

RESEARCH REPORT

THE IMPACT OF NON-SELECTIVE-GRAZING ON RANGELAND ECOLOGY

FARM: VAN ROOYENSWONING

2019 - 2024

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SUMMARY

The pivotal role of grazing management in shaping rangeland conditions has been widely acknowledged in numerous studies within the field of rangeland management. The concept of non-selective-grazing, pioneered by Acocks (1996) and Goodloe (1969) and further developed by Savory, Zietsman, and Lund, has emerged as both widely popular and controversial in grazing management. Non-selective-grazing aims to increase stocking density while preserving rangeland durability. Despite limited research on its ecological impact, non-selective-grazing holds the potential for significant rangeland improvements.

In this context, a long-term research project was initiated in 2019 on the Vanrooyenswoning farm, situated in the eastern Free State, to investigate the impact of non-selective-grazing on rangeland ecology. The farm implements ultra-high-density grazing (UHDG), known for its low levels of selective grazing, providing an ideal setting for studying non-selective-grazing effects. Additionally, a section of a neighbouring farm, characterized by high levels of selective grazing, was included in the study, representing contrasting grazing management approaches.

Data on grass species composition, forb species composition, grass biomass production and water infiltration were sampled at eight sites during February 2019, February 2021, February 2023, and January 2024. This data was analysed to obtain various results. These results were then used to track changes at the non-selective-grazing sites between 2019 and 2024 and to compare the results between the two grazing management approaches.

At the conclusion of this five-year study, several encouraging outcomes were observed at the non-selective-grazing sites. These include notable increases in the number of grass species, the abundance of good grazing grasses, the presence of climax grasses, an increase in C3 (cool-season) grasses, as well as improvements in overall veld condition and grazing capacity.

In comparison to the selective-grazing sites, the non-selective-grazing sites demonstrated greater performance across all criteria, albeit to varying degrees. The most significant variances favouring non-selective-grazing included the proportion of good grazing grasses, botanical diversity, water infiltration capacity, and estimated grazing capacity based on the grass biomass method.

The smallest disparities between the two grazing management approaches, although still in favour of non-selective-grazing, were observed in the veld condition score and grazing capacity, both analysed using the benchmark method. These minor differences primarily stem from the remarkable resilience of a few strongly perennial, unpalatable grass species to the impact of non-selective-grazing. Notably, these species include Ngongoni three-awn (*Aristida junciformis*), Threat-leaved turpentine grass (*Cymbopogon dieterleniae*), and Tough love-grass (*Eragrostis plana*). While these species persist longer than anticipated in the data sets, evidence of significant trampling damage and a gradual decline in their numbers are recorded. These slow changes underscore the importance of long-term research, particularly in the mesic grassland biome, where botanical composition alterations occur at a notably slow pace.

1. INTRODUCTION

The pivotal role of grazing management in shaping rangeland conditions has been widely acknowledged in numerous studies within the field of rangeland management. These studies have highlighted the diverse outcomes of grazing, ranging from maintenance and improvement to degradation. While some research reports varying impacts of grazing, from positive to neutral, collectively, they underscore its significance in enhancing productivity and biodiversity (Dorrrough et al., 2007; Kohyani et al., 2008).

The concept of non-selective-grazing, pioneered by Acocks (1996) and Goodloe (1969) and further developed by Savory, Zietsman, and Lund, has emerged as both widely popular and controversial in grazing management (Mounir et al., 2022). Non-selective-grazing aims to increase stocking density while preserving rangeland durability (Savory, 1978). Despite limited research on its ecological impact, non-selective-grazing holds the potential for significant rangeland improvements (Goodloe, 1969; Weltz and Wood, 1986; Joseph et al., 2002; Mounir et al., 2022).

In this context, a long-term research project was initiated in 2019 on the Vanrooyenswoning farm to investigate the impact of non-selective-grazing on rangeland ecology. The farm implements ultra-high-density grazing (UHDG), known for its low levels of selective grazing, providing an ideal setting for studying non-selective-grazing effects. Additionally, a section of a neighbouring farm, characterized by high levels of selective grazing, was included in the study, representing contrasting grazing management approaches.

The study aims to quantify the changes in rangeland ecology resulting from non-selective-grazing, focusing on monitoring botanical composition and primary production. By comparing data between non-selective-grazing and selective-grazing sites, the research seeks to provide insights into the relative impacts of these grazing management practices. It's essential to acknowledge that this study's findings are specific to the mesic grassland area and may not be universally applicable to all rangeland ecosystems.

1.1. Background

Mr Danie Slabbert, the owner of Vanrooyenswoning farm, implemented ultra-high-density grazing (UHDG) in December 2017, following a history of selective grazing practices. Under UHDG, a single herd of approximately 500 cows is systematically moved forward within a 100-wide strip every hour (Figure 1). The distance of hourly movements, ranging from 7 to 15 meters (with an average of 10 meters), is determined based on the quantity of grass biomass available. Notably, the rear end of the strip is deliberately left open to provide animals with access to water. This grazing regime operates exclusively during daylight hours (6 am to 7 pm), followed by a larger portion of grazing allocated for the evening. Importantly, each grazing portion is utilised only once per annum, minimising repeated grazing pressure.

As Vanrooyenswoning farm operates within a mixed farming system, UHDG is restricted to natural rangelands during the summer months (mid-October to mid-April). Conversely, during the winter months (mid-April to mid-October), a similar grazing approach is employed on croplands, utilizing maize and soy residue as well as cover crops.

The ultra-high animal density of 500 Livestock Units (LSUs), and the average size of hourly grazing portions (1,000 m²), result in an exceptionally high average animal density of approximately 5,000 LSUs per hectare (or 1.2 hectares per LSU per year). This intensive stocking density promotes non-selective-grazing, extensive trampling, and a concentrated and evenly deposition of residual manure and urine. Although field data is unavailable, it is understood that the rangeland was significantly overgrazed before the initiation of UHDG in 2017.

