This study adopted a cross-sectional survey design using a transect method to develop an inventory of natural pastures in the regularly and minimally grazed and burned sites of the ranch. Herbaceous vegetation species were inventoried to assess the diversity, dominance, and richness of natural pastures under defined grazing intensities and burning intensities. The inventories were

corroborated by focus group discussions through which the perceptions of herdsmen on the composition of herbaceous pastures were investigated. These discussions were centred around the abundance and utility value of natural pastures and anthropogenic factors affecting the composition of pastures in the ranch.

3.3 Sampling Procedure

3.3.1 Field survey

Approximately 80 heads of cattle were organised into kraals in the ranch and grazing areas designated for the kraal. The study aimed to sample the vegetation of grazing areas belonging to the selected kraals. Six grazing grounds(sites) belonging to six kraals were randomly selected for the study, with three sites selected from each of the nine major kraals of Aswa Ranch's two locations (Aswa main in Angagura and Zebu farm in Laguti).

In this study, five 20 m² plots were systematically placed at 20 m intervals along a 100 m transect in each sampling site (minimally grazed and regularly grazed) per kraal. Five 1m² plots (quadrats) were then fitted in each of the 20 m² plots placed along each transect.

Therefore, 25 1m² plots were sampled at each sampling site, resulting in 50 plots per kraal. With three kraals sampled per location, a total of 150 1m² plots were sampled in each of the locations. It was not possible to define grazing intensity based on stocking density, given the grazing system in the study area. Cattle are mostly grazed on free range for most of the year without confining them into paddocks. Therefore, the selection of minimally grazed and regularly grazed sites for each herd was based on the frequency of grazing by animals in a grazing season, observations and past grazing pressure, including signs of grazed vegetation, evidence of dung and trampling, grazing history, as well as herders' knowledge, based on general recommendations for rangeland condition assessment (Parker, 1954; Sanaei *et al.*, 2021; Mannetje & Jones, 2000).

Minimally grazed areas were also identified as grazing grounds (paddocked or open), which could spend more than one season without being grazed, grazed once in a year or completely ungrazed. Conversely, regularly grazed areas were identified as areas that are grazed every season throughout the year.

The sampling of areas according to burning intensities also followed the same procedure described above. Burning intensities were defined based on the frequency of burning, where minimally burned areas meant areas burnt once a year, and regularly grazed areas were areas burnt more than once in a year.

3.3.2 Selection of focus group participants

Four focus group discussions (FGDs) were conducted, two in Aswa Main and two in Aswa Zebu. Krueger (1994) and Morgan (1997) have suggested that three to six different focus groups are adequate to reach data saturation and/or theoretical saturation. Each of the groups consisted of nine participants, as per Hennink (2007), chosen purposively based on their experience and years spent grazing animals on the ranch. Potential participants were contacted by the researcher through the ranch Animal Husbandry Officers and invited to participate. All participants volunteered and gave their informed consent to take part in the study. They were all male, aged between 25 and 35 years. These had been rearing animals on the ranch for at least 5 years.

3.4 Sample Size

3.4.1 Assessment of the phytosociological parameters of herbaceous species under different grazing intensities

For grazing intensity, a vegetation survey of 300 plots (1m² quadrats) nested within 4 m x 5 m plots along a 100 m transect line in each sampling site was conducted.

3.4.2 Assessment of the diversity of herbaceous plants under different burning intensities

A similar number of plots were surveyed for burned areas following the same procedure as stated in section 3.4.1 above.

3.4.3 Assessment of herders' perceptions of the composition and utility value of dominant herbaceous pastures

A total of 36 herdsman participated in the four focus group discussions as already described in section 3.3.2.

3.5 Data Collection

3.5.1 Assessment of the phytosociological parameters of herbaceous species under different grazing intensities

Herbaceous species assessment was conducted between November and December towards the end of the main rainy season when most plants attain full flowering stage (Angassa, 2012). Herbaceous species are easily distinguished by their flower colour, shape, and appearance. Floristic sampling procedures stipulated by Kent (2011) were used. A standard quantitative ecological method for recording field observations in phytosociology by relevés was adopted (Kent, 2011). A 1x1 m² (Rajvanshi *et al.*, 1987; Sharma *et al.*, 1983) quadrat was used to determine species richness and abundance.

Species abundance was measured in terms of percent cover because many types of grass tend to be clonal, thus making it difficult to distinguish between discrete individuals (Magurran, 1988). The percentage of cover occupied by each herbaceous species was visually estimated per plot using the method of Braun-Blanquet (1932) with the cover classes r (rare species), +: cover less than 1%, 1a: cover between 1 and 3%; 1b: cover between 3 and 5%; 2a: cover between 5 and 15%; 2b: cover between 15 and 25%; 3: cover between 25 and 50%; 4: cover between 50 and 75%; and 5: cover between 75 and 100%.

Species present on the plot, but not covering 1% of the plot area, were recorded as 1% cover to indicate presence. Species richness and abundance were determined by observing pastures within the 300 1 m² plots and taking the average. Herbaceous species rooted within each quadrat were identified, counted, and recorded using presumptive local names as guided by experienced herdsman and illustrated guides to tropical grasses.

3.5.2 Assessment of the diversity of herbaceous plants under different burning intensities

Data collection for minimally and regularly burned intensities followed the same procedures as those explained for objective one.

3.5.3 Assessment of herders' perceptions of the composition and utility value of dominant herbaceous pastures

The study adopted a focus group discussion (FGD) approach to assess herders' perceptions of the composition and utility value of herbaceous pastures. The FGDs were managed by three

facilitators, including the researcher, who knew the commonly used languages in the ranch (Runyankore, Acholi, Karamojong) and English. Whereas all the participants were able to understand basic English, some of the concepts were translated by the facilitators into the local languages to provide more clarity. The facilitators were briefed by the researcher about the study objectives, and the guiding questions were clearly explained as presented in the focus group discussion guide (see Appendix A1) before conducting the FGDs. Consequently, the participants were briefed about the study objectives and time compensation benefits. Participants were given UgShs. 7000/= at the end of every focus discussion session. Each focus group session was conducted at the ranch offices between 10:00 am and 12:00 pm and lasted between 60-75 minutes. In addition to note-taking and participant observation, the discussions were audio-recorded after obtaining permission from the participants, following the procedures described by Stewart *et al.* (2007). The lead researcher posed the questions in English, while the second facilitator translated the conversation into local languages to provide clarity for the participants. The third facilitator supported the translation, detailed note taking and managed audio recordings. The audios were later transcribed into scripts for analysis. Disagreements were settled by encouraging members with differing views to give reasons for their opinions and, in some instances, establish a common ground where all the participants agree on shared experiences.

During the discussions, a list of herbaceous species was generated, and participants were requested to categorise pasture species into high, moderate, and low abundance using a participatory ranking approach as described in Ager *et al.* (2013). Similarly, participants characterised the grazing desirability of dominant grasses in terms of highly desirable, desirable, less desirable, and undesirable using the same method. The criteria used for classifying pasture abundance and desirability are presented in Appendices F and G.

Additionally, herdsmen were asked to explain whether grass composition had changed over the past 5 years by pointing out whether particular pasture species had decreased, increased, or unchanged and the likely causal factors linked to the observed situations. The description was based on an earlier study by Roba & Oba (2009), who noted that livestock herders commonly use terms such as “increasing”, “not changing” and “decreasing” to describe differences in the trend of pasture species composition.

Furthermore, with guidance from literature (Cook *et al.*, 2020), herdsmen (identified during the focus groups as more knowledgeable) worked with the facilitators to match the identified species of pastures with botanical names.

Finally, herdsmen were asked to rank in relative terms the factors affecting herbaceous species composition and diversity in the ranch.

3.6 Analysis

3.6.1 Assessment of the phytosociological parameters of herbaceous species under different grazing intensities

Data obtained through the field survey was used to compute diversity indices and consequently analysed as explained below.

Species diversity and evenness measures were determined according to Krebs (1989) as follows:

- i. S (species richness), that is, the number of species in a plot or locality, regardless of their abundance (the number of individuals or the biomass of each taxon). It was calculated as the total number of species per chosen (1 m x 1 m) quadrant (Kent & Coker 1992).
- ii. H' (Shannon-Wiener Index) or Shannon diversity index = $-\sum P_i \ln(P_i)$; p_i is the relative abundance of species i or the ratio between a number of individuals of species i and the total number of individuals of all species present in a sampling plot/locality. The higher the value of H' , the higher the diversity.
- iii. Evenness (E) = $H'/\ln S$ is an expression of the balance in the distribution of individuals among the species. Its value approaches 0 when one species is highly dominant and 1 when all species have similar densities. E is independent of the species numbers occurring on a plot.
- iv. $e^{H'}$, a measure of the number of abundant species in the sample, where H' is Shannon-Wiener index
- v. $R3=1-D$, or Gini-Simpson Index, representing the number of very important species and where
- vi. $D = \sum ni (ni - 1) / (N (N - 1))$ is the Simpson index, ni is the quantity of individual species per subplot, while N is the total quantity of species within the same plot or locality.

Significant differences in mean species richness, evenness, and Shannon diversity index between regularly grazed and minimally grazed plots for the two sites were evaluated by a non-parametric test, the Mann-Whitney U, because data failed to meet the conditions for variance of homogeneity based on Levene's test. The diversity indices were treated as dependent variables, and the grazing intensity (minimally grazed and regularly grazed) as independent variables.

To examine the effect of site location and grazing intensity on specific richness, family richness, genera richness, and species richness were regarded as the number of families or genera or species occurring in a given site location or grazing intensity type. Generalised linear models with Poisson errors (Zerbo *et al.*, 2016) were applied to analyse the effect of explanatory variables, site location, and grazing intensity on family richness, genera richness, and species richness. To account for overdispersion, penalised quasi-likelihood estimation was used (Bognounou *et al.*, 2009).

To assess the dominance of herbaceous species in the vegetation communities, frequency and dominance were converted to relative values and summed to obtain importance value index (IVI) per herd according to Chaudhry *et al.* (2006) and Dangoli & Shivakoti (2001).