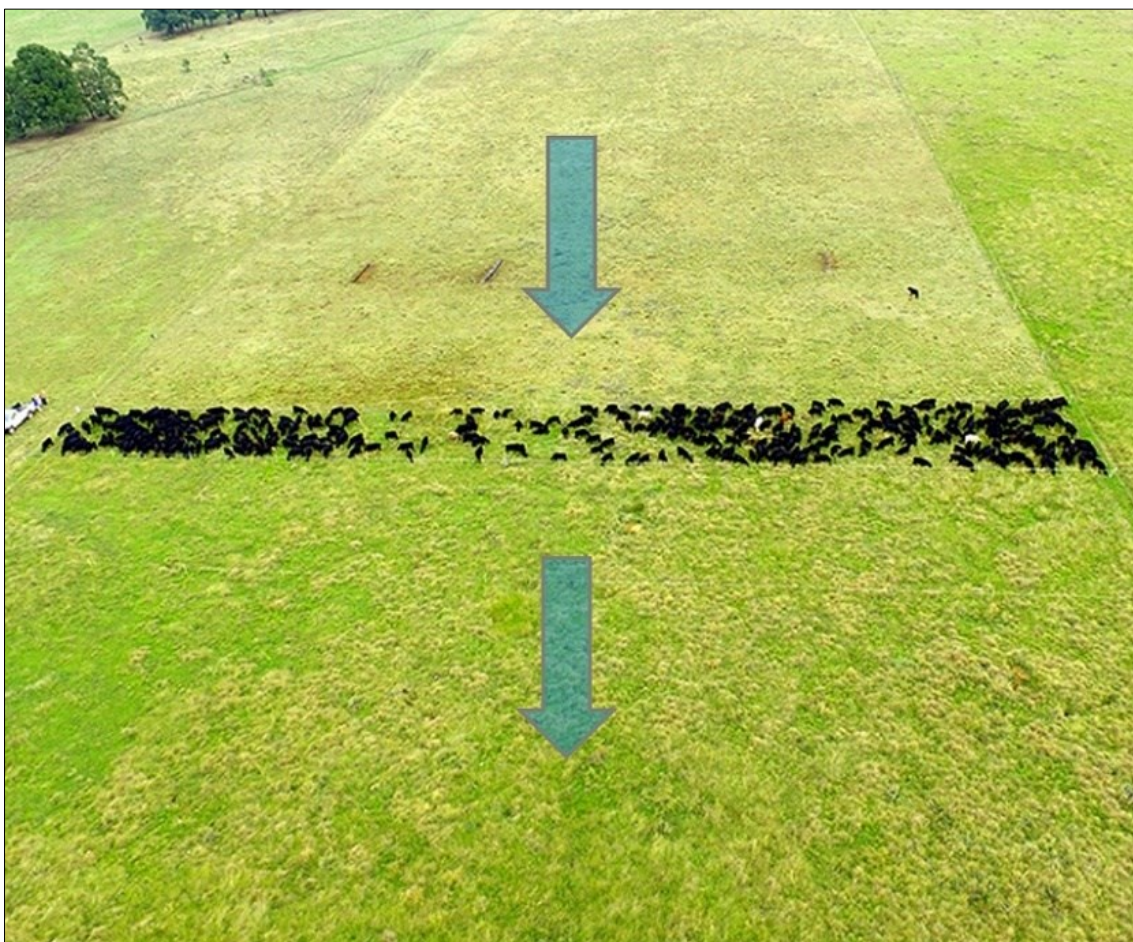


Figure 1: Aerial view of a grazing strip during UHDG. A herd of about 500 cows is moved upward within a 100-wide strip every hour.

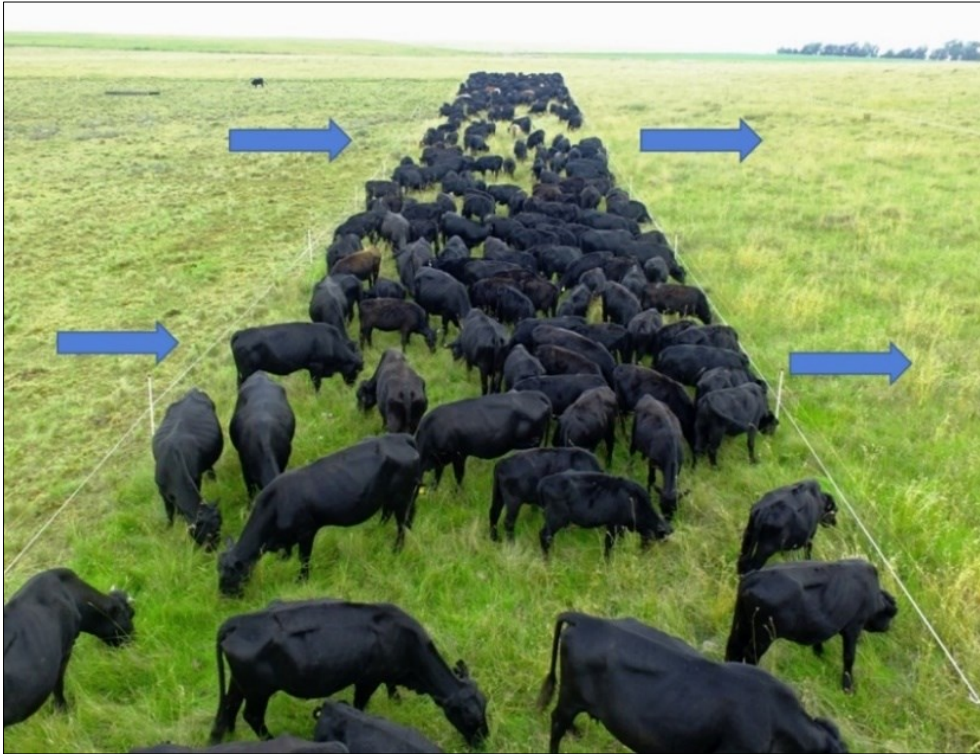


Figure 2: A view of the animal density in the UHDG portion of the study. The animals are moved forward by about 10 m every hour (during the day only).

Additionally, the study encompasses a second section situated on a neighbouring farm adjacent to the UHDG area. This section employs a two-camp rotational grazing system, wherein each of the two camps is alternately grazed for one month (see Figure 3). This grazing approach fosters high levels of selective grazing. The stocking density in this section adheres to the governmental grazing capacity norm for the study area, set at 4 hectares per LSU.

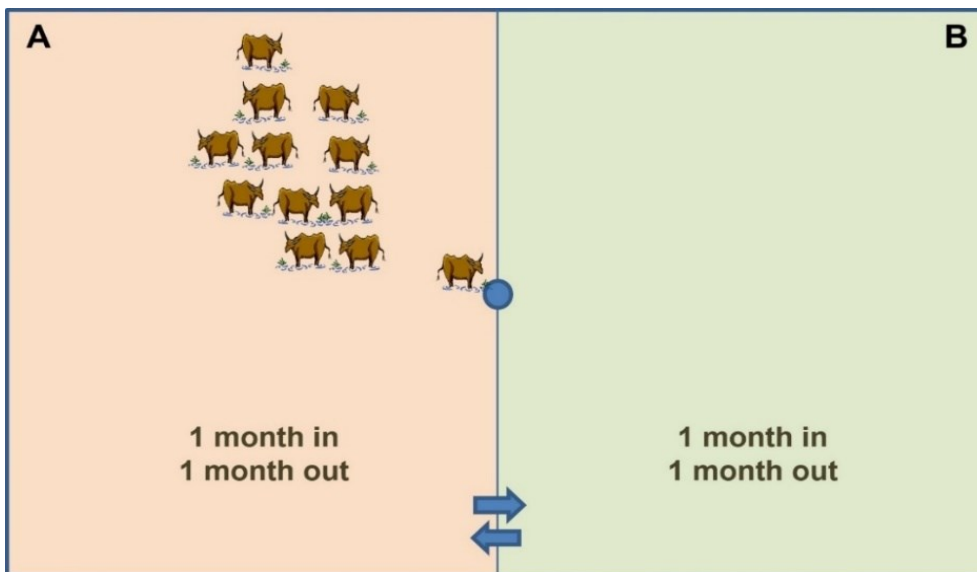


Figure 3: In the selective-grazing portion of the study area animals are rotated between two camps on a 1-month cycle.

2. STUDY AREA

The study area is located in the highveld region of South Africa, about 15 km southeast of the town of Reitz, in the eastern part of the Free State province (see Figure 4).



Figure 4: The study area is located on the farm Van Rooyenswoning, which is situated about 15 km southeast of Reitz in the eastern Free State province.

Below is a short description of the environmental conditions in the study area.

2.1. Topography, geology and soils

The study area, situated at approximately 1,670 meters above sea level (m.a.s.l.), exhibits an undulating terrain morphology characterised by wide crests and extended slopes (see terrain sketch below). Geological formations in the area comprise mudstone, sandstone, and shale, often interspersed with dolerite sills and dykes in select locations. These geological features contribute to the diversity of soil types observed within the study area.

The soils within the study area predominantly range from sandy to sandy-loams, with clay content typically ranging from 7% to 20%. Certain areas may exhibit more structured soils attributed to the presence of dolerite dykes. Soil depth varies considerably across the landscape, spanning from 300 to 1,000 millimetres. Common soil forms on the crests and slopes include Glenrosa, Bonhein, Avalon, and Mayo, while Arcadia and Rensburg soils prevail in bottomland areas. Of particular note is the generally shallow nature of soils within the immediate study area, rendering them marginal for cropping purposes.

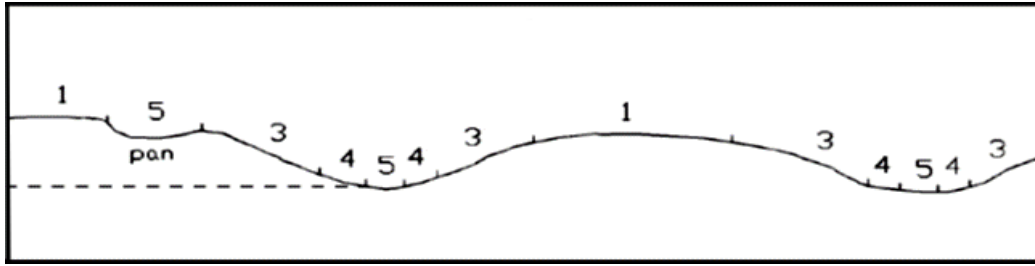


Figure 5: Typical terrain morphology of the study area. The numbers indicate the terrain units as follows: 1 - Crests, 3 – Midslopes, 4 – Footslopes and 5 – Valley bottoms.

2.2. Climate

The study area falls within the Cwb Köppen-Geiger climatic zone, characterised as a warm temperate climate with cold, dry winters and warm, wet summers (Conradie & Bole, 2010). This climatic zone typically exhibits a substantial difference between average winter and summer temperatures, contributing to pronounced seasonal variations in weather patterns. Frost is a common occurrence in the study area, further accentuating the transition between winter and summer conditions.

Rainfall is predominantly received between October and April, with an average annual precipitation of approximately 665 mm. The distribution of rainfall results in a distinct wet season during the summer months, followed by drier conditions in the winter.

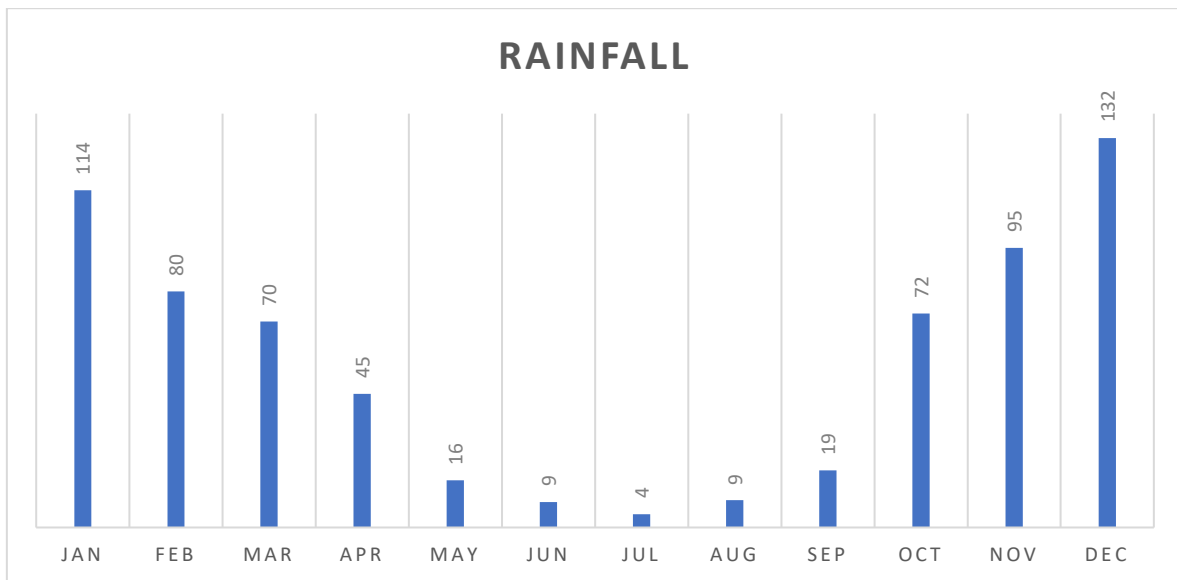


Figure 6: Approximate rainfall distribution for the study area. The long-term average rainfall is about 665 mm/annum.