Importance value index (IVI) = Relative frequency + relative dominance, or

$$IVI = (100f/F) + (100 t/T).$$

Where f is the frequency of a species, F is the sum of the frequencies of all species, t is the total cover of a species, and T is the total cover for all the species.

Data were entered into Microsoft Excel to compute phytosociological parameters and consequently analysed using SPSS version 25 for descriptive statistics and a Mann-Whitney U test, and R software (version R 4.4.1) for generalised linear regression models.

3.6.2 Assessment of the diversity of herbaceous plants under different burning intensities

Diversity indices were computed following procedures explained in section 3.6.1 above. Significant differences in mean species richness, evenness and Shannon diversity index between regularly burned and minimally burned plots for the two sites were evaluated by a non-parametric test, the Mann-Whitney U, because data did not meet the conditions of normality and variance of homogeneity (Appendix E). The diversity indices were treated as dependent variables, and the burning intensity (minimally burned and regularly burned) as independent variables.

Generalised linear models with Poisson errors (Zerbo *et al.*, 2016) were applied to analyse the effect of site location and burning intensity on family richness, genera richness, and species richness. To account for overdispersion, penalised quasi-likelihood estimation was used as per the procedures in Bognounou *et al.* (2009). Data was entered into Microsoft Excel and consequently analysed using SPSS version 25 and R software (version R 4.4.1), as in 3.6.1 above.

3.6.3 Assessment of herders' perceptions of the composition and utility value of dominant herbaceous pastures

Audio recordings from the focus group discussions were transcribed into scripts for analysis. Using an inductive qualitative approach (Thomas, 2006), all data were coded into themes and subsequently into categories, which included reasons responsible for the current state of grazing areas, herders' basis for selecting a grazing area, and land use practices perceived by herdsman as affecting the composition of natural pastures in the ranch (Appendix B). Consequently, these ranked factors (as earlier explained in section 3.5.3) were analysed by rank analysis in addition to the participants' direct quotes.

For all the ranked data, indices were calculated to analyse the ranking of individual responses. The index was calculated according to Formula (1) developed by Kosgey *et al.* (2008).

$$\text{Index} = \frac{[(N \cdot F_1) + ((N-1) \cdot F_2) + \dots + (1 \cdot F_n)]}{\Sigma[(N \cdot F_1) + ((N-1) \cdot F_2) + \dots + (1 \cdot F_n)]} \quad (1)$$

Where N=maximum level of rank, F1=frequency of the 1st rank, F2=frequency of the 2nd rank, and Fn=frequency of the last rank.

Descriptive statistics using Microsoft Excel and inductive content analysis were employed to analyse the data obtained from the research participants.

3.7 Data Quality Control (Validity and Reliability)

The focus group discussion guide and field data collection templates were pretested and the preliminary data collected was used to test for data consistency and modify the tools into valid and reliable instruments.

3.8 Ethical Consideration

Ethical approval was obtained from the Gulu University Research and Ethics Committee, under reference number GUREC-2023-506, prior to the commencement of the study. Before engaging

the herdsmen and commencing data collection, permission was sought from the Chief Administrative Officer (CAO), the Resident District Officer (RDC), the District Production Departments, and local council leaders of the study areas.

During data collection, the respondents were presented with an introductory letter from the Faculty of Agriculture and Environment in order to build their confidence to voluntarily participate in the research. They were thoroughly briefed on the purpose of the study and subsequently requested to sign the consent form upon agreeing to participate in the study. The privacy of respondents and the confidentiality of their identities were strictly ensured at any point. Also, the information obtained from the study participants was only used for academic purposes.

3.9 Limitations of the Study

Assessment of pastures was conducted at the peak of the growing season and did not take into account other factors such as seasonal dynamics, bush encroachment, and shifts in climate, all of which affect the composition of natural pastures and therefore could have had an impact on the current findings. To minimise information loss error, the discussions were interpreted to a common language (English) in addition to audio recordings (Quintanilha *et al.*, 2015).

CHAPTER FOUR: PRESENTATION OF RESULTS

4.1 Assessment of the Phytosociological Parameters of Herbaceous Species under Different Grazing Intensities

4.1.1 Relative abundance of herbaceous species in the study area

Field examination of herbaceous species revealed 17 herbaceous species belonging to 3 families and 14 genera Table 4.1. Overall, *Hyparrhenia species* and *Digitaria abyssinca* were abundant in minimally grazed areas while *Brachiaria decumbens* and *Sporobolus pyramidalis* were abundant in regularly grazed sites. Aswa Main was the most abundant with the highest number of species compared to Aswa main.

Table 4. 1: Relative abundance of herbaceous species in the study area (species abundance = % cover represented by the species)

Species			LOCATION					
Family	Scientific name	Local name	ASWA MAIN		ASWA ZEBU		MAIN + ZEBU	
			Regularly grazed	Minimally grazed	Regularly grazed	Minimally grazed	Regularly grazed	Minimally grazed
Poaceae	<i>Hyparrhenia rufa</i>	Lagang	28.14	39.44	11.86	25.2	30.03	34.07
Poaceae	<i>Hyparrhenia filipendula</i>	Ajuu	24.28	14.39	14.61	29.7	13.55	23.85
Poaceae	<i>Brachiaria decumbens</i>	Ogema	18.63	8.27	38.80	29	26.67	18.00
Poaceae	<i>Sporobolus pyramidalis</i>	Oywec dyang	13.84	4.72	4.02	0.28	8.33	2.27
Poaceae	<i>Imperata cylindrica</i>	Obiya	2.73	3.18	0.24	-	1.37	1.48
Poaceae	<i>Digitaria abyssinica</i>	Cogamacon	6.06	11.08	10.25	12.3	7.59	10.11
Cyperaceae	<i>Cyperus rotundus</i>	Lugakur	0.13	0.67	1.94	-	1.00	0.34
Poaceae	<i>Paspalum spp.</i>	na	2.13	9.37	5.09	1.13	3.36	4.83
Fabaceae	<i>Desmodium heterophyllum</i>	na	1.66	0.37	-	0.14	0.75	0.23
Fabaceae	<i>Desmodium incanum</i>	na	0.27	-	-	0.07	0.12	0.06
Poaceae	<i>Themeda triandra</i>	Abii	2.06	0.61	-	0.14	1.00	0.34
Fabaceae	<i>Centrocema pubescens</i>	na	0.07	0.37	-	-	0.06	0.18
Poaceae	<i>Cenchrus ciliaris</i>	na	-	0.67	13.07	1.98	6.09	1.08
Poaceae	<i>Cynodon dactylon</i>	Mwodo	-	0.12	-	-	-	0.06
Poaceae	<i>Eragrotis curvula</i>	Mwodo	-	-	0.034	-	0.06	-
Cyperaceae	<i>Cyperus esculentus</i>	Lugakur	-	-	0.07	-	0.02	-
Poaceae	<i>Panicum maximum</i>	Otok	-	6.74	-	-	-	3.12

4.1.2 Effect of grazing intensity on specific richness

In Table 4.2, the richness of family, genera, and species was significantly lower ($p < 0.05$) under minimal grazing than in regular grazing in Aswa Zebu, but no significant difference ($p > 0.05$) was detected in Aswa Main between the two grazing intensities. Overall, family, genera, and species richness were significantly higher ($p < 0.05$) in regularly grazed plots than in minimally grazed plots.

Table 4.2: GLM estimates of the effect of grazing intensity on specific richness

Specific richness	Location	Grazing regime		F-value	p-value
		Minimally grazed	Regularly grazed		
Family richness	Aswa Main	3	3	3.2823	0.0721
	Aswa Zebu	3	2	16.7921	0.0001*
	Main + Zebu	3	3	14.8076	0.0001*
Genera richness	Aswa Main	9	14	1.1601	0.2832
	Aswa Zebu	9	7	44.7576	<0.0001*
	Main + Zebu	12	14	16.8933	0.0001*
Species richness	Aswa Main	12	14	0.8672	0.3532
	Aswa Zebu	11	9	28.5948	<0.0001*
	Main + Zebu	15	17	13.4985	0.0003*

*Shows significant values; Specific richness = total number of species, families, and genera found in a particular location on the ranch

4.1.3 Diversity of herbaceous species according to grazing intensity

The differences in mean species numbers (S), Shannon Weiner (H'), Gini Simpson (G), and species evenness (J) between the two locations and grazing intensities are shown in Table 4.3. Mean species richness by plot (S) showed that Aswa Main was more diverse than Aswa Zebu. In Aswa Main, mean species richness was statistically significant ($p < 0.05$) between minimal and regular grazing intensities in Aswa Zebu. Considering Shannon Weiner and Gini Simpson, significant differences ($p < 0.05$) were detected between minimally and regularly grazed plots for both locations. In Aswa Zebu, the evenness index differs significantly ($p < 0.05$) between minimally and regularly grazed plots in Aswa Main.

Table 4. 3: Effect of grazing intensity on the diversity of herbaceous species on Aswa ranch

Location	Grazing regime	Mean species richness (S)	Shannon Weiner (H')	Gini Simpson Index (G)	Species evenness (J)
Aswa Main	Minimally grazed	4.40±1.19	1.15±0.27	0.63±0.10	0.80±0.10
	Regularly grazed	4.21±1.27	0.89±0.30	0.47±0.16	0.65±0.18
	<i>p-value</i>	0.35	<0.0001*	<0.0001*	<0.0001*
Aswa Zebu	Minimally grazed	3.75±1.21	1.02±0.33	0.58±0.16	0.81±0.15
	Regularly grazed	2.88±0.77	0.82±0.24	0.50±0.12	0.81±0.12
	<i>p-value</i>	<0.0001*	0.0001*	0.0002*	0.948

*Shows significant values; S = mean number of species per quadrant

4.1.4 Herbaceous species composition and dominance based on Importance Value Index (IVI)

Hyparrhenia species and *Digitaria abyssinica* were dominant in minimally grazed plots while *Brachiaria decumbens*, *Sporobolus pyramidalis*, *Paspalum spp.*, and *Cenchrus ciliaris* were dominant in regularly grazed areas (Table 4.4). *Hyparrhenia rufa* was dominant in Aswa Main, while *Hyparrhenia filipendula* and *Cenchrus ciliaris* was dominant in Aswa Zebu.