2.3. Natural vegetation

The study area is situated within the Grassland biome and the Mesic highveld grassland bioregion, characterised by expansive grasslands and diverse vegetation communities. On a finer scale, it falls within the Eastern Free State Clay Grassland vegetation type (Mucina & Rutherford, 2006). This vegetation type is typified by a flat to gently rolling grassland landscape, predominantly dominated by grasses with a notable presence of forbs.

Selective overgrazing poses a significant threat to the ecological integrity of the study area, exacerbated by the high differentiation between palatable and unpalatable grass species. This phenomenon results in a patchy appearance of the grassland, with dominant and diagnostic unpalatable species associated with patches ranging from small to large, spanning several hectares in diameter. The fragmentation of the landscape is further intensified by a wide range of grazing regimes observed both at the macro-scale and within individual grazing units on the micro-scale (Fuls, 1993).

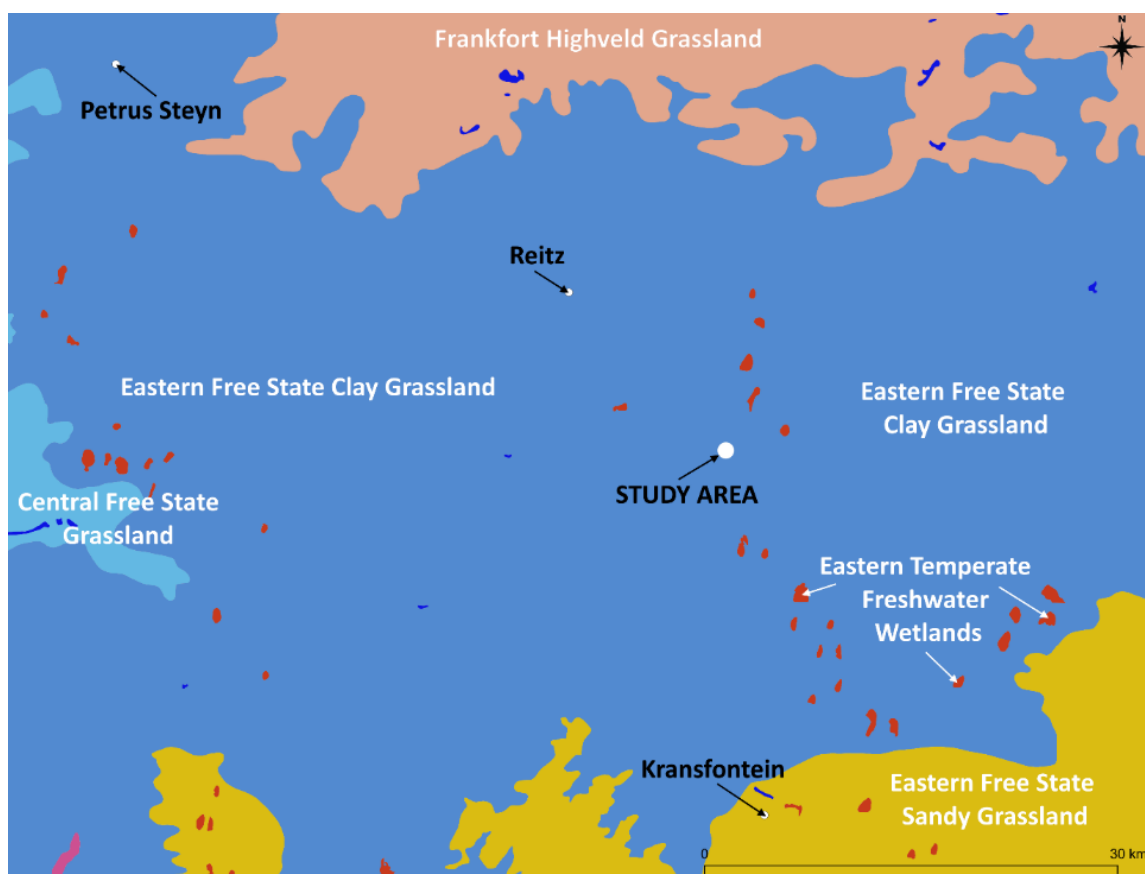


Figure 7: The study area falls in the Eastern Free State Clay Grassland vegetation type (Mucina & Rutherford 2006).

2.4. Grazing capacity norms

The National Department of Agriculture in South Africa maintains grazing capacity norms, which serve as general stocking guidelines for veld in moderate to good condition. These norms are expressed in hectares per Large Livestock Unit (LSU) per year, with one LSU representing the energy requirements of a grazing animal, typically a steer weighing 450 kg. According to the latest updated norms, published by Avenant in 2017, the study area is assigned a grazing capacity norm of 4 hectares per LSU per year (see map below).

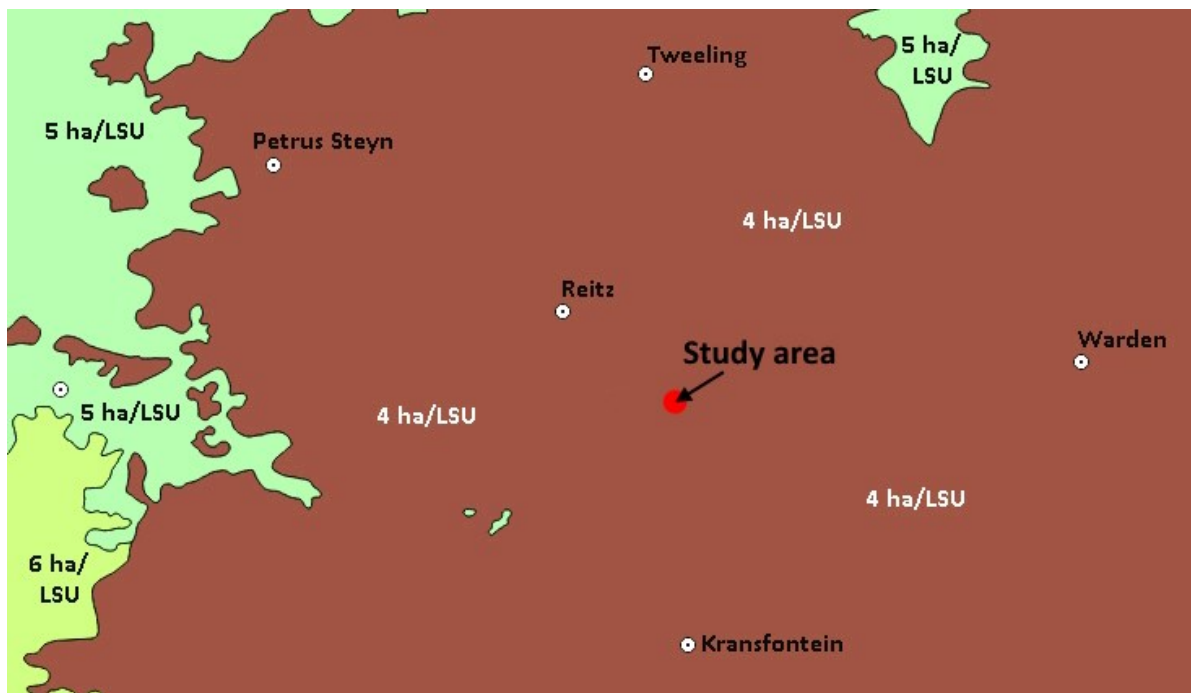


Figure 8: The grazing capacity norm for the study area is 4 ha/LSU/year.

3. METHODS

Below is a description of the methods used in this study.

3.1. Sample sites

To capture temporal variations in rangeland condition data were collected during February 2019, February 2021, February 2023, and January 2024. Initially, the study focused on collecting data at sites where ultra-high-density grazing (from here on referred to as non-selective-grazing) was practised. Subsequently, the study was expanded to include sample sites where selective-grazing takes place, allowing for analysis between two opposite grazing management approaches. The study now encompasses a total of 8 sample sites, evenly distributed between non-selective-grazing and selective-grazing areas.

The allocation of site positions aimed to represent various positions in the terrain, ensuring the inclusion of diverse landscape features and vegetation types on a micro level. Table 1 provides a summary of the sample sites, including their locations in the terrain and stocking density during the study, while Figure 9 depicts the spatial distribution of each site within the study area.

Table 1: The sites where data was collected.

No.	Grazing management	Site no.	Position in terrain	Stocking density
1.	Non-selective-grazing	2	Slope	1.2 ha/LSU/year
2.	Non-selective-grazing	4	Slope	1.2 ha/LSU/year
3.	Non-selective-grazing	5	Crest	1.2 ha/LSU/year
4.	Non-selective-grazing	6	Valley bottom	1.2 ha/LSU/year
5.	Selective-grazing	1	Slope	4 ha/LSU/year
6.	Selective-grazing	7	Slope	4 ha/LSU/year
7.	Selective-grazing	8	Crest	4 ha/LSU/year
8.	Selective-grazing	9	Valley bottom	4 ha/LSU/year



Figure 9: The position of sample sites and transect lines (yellow), including contour lines (2 m intervals).

The series of photos below depicts the typical vegetation structure present at the two grazing management approaches included in this study (taken during the last assessments - January 2024).