Table 4. 4: Importance value index of different herbaceous species on Aswa ranch

Species			Location					
Family	Scientific name	Local name	Aswa Main		Aswa Zebu		Main + Zebu	
			Regularly grazed	Minimally grazed	Regularly grazed	Minimally grazed	Regularly grazed	Minimally grazed
Poaceae	<i>Hyparrhenia rufa</i>	Lagang	43.06	71.94	25.12	45.04	34.09	58.49
Poaceae	<i>Hyparrhenia filipendula</i>	Ajuu	20.62	33.68	29.64	53.44	25.13	43.56
Poaceae	<i>Imperata cylindrica</i>	Obiya	7.92	11.87	2.03	-	4.98	5.93
Poaceae	<i>Brachiaria decumbens</i>	Ogema	38.45	21.02	57.07	61.06	47.76	41.04
Poaceae	<i>Sporobolus pyramidalis</i>	Oywec dyang	33.30	17.40	10.84	1.63	22.07	9.51
Cyperaceae	<i>Cyperus rotundus</i>	Lugakur	1.13	4.08	10.21	-	5.67	2.04
Fabaceae	<i>Desmodium heterophyllum</i>	na	9.77	3.14	-	1.49	4.89	2.32
Fabaceae	<i>Desmodium uncinatum</i>	na	1.53	-	-	0.50	0.77	0.25
Poaceae	<i>Paspalum spp.</i>	na	13.21	23.06	15.83	4.77	14.52	13.92
Poaceae	<i>Themeda triandra</i>	Abii	6.28	5.21	-	1.05	3.14	3.13
Fabaceae	<i>Centrocema pubescens</i>	na	0.74	1.62	-	-	0.37	0.81
Poaceae	<i>Digitaria abyssinica</i>	Cogamacon	11.23	24.20	21.39	24.09	16.31	24.14
Poaceae	<i>Cynodon dactylon</i>	Mwodo	-	1.01	-	-	-	0.51
Poaceae	<i>Cenchrus ciliaris</i>	na	-	2.86	27.06	6.92	13.53	4.89
Poaceae	<i>Panicum maximum</i>	Otok	-	8.74	-	-	-	4.37
Poaceae	<i>Eragrotis curvula</i>	Mwodo	-	-	0.39	-	0.20	-
Cyperaceae	<i>Cyperus esculentus</i>	Lugakur	-	-	0.40	-	0.20	-

4.2 Determining the Diversity of Herbaceous Species under Different Burning Intensities

4.2.1 Effect of burning intensity on specific richness

In Table 4.5, the genera and species richness were significantly different ($p < 0.01$) between minimally burned and regularly burned plots in both locations sampled. Family richness was only significant (< 0.05) in Aswa Zebu between the two burning intensities.

Table 4. 5: GLM estimates of the effect of burning intensity on specific richness

Specific richness	Location	Minimally burned	Regularly burned	F-value	p-value
Family richness	Aswa Main	3	3	2.1790	0.142
	Aswa Zebu	3	2	16.7920	$< 0.0001^*$
	Main + Zebu	3	3	1.5561	0.2132
Genera richness	Aswa Main	9	14	8.4428	0.0042 [*]
	Aswa Zebu	9	7	13.5650	0.0003 [*]
	Main + Zebu	12	14	0.0305	0.8615
Species richness	Aswa Main	12	14	7.4307	0.0072 [*]
	Aswa Zebu	11	9	18.5640	$< 0.0001^*$
	Main + Zebu	15	17	0.3180	0.5733

*Shows significant values; Specific richness = total number of species, families, and genera found in a particular location on the ranch.

4.2.2 Diversity of herbaceous species according to burning intensity

Table 4.6 revealed significant differences ($p < 0.05$) for species richness and Shannon-Wiener between minimally burned and regularly burned intensities for both locations. Unlike in Aswa Main, the Gini-Simpson index was statistically significant ($p < 0.05$) between the two burning intensities in Aswa Zebu.

Table 4. 6: Effect of burning intensity on the diversity of herbaceous species on Aswa ranch

Location	Burning regime	Mean species richness (S)	Shannon Weiner (H')	Gini Simpson Index (G)	Species evenness (J)
Aswa Main	Minimally burned	4.04±1.13	0.98±0.03	0.54±0.13	0.73±0.02
	Regularly burned	4.57±1.26	1.07±0.04	0.56±0.18	0.72 ±0.02
	P-value	0.007 [*]	0.041 [*]	0.12	0.822
Aswa Zebu	Minimally burned	3.75±1.10	1.03± 0.30	0.59±0.14	0.81±0.14
	Regularly burned	3.05±0.87	0.88 ± 0.26	0.52±0.13	0.82 ± 0.13
	p-value	$< 0.0001^*$	0.001 [*]	0.003 [*]	0.5364

*Shows significant values; S = mean number of species per quadrant

4.3 Assessing Herdsmen's Perceptions of the Composition and Utility Value of Herbaceous Pastures in Aswa Ranch

4.3.1 Abundance of herbaceous species as perceived by the herdsmen in Aswa Ranch

Findings from focus group discussions revealed 25 herbaceous species as available forage within the grazing areas in the research area (Table 4.7). The participants of the focus groups perceived *Hyparrhenia spp.*, *Brachiaria decumbens*, *Panicum maximum*, *Sporobolus pyramidalis*, and *Cynodon dactylon* as highly abundant in the study area. Likewise, *Cymbopogon afronadus*, *Eleusine indica*, *Chloris pycnorrhix*, and *Desmodium uncinatum* were some of the species reported to have low abundance.

Table 4. 7: Utility value and abundance rating by herders of herbaceous species available in the study area

Family	Scientific names	Local name	Desirability as livestock feeds	Abundance
Poaceae	<i>Hyparrhenia rufa</i>	Lagang	H	xxx
Poaceae	<i>Hyparrhenia filipendula</i>	Ajuu	H	xx
Poaceae	<i>Brachiaria decumbens</i>	Ogema	H	xxx
Poaceae	<i>Imperata cylindrica</i>	obiya	L	xx
Poaceae	<i>Panicum maximum</i>	Otok	H	xxx
Poaceae	<i>Sporobolus pyramidalis</i>	Oywec dyang	U	xxx
Poaceae	<i>Cynodon dactylon</i>	Mwodo	H	xxx
Poaceae	<i>Cymbopogon afronadus</i>	na	U	x
Poaceae	<i>Digitaria abyssinica</i>	Cogamacon	L	xx
Poaceae	<i>Cenchrus ciliaris</i>	na	D	xx
Poaceae	<i>Eleusine indica</i>	na	L	x
Poaceae	<i>Themeda triandra</i>	Abii	L	xx
Poaceae	<i>Chloris pycnorrhix</i> ,	na	L	x
Fabaceae	<i>Desmodium uncinatum</i>	na	H	x
Fabaceae	<i>Centrocema pubescens</i>	na	D	x
Poaceae	<i>Paspalum spp.</i>	na	D	xx
Poaceae	<i>Eragrostis pilosa</i>	na	D	x
Poaceae	<i>Pennisetum spp.</i>	Lagada	D	x
Commelinaceae	<i>Commelina benghalensis</i>	na	L	x
Asteraceae	<i>Bidens pilosa</i>	Labika	U	x
Poaceae	-	Pwa-pwa	L	x
Poaceae	<i>Chloris gayana</i>	Oconge	D	x
Poaceae	<i>Setaria sphacelata</i>	Alene	L	xx
Poaceae	<i>Brachiaria ruziziensis</i>	Oduny	D	xx
Poaceae	<i>Brachiaria humidicola</i>	Lacan Onyaa	D	xx

H=highly desirable, D=desirable, L=less desirable, U=undesirable, Abundance; x=low, xx=moderate xxx=high

4.3.2 Utility value of herbaceous pastures as perceived by herdsman in Aswa Ranch

4.3.2.1 Desirability of pastures and factors responsible for the current state of pastures

Herbaceous species perceived as desirable for cattle included *Brachiaria spp.*, *Panicum maximum*, *Hyparrhennia spp.*, *Desmodium uncinatum*, and *Cynodon dactylon* (Table 4.7). Conversely, species such as *Sporobolus pyramidalis*, *Cymbopogon afronadus*, and *Bidens pilosa* were perceived as undesirable for livestock grazing. A participant quoted, “Because of its tough fibrous characteristics, *Sporobolus pyramidalis* is likely to cause wearing of teeth and cracking or loss of teeth in extreme cases, reducing the feeding efficiency of animals” (FGD2).

Generally, herdsman perceive the condition of pastures in their grazing areas as favourable for optimal cattle grazing and survival. They attribute this positive state to favourable rains (0.21) and burning practices (0.19) (Table 4.8). A participant said, “In the previous years when we had longer episodes of drought, we suffered looking for good grasses for our animals, but in recent years, it has been raining well; that’s why we have enough pastures you are seeing today” (FGD1).

Table 4. 8: Factors responsible for the current state of the grazing areas

Factors	Location				Overall Index
	Aswa Main		Aswa Zebu		
	FGD1	FGD2	FGD3	FGD4	
Favourable rainfall conditions	0.12	0.39	0.16	0.17	0.21
Burning practices (1-2 times a year)	0.5	0.11	0.14	0.02	0.19
Adaptability of pastures	0.04	0.12	0.24	0.23	0.16
Long distance between kraals	0.07	0.05	0.08	0.32	0.13
Favourable soil type	0.03	0.08	0.27	0.1	0.12
Topography	0.08	0.24	0.07	0.05	0.11
Low pest populations	0.16	0.01	0.04	0.11	0.08

4.3.2.2 Herdsman’s reason for selecting an area for cattle grazing

Herdsman strategically select grazing areas for their cattle based on criteria such as the availability of palatable and nutritious pasture species, access to water, altitude, nearness to kraals, and absence of tsetse flies (Table 4.9). A respondent mentioned that “even when you unknowingly take animals to areas infested with tsetse flies, the animals will not graze and will end up escaping to other grazing areas that are devoid of the tsetse flies” (FGD 4). The decision to change grazing areas by herdsman is based on factors such as pest outbreaks, pasture growth rates, seasonal changes, depletion of pastures, and cattle behaviour.