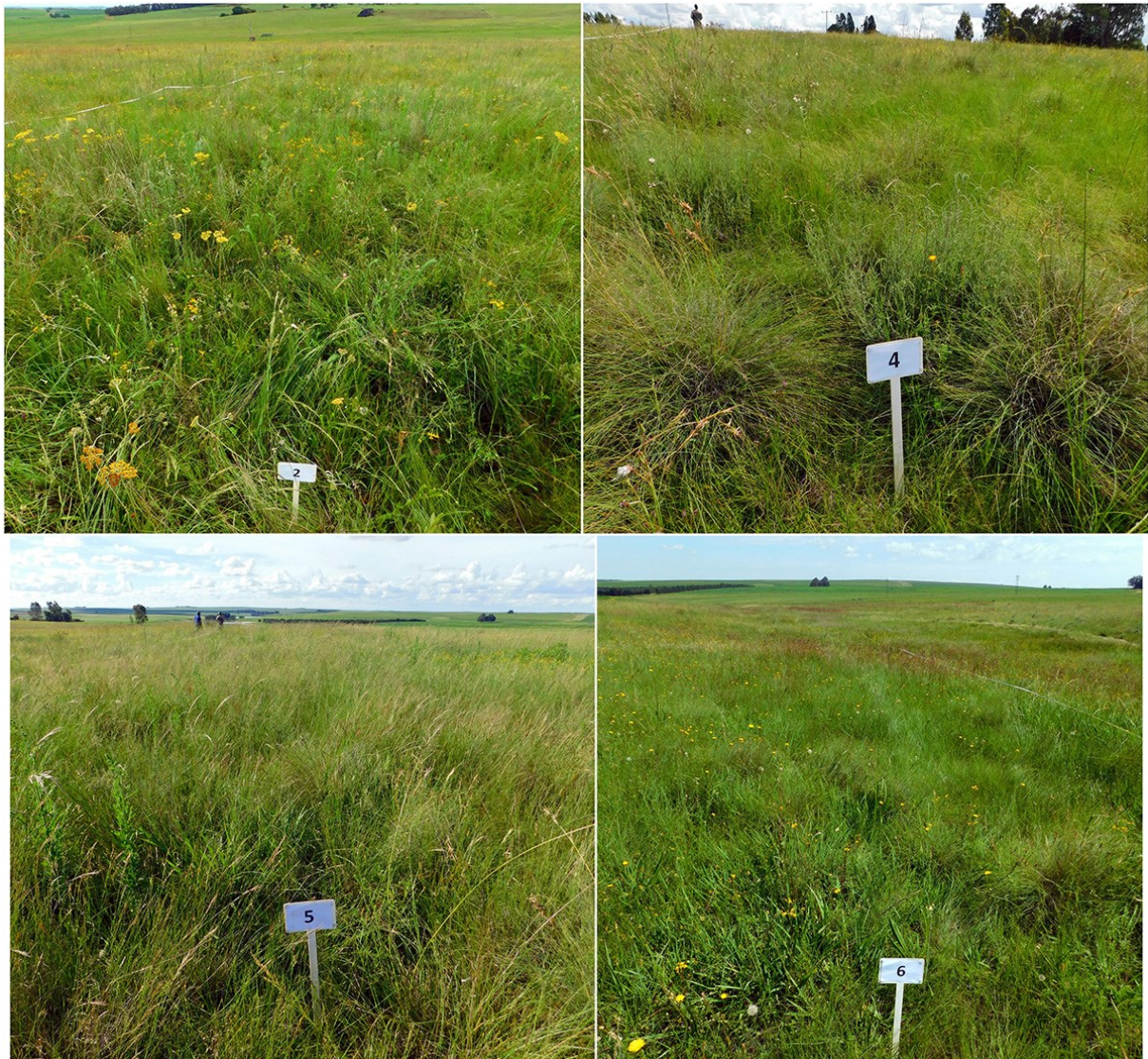


Figure 10: Typical vegetation structure at the non-selective-grazing sites (January 2024).

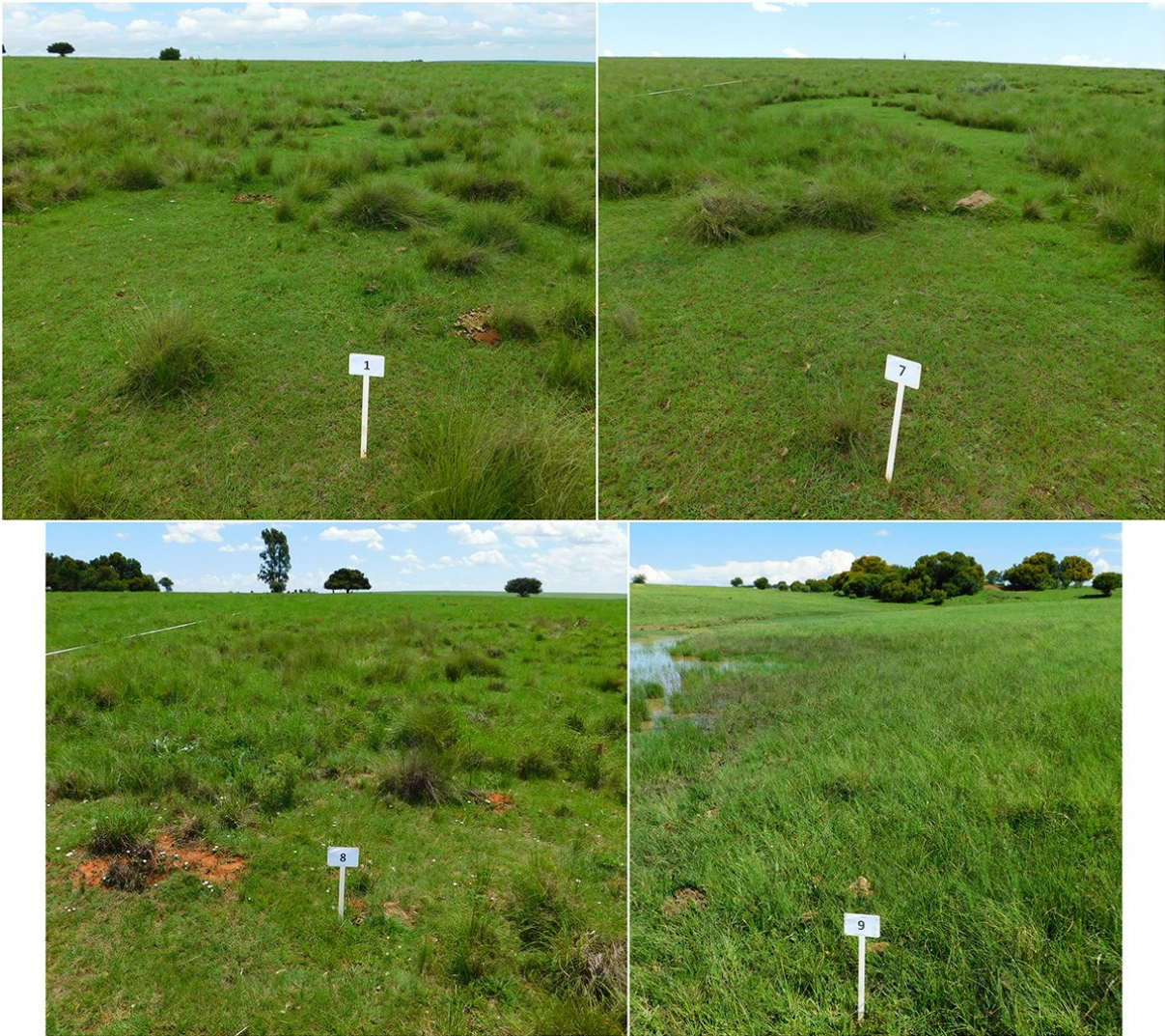


Figure 11: Typical vegetation structure at the selective-grazing sites (January 2024).

In this report data sampled during the first assessment (2019) and last assessment (2024) are used to look at changes that occurred at the non-selective-grazing sites during the five-year study period. Furthermore, data from the last two assessments (2023 and 2024) was combined and used to compare the non-selective-grazing sites with the selective-grazing sites at the end of the study period. Below is a description of the methods used to collect and analyse the data.

3.2. Grass species assessments

Grass species data were collected using the line-transect method. A straight 100-meter transect was established, and at two-meter intervals along the transect, the nearest grass species was identified and recorded. A 100-meter retractable tape measure was used to ensure accurate measurements. Additionally, any grass species observed along the transect, but not recorded during the survey, were noted and incorporated into the dataset.

During the first assessment in 2019, GPS coordinates were recorded at the start and end of each transect to facilitate subsequent surveys and ensure consistent sampling locations. This data was then used to determine the grass species composition for each site and subsequently for each grazing management approach included in the study. The grass species composition data sets were then used to track changes at the non-selective-grazing portion between 2019 and 2024 and differences between non-selective-grazing and selective-grazing at the end of the study period.

For the first comparison, the grasses were grouped into their respective ecological index groups. This index relates to a grass species’s reaction to different levels of grazing (see table below).

Table 2: The ecological index groups, group codes, and group descriptions as used in the study.

Group	Code	Description a	Description b
Decreaser	D	Grasses that decrease with selective overgrazing	Mainly palatable tufted perennial grasses
Increaser 1	I1	Grasses that increase with under-grazing	Large unpalatable tufted perennial climax grasses
Increaser 2a	I2a	Grasses that increase with moderate overgrazing	Mainly subclimax grasses
Increaser 2b	I2b	Grasses that increase with severe overgrazing and soil disturbance	Mainly pioneer grasses
Increaser 3	I3	Grasses that increase with selective overgrazing	Highly unpalatable perennial climax grasses

In addition to ecological index groups, grass species were grouped into various guilds based on characteristics such as growth form/habit, plant size, grazing value, plant succession groups, and photosynthesis pathway. These guilds provided further insights into the functional roles and ecological attributes of grass species within the study area.

To monitor changes in veld condition and estimated grazing capacity over the five-year study period (non-selective-grazing sites only) and to compare the two grazing management approaches, the benchmark method (Van Oudtshoorn, 2015) was used. This method is based on assigning grazing values to individual grass species on a scale of 1 (very poor) to 10 (very high). These grazing values were multiplied by the average percentage occurrence of each grass species in the composition. The resulting figures were summed to obtain the VCS. A benchmark VCS score of 800, as suggested by Trollope et al. (2013), served as a reference point. The percentage of the site's VCS to the benchmark score of 800 was calculated to

determine the veld condition score percentage (VCS%). This metric provided a standardised measure of veld condition relative to the benchmark.

The VCS% was then used to estimate grazing capacity using the equation described by Danckwerts (1989). This equation accounts for the proportion of the benchmark VCS achieved and provides an estimate of the site's grazing capacity relative to its potential.

The equation used for estimating grazing capacity is as follows:

$$GC \text{ (ha/AU)} = 365 / (-31.159 + (1.433 \times \text{VCS \%})) + ((\text{Rainfall mm} - 419.7) \times 0.231)$$

Where:

GC = Grazing capacity in ha/LSU

VCS% = Veld condition index in % of the benchmark veld condition score

Rainfall = Long-term average annual rainfall in mm (665 mm for study area)

3.3. Forb species composition

Forb species composition data were collected during the January assessments of 2022 and 2024. Five 1 m² quadrats were placed along the 100 m transect used for grass assessments. These quadrats were arranged at 25 m intervals along the transect, ensuring systematic coverage at each sample site. Within each quadrat, all forb species present were identified, and the number of plants was recorded.

Additionally, all forb species observed along the transect but not recorded within the quadrats were noted and incorporated into the dataset. This ensured comprehensive coverage of forb species along the transect.

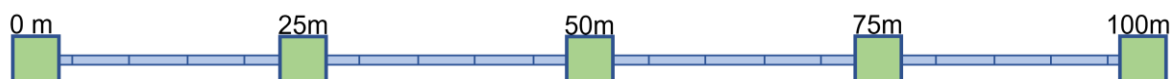


Figure 12: Forb species data were collected in five 1 m² quadrats, arranged at 25 m intervals, along a 100 m transect.

The collected forb species composition data were then analysed. Firstly, the forb species composition and density were calculated for each site based on the data collected from the quadrats. The number of individuals of each forb species within the quadrats was summed to determine species composition, while the total number of individuals counted across all quadrats provided forb species density.

The average forb species composition and density were then calculated for each grazing management approach (non-selective-grazing and selective-grazing) by averaging the data across all sites within each approach. The forb species were also grouped into their respective families, and the composition of forb families was determined for each site group.

3.4. Herbaceous species diversity

To assess herbaceous species diversity, both grasses and forbs datasets were utilised, both separately and in combination. Grass species composition data from the most recent assessments (2023 and 2024) were averaged to obtain the grass species composition for each grazing management approach. Similarly, forb species composition data from the assessments in 2022 and 2024 were averaged to determine the average forb species composition for each grazing management approach.

To obtain a quantified botanical diversity index, the two most widely used diversity indices, namely the Shannon-Wiener index and the Simpson's index, were used. The Shannon-Wiener index takes into account both species richness and evenness, while Simpson's index is more influenced by species dominance. In both indices higher index values indicate higher levels of diversity.

In general, the diversity indices provide insights into the overall richness and evenness of herbaceous species within each data set, allowing for comparisons between different grazing management approaches.

3.5. Water infiltration

Water infiltration capacity was assessed during the 2024 assessment to evaluate soil permeability and infiltration rates. It was measured using a ring infiltrometer consisting of a 150 mm diameter steel cylinder. The cylinder was driven into the ground, creating a sealed area for water application. A known volume of water (440 mm) was then poured into the cylinder, simulating approximately 25 mm of rainfall. The time taken for all water to infiltrate into the soil was recorded using a stopwatch. To ensure consistency, five recordings were taken at 25 m intervals along the same 100 m transect used for grass and forb surveys at each site. If the infiltration time exceeded 20 minutes, counting was ceased,

The average of the five infiltration time readings was calculated for each site. Subsequently, the average infiltration time (in minutes and seconds) for all sites within each grazing management approach (non-selective-grazing and selective-grazing) was determined.

The results are presented as the time it takes for 25 mm of water to fully infiltrate into the soil. Shorter infiltration times indicate higher water infiltration rates and better soil permeability.



Figure 13: Water infiltration was measured by driving a 150 mm cylinder into the ground. 440 mm of water (simulating approximately 25 mm of rainfall) was then poured into the cylinder. The time taken for all water to infiltrate into the soil was then recorded.

3.6. Grass biomass production

To understand the productivity of the grass sward, grass biomass production was assessed during the 2021 and 2024 assessments. For this grass biomass data were sampled using a calibrated disc pasture meter, following the method described by Bransby & Tainton (1977). Measurements were taken at 2-meter intervals along the same transects used for collecting grass and forb species data. The data collected, comprising the average grass sward standing height (in cm), were converted to kilograms of dry grass (DM) per hectare. This conversion was achieved using the average results of two equations developed specifically for sour grassland by Hardy & Mentis (1985) and Kreuter (1985) respectively.