Table 4. 9: Herdsmen's reasons for selecting an area for grazing animals

Factors	LOCATION				Overall Index
	Aswa Main		Aswa Zebu		
	FGD1	FGD2	FGD3	FGD4	
Availability of palatable and nutritious species	0.21	0.27	0.29	0.15	0.23
Access to water resources	0.17	0.19	0.13	0.19	0.17
Absence of tsetse flies	0.07	0.13	0.11	0.25	0.14
Altitude (with respect to season)	0.3	0.1	0.09	0.03	0.13
Nearness to kraals	0.07	0.13	0.18	0.1	0.12
Low weed and shrub density	0.12	0.03	0.11	0.18	0.11
Presence of shade	0.06	0.15	0.09	0.1	0.1

4.3.3 Herders' perceptions of land use practices affecting the composition of herbaceous species in Aswa Ranch

The current study revealed that, while participants generally consider grazing areas to be in good condition, they have observed significant changes in the pasture composition over the past five years. Specifically, there has been a gradual increase in the presence of *Imperata cylindrica*, *Sporobolus pyramidalis*, and *Hyparrhennia rufa*. In contrast, species such as *Centrosema pubescens* and *Panicum maximum* are reported to be diminishing. Land use practices such as grazing land use intensity, charcoal production, indiscriminate burning, proximity of dip tanks, water tanks, and kraals, and crop farming are perceived to have contributed to these changes (Table 4.10).

Table 4. 10: Land use practices affecting the composition of herbaceous species

Land use Practices	Location				Overall Index
	Aswa Main		Aswa Zebu		
	FGD1	FGD2	FGD3	FGD4	
Grazing land use intensity	0.25	0.23	0.18	0.17	0.21
Charcoal production	0.18	0.1	0.15	0.23	0.17
Indiscriminate Burning	0.12	0.14	0.1	0.28	0.16
Proximity of valley tanks, dip tank, spray race, and kraal	0.2	0.17	0.07	0.12	0.14
Crop farming (land clearance for cultivation)	0.04	0.14	0.19	0.06	0.1
Human settlement	0.12	0.05	0.13	0.06	0.09
Other infrastructural activities: electricity lines, access roads, and sand mining.	0.07	0.16	0.04	0.05	0.08
Burning for hunting	0.02	0.01	0.14	0.03	0.05

CHAPTER FIVE: DISCUSSION OF RESULTS

5.1 Assessment of the Diversity of Herbaceous Species under Different Grazing Intensities

The higher abundance of *Hyparrhenia species* and *Digitaria abyssinica* in minimally grazed areas was likely because the low disturbance under minimal grazing supported the grazing-sensitive species to grow, set seed and thrive. Likewise, the prevalence of *Brachiaria decumbens* and *Sporobolus pyramidalis* in regularly grazed areas indicated a shift in grass structure to species that are tolerant to frequent defoliation and trampling. Similarly, Kioko *et al.* (2012), reported a prevalence of grazing-tolerant and less palatable pasture species under heavy grazing regimes. Also, Atuhaire *et al.* (2018) and Egeru *et al.* (2015) reported the abundance of *Hyparrhenia species* in the semi-arid areas of Karamoja. They, however, attributed the high relative abundance of *Hyparrhenia spp.* to high total rainfall in their research area, especially during the rainy seasons. Additionally, the differences observed in the relative abundance of herbaceous species in Aswa Main and Aswa Zebu could be attributed to the grazing history between the two locations. For context, Aswa Zebu had a longer period of grazing exclusion as compared to Aswa Main. Kioko *et al.* (2012) reported that areas excluded from grazing had higher grass biomass as compared to areas continually grazed. This explains a higher occurrence of of increaser II species such as *Cenchrus ciliaris* in Aswa Zebu.

The family of Poaceae dominated the natural pastures in the study area, likely due to their ability to survive in a wide range of climatic and edaphic conditions. The current results agree with those of Agnew (2006) and Zerbo *et al.* (2016), who observed that Poaceae is among the most dominant families in savannah grasslands. The significant differences observed in family, genera, and species richness between regularly grazed and minimally grazed plots are likely that grazing intensities affect herbaceous species composition by either increasing or decreasing the dominance of specific richness. The current results contradict those of Zerbo *et al.* (2016) who found no significant differences in species richness between protected and communal areas. The high richness index observed under regular grazing is likely because regular grazing limits the dominance of a few species, hence encouraging less competitive pastures to thrive. These findings agree with those of Haarmeyer *et al.* (2010), who reported an increase in species diversity under high grazing intensity in the grasslands of South Africa.

Considering Hill's diversity indices, the findings of the present study showed that Aswa Main was more diverse than Aswa Zebu. The fact that species richness was significantly associated with grazing intensity in Aswa Zebu contradicts the findings of Adler *et al.* (2005), Eldridge *et al.* (2016), Jordan *et al.* (2022), and Yeo (2005), who found no significant relationship between species diversity and varying grazing pressure in their studies conducted in water-limited ecosystems. Conversely, Desta *et al.* (2024), Gamoun (2014), and Jawuoro *et al.* (2017) have documented significant differences between species richness and grazing intensity. The insignificant association observed between species richness and grazing intensity in Aswa Main suggests that this grassland community has more dominant species that are likely partly tolerant to the currently observed intensity of grazing.

The significant grazing effect on Shannon-Weiner and Gini-Simpson indices aligns with the findings of Rahmanian *et al.* (2020), who reported a negative effect of high grazing intensity on species diversity in the rangelands of northeastern Iran. Additionally, researchers Akhzari *et al.*, 2015 and Zhao *et al.* (2007) also confirmed that high vegetation diversity was associated with reduced grazing pressure. However, Rutherford & Powrie (2013), Saayman *et al.* (2016), and Todd & Hoffman (2009) found no significant effect of grazing on species diversity in their studies, contradicting the findings of the current study. The low evenness observed at regular grazing in Aswa Zebu is perhaps due to increased grazing pressure, which promotes the dominance of a few grazing-tolerant species, leading to the reduction in the abundance of others. A study conducted by Shu *et al.* (2022) in the degraded grassland of the Qinghai-Tibet Plateau, which revealed that an extremely high grazing intensity promotes evenness, contradicts these results. Nevertheless, the current results on the evenness index for Aswa Main are consistent with the findings of Desta *et al.* (2024), which indicated a significant relationship between evenness and grazing intensity in the Ethiopian semi-arid rangelands. The absence of a significant difference between minimally and regularly grazed plots in Aswa Main is probably due to the long history of grazing, which might have led to the dominance of herbaceous species that are tolerant to grazing, causing a significant reduction in the abundance of other species in the ecosystem. In line with the results obtained for the evenness index in Aswa Zebu, Jordan, *et al.* (2022) found no association between species evenness and grazing intensity in the USA dryland plant community.

Herbaceous vegetation analysis by IVI revealed an overall dominance of the study area by Increaser II species, which are more resistant to grazing (Kioko *et al.*, 2012) and bush burning, which is commonly practiced in the ranch. The observed higher value of *Sporobolus pyramidalis* in regularly grazed areas reflected long-term grazing stress and declining grazing value. This could be due to the defoliation and trampling effect which replaces palatable species with undesirable pastures. A link between a high abundance of these species and degraded rangelands due to grazing has been reported by Atuhaire *et al.* (2018) and Roschinsky *et al.* (2012). The presence of decreaser species such as *Cenchrus ciliaris* among the dominant species in Aswa Zebu in minimally grazed areas was probably due to the longer grazing exclusion reported for Aswa Zebu until 3 years ago, which allowed the regeneration of these species in the grazing areas. Generally, leguminous herbaceous plants were rare across the sampled areas, likely due to the burning practices practiced in the grazing areas. These results concur with those of Atuhaire *et al.* (2018) and Egeru *et al.* (2015), who attributed it to frequent disturbances by intense seasonal fires, which destroy seeds and limit seedling emergence.

5.2 Determining the Diversity of Herbaceous Pastures under Different Burning Intensities

The effect of burning intensity on specific richness, genera richness, and species richness was significantly higher in regularly burned plots than in minimally burned plots in Aswa Main. This could be so because regular burning reduces the dominance of fast-growing and dominant invasive species and woody plants, allowing a broader range of species to germinate and establish. The current results contradict the findings of Akinsoji (2013), who recorded a lower diversity index in burnt plots than in unburnt plots. Unlike the current study, grazing was not recorded as having been practiced on the author's plots, which might have played a significant role in influencing the diversity in the current study.

As for Aswa zebu, lower genera richness, species richness, and family richness values in regularly burned plots could be due to regular fires affecting fire-sensitive species, causing the dominance of fire-resistant species. Sanyaolu (2015) reported similar results for frequently burned plots in Nigeria. In their study, the authors observed that burning enhanced the dominance of certain species at the expense of the fire-sensitive broadleaved herbaceous plants. Similarly, Collins & Calabrese (2012) found higher species diversity in areas infrequently burned and grazed and the lowest diversity in frequently burned and ungrazed sites.

The differences obtained for the burning effect on diversity indices between the two locations for regularly burned and minimally burned plots might be explained by the fact that both locations have different grazing histories, with Aswa Main having had more years of disturbance than Aswa Zebu. However, as with Aswa Zebu results, Sanyaolu (2015) reported similar results in Nigeria, but contrasting findings were registered in Aswa Main.

The significantly higher result for the Gini Simpson index in minimally burned plots in Aswa Zebu implies that under minimal burning, the dominance of species is suppressed since the germination and establishment of more sensitive species is possible, allowing a more even vegetation makeup.

5.3 Assessment of the Herders' Perceptions of the Composition and Utility Value of Herbaceous Pastures in Aswa Ranch

In the assessment of herders' perceptions of abundance and utility value of pastures, most local herdsmen described the general state of the grazing areas as favourable for optimal grazing. This implies that the herdsmen viewed the available natural pastures and water resources as able to meet the dietary and water requirements of their animals. These findings, however, contradict those of a study by Mathewos *et al.* (2023) conducted in the semi-arid rangelands of Ethiopia, where pastoralists described the rangeland conditions as very poor. Analysing the factors responsible for the perceived positive state of the grazing areas revealed favourable rainfall amounts, annual burning practices, and high adaptability of pastures as the major reasons. These results support recent research by Kang *et al.* (2023), Ruvuga *et al.* (2020), and Atuhairu *et al.* (2018), who revealed that rainfall affects the species composition of natural grasslands. Moreover, Holmgren and colleagues (2006) demonstrated that rainfall variability influences the phenological parameters of natural vegetation. However, some showed no effect of precipitation on species composition, especially in situations where only a minimal variation in average rainfall occurs over time (Arévalo *et al.*, 2011).

The indication by herdsmen that bush burning promotes good rangeland conditions might be explained by the ability of fire to stimulate the growth of new palatable pastures. These findings are supported by the literature of Waiswa *et al.* (2019), who reported that “fire *reduces bush encroachment, stimulates the growth of nutritious pastures, controls pests such as ticks, and*

improves soil fertility.” Similarly, Fynn *et al.* (2004) found that burning stimulates the regrowth of native mesic grassland forb species from their underground storage tissues. In terms of adaptability, the claim that some desirable pasture species, such as *Cynodon dactylon*, *Panicum maximum*, *Brachiaria spp.*, and *Hyparrhenia spp.*, are well adapted to the ecological conditions and dominant within the ranch explains the connection between adaptability and good rangeland conditions. These are reported to be available in the grazing lands throughout the year. Additional explanations for the perceived favourable state of the grazing sites could be due to the sufficient distance (5 km apart) between grazing areas for the different kraals coupled with the current cattle grazing levels within the ranch, which did not exceed the carrying capacity of the pasture resources. The spacing ensures that cattle have enough pasture resources within their grazing areas without frequently crossing to adjacent kraals. According to Michler *et al.* (2022), cattle generally graze within a radius of 5 km around the kraals. However, study participants note that this is only sustainable when animal numbers are kept low to avoid rapid depletion of resources within individual grazing areas.

In terms of topography, the ranch was surrounded by the Aswa River, which is flanked by several streams that supply clean drinking water to the livestock throughout the year. Relatedly, access to rivers and streams was identified by Michler *et al.* (2022) as a key preference factor for livestock grazing. Lastly, respondents mentioned the absence of pests as an indicator of good pasture conditions. Similar accounts were recorded by earlier work (Ono & Ishikawa, 2020), who found that the presence of mosquitoes in the rangelands affected pasture utilisation by livestock. Local herdsman were guided majorly by the availability of palatable and nutritious pastures, access to water, and the absence of tsetse flies when selecting grazing areas. These results are in line with those of Ono & Ishikawa (2020), who noted that pastoral societies in Mongolia prioritise the availability of edible grass and easy access to drinking water when choosing grazing sites.

In the present study, herdsman emphasised that cattle instinctively avoid grazing areas with tsetse flies, preferring insect-free areas. These observations are supported by the findings of Michler *et al.* (2022), which indicate that animals tend to prefer grazing areas with a reduced presence of biting insects. Concerning altitude, the study participants acknowledge being guided by the animals’ behaviour. Notably, cattle avoided lowlands during the wet season due to waterlogging, hence, they almost entirely depended on high-altitude pastures. However, during the dry season,

when waterlogging has subsided and upland pastures have been depleted, dried, or lignified, cattle rely on the lowlands for their dietary needs. This demonstrates a distinctive adaptation to seasonal and altitudinal variations in forage availability. Further, the preference for grazing areas near the kraals by herders in the study area was for convenience and safety purposes. Respondents argued that keeping the animals closer to the kraals reduced the risk of theft, as animals could easily be managed and monitored as they graze.

Relatedly, Gusha *et al.* (2023) observed a strong association between grazing animals and anthropogenic features, such as homesteads and kraals. They argued that such areas are characterised by active green growth, suggesting access to better forage. Similar to the observation by Ono & Ishikawa (2020), herdsmen in the present study preferred cool grazing areas with ample shade for their animals during the dry season.

Regarding the decisions to change pastures, the current study showed that pest outbreaks, pasture growth rates, and seasonal changes were the primary reasons for moving to new pastures. Ulziibaatar and Matsui (2021) reported that grass and water availability, resting the pasture, and avoiding severe weather were the primary reasons for herdsmen to move to new pastures.

Based on the present findings, *Hyparrhenia spp.*, *Brachiaria decumbens*, *Imperata cylindrica*, *Panicum maximum*, *Sporobolus pyramidalis*, and *Cynodon dactylon* were identified as the most abundant species in the study area. Comparable research conducted among herdsmen in northern Uganda has similarly revealed the prevalence of *Hyparrhenia spp.*, *Cynodon spp.*, *Panicum spp.*, and *Sporobolus spp.* (Anyait *et al.*, 2023; Atuhaire *et al.*, 2018; Egeru *et al.*, 2015). Similar studies documented these species as tolerant to drought and grazing (Kioko *et al.*, 2012). Moreover, *Hyparrhenia spp.* and *Sporobolus spp.* have been identified among the most dominant grass species in East African rangelands due to their self-seeding ability and spreading capacity (Machogu, 2013; Sabiiti *et al.*, 2004).

Furthermore, *Brachiaria spp.*, *Panicum maximum*, and *Cynodon dactylon*, reported by herdsmen as abundant, were reported to have high nutritional value by several researchers (Anyait *et al.*, 2023; Heneidy & Hamly, 2009). In the current study, the report by herdsmen that *Brachiaria spp.*, followed by *Panicum maximum*, *Hyparrhenia spp.*, and *Cynodon dactylon*, were the most desirable species concurs with research by Atuhaire *et al.* (2018) and Roschinsky *et al.* (2012). In their study, Atuhaire *et al.* (2018) highlighted that *Brachiaria decumbens* was associated with high

digestibility and ability to meet cattle's minimum crude protein requirements. Contrary to the findings of the current study, Anyait *et al.* (2023) and Keba *et al.* (2013) categorised *Hyparrhenia rufa* and *Cynodon dactylon*, respectively as lower-quality pastures.

In line with the current study, Atuhairi *et al.* (2018) and Roschinsky *et al.* (2012) identified *Sporobolus pyramidalis* and *Cymbopogon afronadus* as undesirable species in their research. Participants in the present study argued that these grass species could cause injuries to the animals' teeth and mouth and outcompete desirable pasture species. The present study's findings also reveal a gradual increase in *Imperata cylindrica*, *Sporobolus pyramidalis*, and *Hyparrhenia rufa* and a decrease in *Panicum maximum* and legume species such as *Centrosema pubescens*. These results present several implications; Firstly, the increase of *Sporobolus pyramidalis* likely implies that the grazing value of the grazing land in the study area was diminishing. This observation is supported by the findings of Roschinsky *et al.* (2012) in western Ankole, who argued that these *Sporobolus* species are associated with areas undergoing intensive stress due to grazing. Notably, intensive grazing directly shifts the composition of plant communities selectively towards less palatable pastures with low nutrition value (Metera *et al.*, 2010; Wan *et al.*, 2015). Secondly, the increase in *Hyparrhenia rufa* and *Imperata cylindrica* could be due to their resilience to drought (Roschinsky *et al.*, 2012) and annual fires (FAO, 2014). Additional studies (Butler *et al.*, 2021; Pathak *et al.*, 2018) that support the present observations revealed that *Imperata cylindrica* resprouts rapidly and thrives in frequently burned areas owing to its extensive rhizome structure (Howard, 2005; MacDonald, 2004). Thirdly, the reduction of palatable and highly nutritious species such as *Panicum maximum* and legume species probably points to increasing degradation of the grazing areas. Similarly, Roba & Oba (2009) noted that rangelands experiencing degradation tend to lose palatable grass species, which are subsequently replaced by unpalatable species.

Also, consistent with the current study, earlier research by Atuhairi *et al.* (2018) and Egeru *et al.* (2015) in Karamoja sub-region revealed low or absence of legume pasture species across the study sites. These authors attributed this pattern to uncontrolled annual fires, which are characteristic of the sub-region. The observed shift in vegetation composition within the Aswa ranch is likely to negatively affect the nutritional intake of livestock. Therefore, without proactive measures to curtail the probable declining grazing value, this could potentially hinder both the growth and reproductive rates of grazing animals.

Regarding herders' perceptions of land use practices affecting the composition of herbaceous species, participants identified grazing, indiscriminate bush burning, charcoal production, crop farming, and proximity of dip tanks, water tanks, and kraals as the primary factors influencing the composition of pastures in the study area. These findings are consistent with earlier research (Azadi *et al.*, 2009; Briggs *et al.*, 2002; Collins & Calabrese, 2012; Johnson & Matchett, 2001; Richard Geoffrey Lechmere-Oertel, 2003; Roques *et al.*, 2001) that emphasised fire and grazing as key factors influencing the composition of vegetation in natural grasslands. Likewise, among the human-induced factors mentioned by respondents in a study by Ulziibaatar & Matsui (2021) in Mongolia were mainly overgrazing (91%) and reduced herding mobility (92%).

The report by herdsmen that herbaceous species were majorly impacted by grazing is likely because intense grazing pressure limits the capacity of palatable grasses and legumes to produce and disperse seeds, thereby enabling the less palatable ungrazed plant species to thrive and set seed (Bhasin, 2011). The participants reported that heavily grazed areas were associated with undesirable pasture species such as *Sporobolus spp.* and a low abundance of desirable species. The findings corroborate previous studies by Angassa (2012) and Angassa & Oba (2008). Likewise, undergrazed areas were associated with thick bushes and tsetse flies. A participant mentioned that “*Animals always avoid grazing in thick bushes and tsetse fly infested areas, and even when driven to such places, they only move through or change direction to favourable grazing grounds.*” (FGD 1) According to Metera *et al.* (2010), undergrazing is associated with less stimulation and gradual loss of grazing-dependent endemic grasses and legumes. This is because undergrazing may promote the expansion of bush encroachment, which likely suppresses the proliferation of palatable understory herbaceous species, especially in the absence of fire.

Regarding bush burning, herdsmen evaluated its impact on its ability to clear bushes and promote the sprouting of new fresh nutritious grass at the onset of the rainy season. This was probably because the area was usually subjected to fire annually. However, it was difficult to attribute vegetation change to fire alone. What is clear in the current results is that the dominant species in the ranch were reported in studies as resistant and prevalent in fire-treated ecosystems. Drawing from a recent study that compared burned and unburned sites, Munyai *et al.* (2023) confirmed differences in grass species composition between the two sites investigated. In their study, the authors confirmed higher moribund material and unpalatable species in fire-treated sites than in

burned areas. Collins & Calabrese (2012) also reported higher species diversity in areas infrequently burned and grazed and the lowest diversity in frequently burned and ungrazed sites, further indicating the effect of burning on species composition and diversity.

When asked about the influence of charcoal production and crop cultivation on pastures, herdsmen revealed that these practices reduce the area for cattle grazing, thereby limiting options for livestock feeding. Specifically, herdsmen were inconclusive on how vegetation changes occur in areas where charcoal production is rampant. Hence, further research using long-term field experiments could investigate how charcoal production alters species composition. However, given that charcoal production involves cutting trees and shrubs, one may suggest that reducing upperstory vegetation may promote light penetration and proliferation of understory species that are sensitive to excessive shade. Nevertheless, in situations where this practice leads to excessive soil compaction, exposing the soil to erosion, the regeneration and composition of vegetation may be significantly affected.

In line with the present findings, the impact of dip tanks, water tanks, and kraals on the composition of pasture species has been widely discussed elsewhere (Egeru *et al.*, 2015; Jawuoro *et al.*, 2017; Shahriary *et al.*, 2012). The present observations point to the prevalence of *Sporobolus species* and *Cynodon dactylon* around kraals, dip tanks, and water tanks. As per Jawuoro *et al.* (2017), vegetation in the vicinity of piospheres is associated with reduced species diversity and low nutritive value and tolerant to intense grazing. The authors asserted that excessive defoliation and trampling around piospheres hampers seed germination and slow down plant regeneration after grazing, hence lowering species diversity and composition. These observations are further supported by Angassa *et al.* (2012), who reported that increasing water points in the rangelands was associated with the loss of native species.

CHAPTER SIX: CONCLUSION AND RECOMMENDATION

6.1 Conclusions

High grazing intensity reduced species diversity of natural pastures and the rangelands in such areas were associated with higher proportion of unpalatable *Cynodon dactylon* and *Sporobolus pyramidalis*. Additionally, grazing tolerant species dominated the grazing areas as demonstrated by the importance value index values. Legume species had the lowest importance value index values.

Additionally, regularly burnt areas were associated with higher species diversity and richness in all areas of the ranch studied.

Herdsmen perceived *Brachiaria decumbens*, *Panicum maximum*, *Hyparrhennia spp.*, and *Cynodon dactylon* as the most desirable species present in the grazing areas, while *Sporobolus pyramidalis* and *Cymbopogon afronurdus* were regarded undesirable. Also, herdsmen reported a gradual decline in palatable species and an increase in grazing tolerant and fire-resistant plant species. Grazing and burning intensities were listed by herdsmen as the primary factors affecting the composition and diversity of plant species in the study area.

6.2 Policy Recommendations

The management of the ranch should adopt an incremental restoration strategy involving phased oversowing combined with rest periods and proper rotational grazing management to facilitate natural pasture regeneration, increase species richness and evenness. Legume species should also be incorporated into the restoration strategy to improve nutritive value of the pastures.

Additionally, to lessen the damaging effects of uncontrolled fires on pastures, local herdsmen should implement regulated biannual bush burning which was seen to support higher species diversity.

6.3 Recommendation for Further Research

Establishing a trend in the seasonal variation species composition of natural pastures under different grazing intensities would be an important part of the longitudinal study spanning over at least 2–4 seasons. Such a long-term investigation was not possible with the present study but would be needed to assess the pasture dynamics (trend, species diversity, and abundance) as influenced

by interaction effects of grazing, climatic, and anthropogenic factors. Additionally, this can be instrumental in early identification of emerging invasive and weedy as well as low-utility value species.

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APPENDICES

Appendix A1: Sample of Data collection tool (English)

Version 3.0

FOCUS GROUP DISCUSSION GUIDE

Anthropogenic factors affecting herbaceous species composition

Dear respondents,

The information obtained from you in this group discussion is purely for academic purposes and will be treated with the confidentiality it deserves.

Respondent ID.....District.....

Parish.....Village.....Date.....

...

QUESTIONS

1. How do you rate the present state of your pastures? How has it been if it has not been so always?
2. What factors contribute to the condition of pastures you graze your animals?
3. How do you graze your animals? (Probes: communal grazing land, individual grazing area, fenced, open
4. How is it ensured that the grazing area always has fresh grass? (probes: rotational, resting, burning, weed control, control of bush/shrub encroachment), how is communal grazing area jointly managed?
 - a. If burning is mentioned, what are the reasons? What's the burning cycle, which months? Is it every year? What proportion of grazing land is burned?
 - b. If rotational grazing is mentioned, how long is the rotational cycle?
5. What are the 5 most dominant pasture species on your grazing grounds?

6. Mention 5 pasture species in your grazing land which are liked most by animals (ranked by descending order)

7. In your own opinion, what can be done to improve the condition of natural pastures and boost productivity of your animals?

Appendix A2: Data collection tool (Luo)

Version 3.0

Tic dano timo ma tye ka balo kwayi lum in ikin ping

Apwoyo lagam lok man,

Ngec ma wabi nongo ne kibot in i nywako tam man bi keme ki lok me kwan keken ki bene wa bi neno ni wagwoko obedo mwung ki ma wawinye kwede.

Lanyut pa lagam lok.....

Districk.....

Ter rwot kweri me/parish.....Caro.....Nino
dwer.....

LAPENY

1. Itamo ningo ikom kit ma ka cam pa dyangi ni tye kwede? Bedo kuman jwi?

2. Peko angoma miyo kit cam pa dyangi bedo kuman?

3. Kit angoma ipito ki dyangi? (iyi adwol dyangi palwak? Iyi adwol pa ngat acel aceladwol magi celo?, onyo ka mo keken?

4. Ngo ma itimo owek cam pa dyangi obed nyen jwijwi? Peny ka iloko adwol aloka?, onyo iweko adwol dyangi ywee?, onyo iwango wek olot manyen?, onyo idoyo? Onyo iputu yen ma dyangi pe camo?), yoo angoma ogwoko adwol palwak kacel maber?

a. Ka ce wango adwol owace, pingo gi wango lum?, dwe mene ma gi maro wango iye lum, kiwango imwaka weng? Kiwango marwom kwene?

- b. Ka loko adwol aloka owace, tero kare marwom kwene ka giloko dyangi?
5. Kit cam abic mene manonge i adwol pa dyangi?
6. Waci wit cam abic ma dyangi maro I adwol.
7. I tammi, ngo ma kiromo timone me loko kit cam i adwol dyangi me wek omed kero pa dyangi?

Appendix A3: Data collection tool for vegetation survey

Version 2.0

FIELD DATA COLLECTION TEMPLATE

DETERMINATION OF PASTURE SPECIES COMPOSITION AND DIVERSITY

District.....Parish.....Village Date.....

Plant species (n)	Number of quadrants employed in the study															Number of quadrants in which the species is present(N)	Percentage of frequency (F=N/Q x100)
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV		
A																	
B																	
C																	
D																	
E																	

Appendix B: Coding of transcripts from focus group discussion in a study conducted in Pader in 2022

Extracts from transcripts	Primary codes	Themes	Categories
The condition of our pastures was not in good state in the past because of drought. Grasses are in good condition and abundant throughout the year because of the good rains experienced in the last two years	Favourable Rainfall	Favourable rainfall contributes to good pastures in the grazing areas.	Factors responsible for the current state of the grazing areas.
Burning clears overgrown bushes and gives way for fresh grass. Burning is used to control bush encroachment Burning eliminates diseased pastures. Burning supports the growth of some species, such as spear grass in the grazing areas.	Burning practices	Burning practices practised once or twice a year (1-2 times) improve the pasture conditions.	
Pastures such as Hyparrhenia spp. are abundant in the grazing areas because they do well on such soils.	Adaptability of pastures	The pastures are well suited to the climatic and edaphic conditions in the grazing areas.	
Each kraal has been allocated grazing areas which are considered sufficient to supply pastures to the animals per Kraal location. The distance between the grazing areas per Kraal reduces competition for pasture resources.	Grazing areas	The long distance/sufficient pasture areas allocated per Kraal reduces competition/strain on the resources.	
The ranch is surrounded by river Aswa and several water streams. Animals can access water throughout the year	Topography	The topography of the ranch supports continuity of grazing throughout the year.	
There is a variety of species because of the soil types. The soil types are different from upland to low land and support different pasture species	Favourable soil types	The soil types support a variety of pasture species in the grazing areas	
Pest infestations are low Animals do not like grasses infested with pests Animals avoid pest infested grasses	Low pest populations	Low pest populations in the grazing areas allows maximum utilization of pastures.	

Animals prefer fresh green grass Animals follow the path of fresh green and abundant grass Animals will consume palatable grasses before the less palatable ones. Survey areas with fresh and good grass before shifting from one grazing area to another.	Availability of palatable and nutritious species	Animals often take the direction of palatable and nutritious species	Reasons for selecting areas for grazing animals
Consider water access before taking animals to graze.	Access to water	Priority is given to grazing areas where water access is possible.	
Tsetse flies can bite animals and interfere with their utilization of pastures Tsetse flies are normally in areas where there are thick bushes	Absence of tsetse flies	Animals avoid places where there are tsetse flies	
Lowlands are waterlogged during the rainy seasons Animal movement is difficult in the lowlands during the rainy season Animals mainly concentrate their grazing on uplands Animals deplete pastures on uplands during the wet seasons Waterlogging in lowlands reduces in the dry seasons Animals have access to fresh green grass in the lowlands during the dry season	Altitude (with respect to seasons)	Animals can access palatable grasses in the wet season on uplands and in the dry season in lowlands	
Prefer grazing animals near their respective kraals for easy monitoring. Grazing near kraals reduces on cases of theft	Nearness to kraals	Animals are better monitored and protected near Kraals	
Areas with weeds are not good for animal grazing Areas with shrubs do not have good quality pastures for grazing	Low weed and shrub density	Areas with low weeds and shrubs are good grazing grounds.	

Animals prefer grazing areas with some shade	Presence of shade	Cool grazing areas with shade are comfortable for animals especially during the dry season	
Over grazed areas have poor pasture species such as <i>Sporobolus pyramidalis</i>	Grazing land use intensity		Land use practices affecting the composition of natural pastures
Burning charcoal reduces area for grazing Areas where charcoal is burnt are prone to trampling and may affect	Charcoal production	Charcoal production can affect pasture composition due the trampling effect.	
Pasture composition improves with distance away from the farm infrastructure. Intense trampling and overgrazing Pastures are less palatable and have low nutritive value Excessive defoliation	Proximity of valley dams, dip tanks, spray race and Kraal	The presence of valley dams, dip tanks, spray race and kraals influence pasture composition	
Farming reduces area for grazing Some pastures are abundant in cultivated areas compared to others.	Crop farming	Crop farming influences pasture composition and diversity	
Human settlements reduce grazing areas The intensity of grazing is high on the remaining grazing grounds	Human settlement		
The creation of electricity lines, access roads interfere with pasture species composition The areas where these activities are carried by species resistant to trampling. Pasture composition changes as one moves away from areas of intense activities	Other infrastructural activities: electricity lines, access roads, sand mining	Pastures in the vicinity of infrastructural activities face intense pressure due to trampling	
Hunters looking for “anyeri” burn pastures The burning intensity depends on the demand for “anyeri”	Burning for hunting	Burning can support proliferation of fire-resistant species	

Appendix C: Community Engagement Plan

Version 2.0

Community Engagement Plan

The key community stake holders to be involved include; District Agricultural/ Extension Officers, Sub- County/parish chiefs and LC1 Chairpersons.

The research team will include the following;

- The research project leader: I will train the research team, oversee the activities and provide all necessary assistance to ensure success of the project.
- Supervisor (one); he/she will provide maximum guidance on the tool and all relevant support for enumerators to ensure that timely and quality data is collected.
- Research assistants; a maximum of 2 research assistants and 1 facilitator will be recruited to aid the data collection exercise and the focus group discussions respectively.

Pre-study activities; community mapping to help in resource coordination; identifying and consulting with the relevant key stakeholders, meeting with local/community leaders, identifying the values and norms of the community, recruitment, training and introduction of the research team to the community, mobilization of the target audience, community sensitization and formative consultations all of which will set a good foundation for implementation.

Study Implementation activities; continuous consultation with the relevant key stakeholders, community sensitization about the ongoing research project; organizing the community for participation in the research project as key respondents. Community members who are conversant with the study area will be recruited to aid in selection of sampling plots during the transect walks. Experienced cattle and/or goat farmers of the same parish will also be organized to participate in the focus group discussions. Data collection and compilation will be conducted by the research team. Study participants will be rewarded for their time committed towards the study.

Post-study activities: these will include feedback and dissemination of study findings, discussion of application of study results with host community and other relevant key stakeholders.

Appendix D1: Sample of Informed Consent Document (English)

Version 2.0

INFORMED CONSENT DOCUMENT

Title of the study: Impact of rangeland use on herbaceous species composition and diversity of natural pastures in Gulu and Kitgum districts

Investigator(s): Waiswa Caleb Institution: Gulu University

Introduction

I am Waiswa Caleb, a student of Gulu University pursuing Master of Science in animal production and marketing. I am currently conducting a study on the impact of rangeland use on herbaceous species composition and diversity of natural pastures in Gulu and Kitgum districts. I hereby request for your support towards the completion of this study. This informed consent explains the study to you. After the study has been explained, any questions you may have are answered, and you have decided to participate in the study, you will be asked to sign a consent, which you will be given a copy to keep.

Sponsors of the research project

This research project is funded by the research investigator.

Purpose

The study seeks to assess the impact of rangeland use herbaceous species composition and diversity of natural pastures in Gulu and Kitgum districts. The findings of this study will add to the body of knowledge available on herbaceous species composition and diversity for northern

Uganda, guide policy makers in the design of localized programs like introduction of new pasture species important in improving livestock productivity.

Procedures

Your participation in this study will involve contribution of your views in an hour's focus group discussion on the management and pasture composition of grazing land in your area. You will also be requested to guide the researchers during the identification of sampling sites.

Who will participate in the study?

You have been chosen to participate in this study because of your experience and involvement in livestock grazing in this area. The transect walks and focus group discussions will take not more than an hour of your time. About 10 participants will be required for each focus group discussion.

Risks/discomforts

There is no foreseeable risk of harm or discomfort that will arise from your participation in this study. The only risk or discomfort will be the inconvenience in terms of time spent during the interview.

Benefits

All the information which will arise out of this research will be compiled into a report and the findings and recommendation will be availed to the research participants. A statement that research participants will get feedback on findings and progress of the study, and that any new information that affects the study participants (including incidental findings) will be made available to research participants.

Confidentiality

Your identity will not be revealed to any one as we shall only use codes to identify participants. Information obtained will only be accessible by the research team. Soft copies of the data will be protected by password and hard copy files will be kept under lock and key. Confidential information will only be accessed by the principal investigator.

Alternatives

You do not have to participate in this study if you are not interested. You will not lose any benefit in case of no participation.

Cost

There will not be any additional cost incurred as a result of participating in this study.

Questions

If you have any questions related to the study as a research participant, you can contact the principal investigator, Waiswa Caleb on telephone number 077420302 or via email on calebwaiswa@gmail.com.

Statement of voluntariness

Participation in the research study is voluntary, and you may join on your own free will. You have a right to withdraw from the study at any time without penalty. If you have any issues pertaining to your rights and participation in the study, please contact the Chairperson, Gulu University Research Ethics Committee, Dr. Gerald Obai Tel: No., 0772305621; email: lekobai@yahoo.com/lekobai@gmail.com; or the Uganda National Council for Science and Technology, on plot 6 Kimera Road, Ntinda, Kampala on Tel 0414705500.

Statement of consent

I hereby declare that the researcher has described to me what is going to be done, the risks, the benefits involved and my rights as a participant in this study. I understand that my decision to participate in this study will not affect me in any way. In the use of this information, my identity will be concealed. I am aware that I may withdraw at any time. I understand that by signing this form, I do not waive any of my legal rights but merely indicate that I have been informed about the research study in which I am voluntarily agreeing to participate. A copy of this form will be provided to me.

Name of participant.....Signature/Thumbprint.....Date

.....

Name of witness..... Signature.....

Date.....

Name of interviewer..... Signature

.....Date.....

Appendix D2: Sample of Informed Consent Document (Luo)

Version 2.0

KARATAC ME YEYO IYONGE NIANG

Wilok me gin kweda: Adwogi me tic ki olet ikom kwayi lum cam mapatpat pa lee ii Gulu kii

Kitgum

Lakwed : Waiswa Caleb

Gang pwonye: Gulu University

Nyute

An Waiswa Caleb latin kwan me Gulu University matye ka timo irwom me degree me aryo

igwoko lee kicato. An ikare man atye ka timo kwed ikom tic ki olet ki kwayi cam mapatpat pa

lee ii Gulu kii Kitgum. An dong alego konyi me wek atyek kwed eni. Waraga me yeyo tito boti

kwed man. Iyoo nge titi maber kwed man ajolo lapeny mo keken ma itye kwede, kit ma in dong iyee me bedo but kwed man, abilegi me keto cingi ikaratac man me yeyo, karatac man acel bidong boti.

Lacul pi kwed man

Ngat matye kaculo pi kwed man en aye obedo ngat matye katimo kwed ni.

Tyen lok

Kwed man tye me niang matut ikom adwogi me tic ki olet ikom kwayi lum cam mapatpat pa lee ii Gulu kii Kitgum. Adwogi me kwed man obimedo ngec madong tye ikom kwayi lum cam mapatpat pa lee pi komalo me Uganda, konyo lumok cik me yubo gin atima i adwol macalo kelo kwayi lum manyen ma pirgi tek me medo kero pa lee.

Yoo me tic

Bedo ni ibut kweda man obibedo miyo tammi inywako ikom kit me tic ki olet i adwoli. Ki bilegi me konyo lukweda ikare me nongo kabedo me timo kweda.

Anga ma obibedo ikweda man?

Kiyero me bedo ibut kweda man pi ngec ma itye kwede ikit me dwoko lee idwol man. Wot iolet ki nwako tam pe bitero wang cawa ni makato acel.dano maromo aboro bimate inwako tam idul acel acel.

Peki maromo ngole/ jami maromo weko pe iwinyo maber

Pe tye peko mo onyo jami matyero time marac mabi aa ibedo pa in ibut kwed man. Gin matwero time marac aye cawani ma gibitiyo kwede ikare me gamo lapeny.

Ber pa kwed man

Ngec ma obi aa ki ikwed man kibi guru doge kacel ki adwogi ne kibimiyo ki jo ma gubedo ibut 2

kwed man. Ngec mo keken manyen ma gudo kom ngat ma obedo ibut kwed man kibi weko ngee ne bote.

Mung

Pe wa biweko ingene bot ngat mo keken macalo wabi tic ki namba me ngeno jo ma watiyo kwedgi. Ngec ma wa nongo jo matwero nongo ne aye jo ma gubedo ibut kwed man keken. Ngec ma pire tek lakwed madit keken aye twero nongo ne.

Yoo mukene

Pe myero ibed ibut kwed man ka ipe kimiti iye. Pe ibi rwenyo gi mo maber pi bedo pe ni ibut kwed man

Acara

Pe ibimedo kit acara mo keken pi bedo ni ibut kwed man.

Lapeny

Ka itye ki lapeny mo keken malube ki kwed man iromo goyo cim bot Waiswa Caleb inamba

0777420302 onyo ki e-mail **calebwaiswa@gmail.com**. **Lok me dyere**

Bedoni ikwed man obedo dyere. Itwero bedo iye imiti ni. Itye ki twero me weko bedo ikwed man labongo pwod mo keken.

Ka itye ki lok mo malube ki tweroni ikwed goo cim bot won kom maloyo kwed i Gulu

University Doktor Gerald Obai inamba cim **0772305621** onyo ki e-mail:

lekobai@yahoo.com/lekobai@gmail.com; or the Uganda National Council for Science and

Technology, on plot 6 Kimera Road, Ntinda, Kampala on Tel **0414705500**.

Lok me yeyo

An ayaro atyer ni lakwed otita ngo ma obitime, peki maromo ngole, ber ma wa binongo iye ki twero na macalo ngat ma obibedo ibut kwed man. Aniang ni moko tama me bedo ikwed man pe

bitimo gin mo keken. Itic ki ngec man, lok koma bibedo imung. Atye ki ngec ni atwero aa icawa
mo keken. Aniang ni teko cinga I karatac man pe nyuto ni ajalo twero na ento kitita aniang ikom
kwed man ci aye dyere. Karatac man kibi mina adong kwede bene.

Nying lagam lok..... cing/ko cing.....Nino
dwe.....

Nying pa caden.....Cing/ko cing.....Nino
dwe.....

Nying lapeny tam Cing Nino
dwe.....

Appendix E: Test Of Homogeneity of Variances based on Levene Test

E1: Levene test results for diversity indices of herbaceous species according to grazing intensity in Aswa Main.

Test of Homogeneity of Variances					
		Statistic	df1	df2	Sig.
SPECIES RICHNESS	Based on Mean	0.100	1	148	0.752
	Based on Median	0.147	1	148	0.702
	Based on Median and with adjusted df	0.147	1	147.972	0.702
	Based on trimmed mean	0.079	1	148	0.779
SHANNON INDEX	Based on Mean	0.996	1	148	0.320
	Based on Median	0.798	1	148	0.373
	Based on Median and with adjusted df	0.798	1	143.218	0.373
	Based on trimmed mean	0.972	1	148	0.326
SPECIES EVENNESS	Based on Mean	28.851	1	148	0.000
	Based on Median	25.430	1	148	0.000
	Based on Median and with adjusted df	25.430	1	117.011	0.000
	Based on trimmed mean	29.128	1	148	0.000
GINI-SIMPSON INDEX (G)	Based on Mean	12.197	1	148	0.001
	Based on Median	12.218	1	148	0.001
	Based on Median and with adjusted df	12.218	1	128.947	0.001
	Based on trimmed mean	12.249	1	148	0.001

E2: Levene test results for diversity indices of herbaceous species according to grazing intensity in Aswa Zebu.

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
SPECIES RICHNESS	Based on Mean	18.687	1	148	0.000
	Based on Median	14.255	1	148	0.000
	Based on Median and with adjusted df	14.255	1	132.115	0.000
	Based on trimmed mean	18.783	1	148	0.000
SHANNON INDEX	Based on Mean	8.079	1	148	0.005
	Based on Median	7.770	1	148	0.006
	Based on Median and with adjusted df	7.770	1	134.688	0.006
	Based on trimmed mean	7.857	1	148	0.006
SPECIES EVENNESS	Based on Mean	3.496	1	148	0.063
	Based on Median	1.714	1	148	0.192
	Based on Median and with adjusted df	1.714	1	131.993	0.193
	Based on trimmed mean	2.834	1	148	0.094
GINI-SIMPSON INDEX	Based on Mean	5.519	1	148	0.020
	Based on Median	3.840	1	148	0.052
	Based on Median and with adjusted df	3.840	1	133.220	0.052
	Based on trimmed mean	4.872	1	148	0.029

E3: Levene test results for diversity indices of herbaceous species according to burning intensity in Aswa Main.

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
RICHNESS	Based on Mean	2.319	1	148	.130
	Based on Median	1.824	1	148	.179
	Based on Median and with adjusted df	1.824	1	141.962	.179
	Based on trimmed mean	2.507	1	148	.115
SHANNON	Based on Mean	3.644	1	148	.058
	Based on Median	3.574	1	148	.061
	Based on Median and with adjusted df	3.574	1	135.658	.061
	Based on trimmed mean	3.641	1	148	.058
EVENNESS	Based on Mean	.409	1	148	.524
	Based on Median	.099	1	148	.754
	Based on Median and with adjusted df	.099	1	133.657	.754
	Based on trimmed mean	.212	1	148	.646
G	Based on Mean	7.053	1	148	.009
	Based on Median	4.223	1	148	.042
	Based on Median and with adjusted df	4.223	1	124.767	.042
	Based on trimmed mean	5.891	1	148	.016

E4: Levene test results for diversity indices of herbaceous species according to burning intensity in Aswa Zebu.

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
RICHNESS	Based on Mean	6.708	1	148	.011
	Based on Median	5.895	1	148	.016
	Based on Median and with adjusted df	5.895	1	144.157	.016
	Based on trimmed mean	7.672	1	148	.006
SHANNON	Based on Mean	.712	1	148	.400
	Based on Median	.696	1	148	.405
	Based on Median and with adjusted df	.696	1	144.315	.405
	Based on trimmed mean	.668	1	148	.415
EVENNESS	Based on Mean	.000	1	148	.996
	Based on Median	.019	1	148	.891
	Based on Median and with adjusted df	.019	1	142.815	.892
	Based on trimmed mean	.002	1	148	.961
G	Based on Mean	1.222	1	148	.271
	Based on Median	.964	1	148	.328
	Based on Median and with adjusted df	.964	1	143.800	.328
	Based on trimmed mean	1.022	1	148	.314

Appendix F: Criteria used by participants for placing pastures into the different abundance categories

Abundance Category	Definition (for FGD participants)	Frequency or cover percentage (a modification from Zerbo <i>et al.</i> , 2016)
High Abundance	Seen in most grazing areas across the ranch. Appears in dense patches or nearly continuous stands.	Species with $\geq 50\%$ cover or frequency $\geq 50\%$.
Moderate Abundance	Found in several grazing areas in the ranch but not dominant. Intermittent patches or scattered distribution	$25 \leq 50\%$ cover or frequency of $25 \leq 50\%$
Low Abundance	Seen only in few places, rare in the grazing areas. Present as isolated individuals or small patches	$<25\%$ cover or $<25\%$ frequency

Appendix G: Criteria used by participants for categorising the desirability of pastures.

Desirability Category	Definition for FGD Participants	Criteria based on a modification of USDA, 2020
Highly Desirable	They are well-adapted to the site, readily consumed, persistence, and provide high tonnage and quality. Animals eagerly seek and consume this grass. Always grazed first and completely.	Highly palatable, nutritious, tender, high digestibility and CP content.
Desirable	Often eaten, especially when young and green. Less preferred than highly desirable species. Provides moderate animal performance.	Good palatability, moderate nutrients, but may be less preferred in mature stages.
Less Desirable	Species that are grazed reluctantly or only when preferred grasses are scarce. They may be fibrous, low in nutrients, or difficult to digest. Coarse or tough. May lead to lower animal productivity.	Low palatability, fibrous, or nutrient poor; selectively avoided when better forage is available.
Undesirable	Avoided by animals unless forced. Can cause illness or has thorns/toxins. May dominate and suppress good grasses.	Unpalatable, toxic, invasive, or harmful; little/no feed value, may cause undesirable effects when eaten.

Appendix H: Clearance from Gulu University Research Ethics Committee (GUREC)

GULU UNIVERSITY

P.O. Box 166, Gulu (U)
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Email: gurec@gu.ac.ug

Tel: +256 471 432 096
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Mob: +256 772 305 621
+256 776 812 147

RESEARCH ETHICS COMMITTEE

To: CALEB WAISWA 02/09/2023

GULU UNIVERSITY
0777420302

Type: Initial Review

Re: GUREC-2023-506: IMPACT OF RANGELAND USE ON HERBACEOUS SPECIES COMPOSITION AND DIVERSITY OF NATURAL PASTURES IN GULU DISTRICT

I am pleased to inform you that at the **102nd** convened meeting on **18/05/2023**, the Gulu University REC meeting voted to approve the above referenced application.

Approval of the research is for the period of **02/09/2023** to **02/09/2024**.

As Principal Investigator of the research, you are responsible for fulfilling the following requirements of approval:

1. All co-investigators must be kept informed of the status of the research.
2. Changes, amendments, and addenda to the protocol or the consent form must be submitted to the REC for review and approval **prior** to the activation of the changes.
3. Reports of unanticipated problems involving risks to participants or any new information which could change the risk benefit: ratio must be submitted to the REC.
4. Only approved consent forms are to be used in the enrollment of participants. All consent forms signed by participants and/or witnesses should be retained on file. The REC may conduct audits of all study records, and consent documentation may be part of such audits.
5. Continuing review application must be submitted to the REC **eight weeks** prior to the expiration date of **02/09/2024** in order to continue the study beyond the approved period. Failure to submit a continuing review application in a timely fashion may result in suspension or termination of the study.
6. The REC application number assigned to the research should be cited in any correspondence with the REC of record.
7. You are required to register the research protocol with the Uganda National Council for Science and Technology (UNCST) for final clearance to undertake the study in Uganda.

The following is the list of all documents approved in this application by Gulu University REC:



A rectangular blue stamp from Gulu University Research Ethics Committee. It contains the text: 'GULU UNIVERSITY RESEARCH ETHICS COMMITTEE APPROVED UNTIL' followed by a red date stamp '02 SEP 2024' flanked by two stars. Below this, it says 'FACULTY OF MEDICINE' and 'P. O. Box 166, Gulu'.

No.	Document Title	Language	Version Number	Version Date
1	Protocol	English	3.0	2023-09-01
2	Data collection tools	English	3.0	2023-09-01
3	Data collection tools	English	2.0	2023-08-09
4	Data collection tools	Luo	2.0	2023-08-09
5	Informed consent form for the recruitment of research participants	Luo	2.0	2023-08-09
6	Informed consent form for the recruitment of research participants	English	2.0	2023-08-09
7	Covid 19 management plan	English	2.0	2023-08-09

Yours Sincerely

Julaina A. Obika

Julaina A. Obika (PhD)
For: Gulu University REC



Appendix I: Plagiarism check copy

7/9/25, 7:47 AM

Turnitin - Originality Report - WAISWA CALEB_ DISSERTATION 08-07-2025 -1.docx

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< 1% match (student papers from 09-Aug-2023)	