The grass biomass data were further utilised to estimate grazing capacity using the biomass method described by Moore & Odendaal (1987). The utilisation factor used in this equation was derived from the VSC% (Veld Condition Score Percentage) described above. The equation used for estimating grazing capacity through the biomass method is as follows:

$$y = d \div \frac{[DM \times f]}{r}$$

Where;

y = grazing capacity (ha/LSU)

d = number of days in the year (365 days)

DM = dry matter (biomass) in kg DM/ha

f = utilisation factor (between 0.20 and 0.50 based on VCS%)

r = daily dry matter required by one LSU at 12.6 kg DM/LSU/day (@ 2.8% of body weight).

4. RESULTS AND DISCUSSION

Presented below are the results and discussions based on the assessments described earlier. The section begins with findings concerning changes in grass species composition at the non-selective-grazing sites from the study's commencement in 2019 to its conclusion in 2024. Subsequently, the section compares the data collected at both non-selective-grazing and selective-grazing sites at the study's endpoint, representing an average of the 2023 and 2024 datasets.

4.1. Non-selective-grazing sites 2019 to 2024

Below is a comparison of the grass species composition between 2019 and 2024 for the non-selective-grazing sites. It encompasses the grouping of grasses into their respective ecological index groups, categorisation into various other guilds, and finally, the assessment of veld condition score and estimated grazing capacity using the benchmark method.

4.1.1. Grasses and ecological index groups

The table below presents the average grass species composition (%) for the non-selective-grazing sites during the initial assessment in 2019 and the final assessment in 2024. Grass species are categorised based on their ecological index groups, and the total percentage of each ecological index group is provided (refer also to Table 2). A total of 23 grass species were recorded during the 2019 assessment, while 34 species were identified in the 2024 assessment.

Table 3: The average grass species composition of the non-selective-grazing sites for the first (2019) and last (2024) assessments and variance between the two years. Species are grouped according to their ecological index (EI) status. The table also shows the combined percentage of each ecological index group. Arranged from most to least common species in each group.

Species names	English common names	EI group	2019	2024	Variance
<i>Andropogon appendiculatus</i>	Vlei bluestem	D	0.6	3.6	3.1
<i>Leersia hexandra</i>	Rice grass	D	0.0	2.5	2.5
<i>Helictotrichon turgidulum</i>	Small oats grass	D	0.5	2.6	2.1
<i>Festuca scabra</i>	Munnik Fescue	D	0.0	1.8	1,8
<i>Themeda triandra</i>	Red grass	D	1,9	3.6	1,8
<i>Paspalum dilatatum</i>	Dallis grass	D	6.1	7.7	1.5
<i>Digitaria tricholaenoides</i>	Purple finger grass	D	1.4	2.5	1.1
<i>Festuca longipes</i>	Candelabrum Fescue	D	0.0	1.1	1.1
<i>Setaria nigrirostris</i>	Vlei bristle grass	D	0.5	1.5	1.0
<i>Digitaria eriantha</i>	Smuts finger grass	D	0.0	0.7	0.7

<i>Harpochloa falx</i>	Caterpillar grass	D	2.3	2.9	0.6
<i>Hemarthria altissima</i>	Swamp couch	D	0.0	0.4	0.4
<i>Brachiaria serrata</i>	Velvet signal grass	D	0.9	0.7	-0.2
<i>Panicum coloratum</i>	Small buffalo grass	D	1.1	0.4	-0.7
DECREASERS %			15.2	32.0	16.7
DECREASER SPP.			9	14	5
<i>Cymbopogon dieterleniae</i>	Large turpentine grass	I1	10.6	8.1	-2.6
<i>Tristachya leucothrix</i>	Hairy trident grass	I1	0.9	1.1	0.2
INCREASER I's %			11.6	9,2	-2.4
INCREASER I's spp.			2	2	0
<i>Eragrostis plana</i>	Tough love grass	I2a	9,5	8.7	-0.7
<i>Eragrostis chloromelas</i>	Curly leave love grass	I2a	9,4	5.8	-3.6
<i>Eragrostis curvula</i>	Weeping love grass	I2a	0.5	4.1	3.6
<i>Setaria sphacelata torta</i>	Creeping bristle grass	I2a	7.0	2.2	-4.8
<i>Agrostis lachnantha</i>	Bent grass	I2a	0.0	2.2	2.2
<i>Heteropogon contortus</i>	Spear grass	I2a	1.9	1.1	-0.9
<i>Koeleria capensis</i>	June grass	I2a	0.0	0.8	0.8
<i>Eragrostis racemosa</i>	Narrow heart-seed love grass	I2a	0.0	0.7	0.7
<i>Agrostis eriantha</i>	Large plume Agrostis	I2a	0.0	0.7	0.7
<i>Eragrostis gummiflua</i>	Gum grass	I2a	0.0	0.4	0.4
<i>Cynodon dactylon/hirsutus</i>	Couch grass	I2a	0.5	0.4	-0.1
<i>Eragrostis capensis</i>	Heart-seed love grass	I2a	0.9	0.7	-0.2
<i>Eragrostis micrantha</i>	Finesse love grass	I2a	10.0	0.0	-10.0
INCREASER 2a's %			39,7	27.8	-11.9
INCREASER 2a's spp.			8	12	4
<i>Bromus catharticus</i>	Rescue grass	I2b	0.5	2.2	1.7
INCREASER 2b's %			0.5	2.2	1.7
INCREASER 2b's spp.			1	1	0
<i>Aristida junciformis</i>	Ngongoni three-awn	I3	28.3	20.1	-8.2
<i>Elionurus muticus</i>	Wire grass	I3	1.4	3.3	1.9
<i>Pennisetum sphacelatum</i>	Bull grass	I3	3.3	3.3	-0.1
<i>Eragrostis planiculmis</i>	Vlei love grass	I3	0.0	1.4	1.4
<i>Fingerhuthia sesleriiformis</i>	Vlei thimble grass	I3	0.0	0.7	0.7
INCREASER 3's %			33.0	28.8	-4.2
INCREASER 3's spp.			3	5	2

Decreaser grasses

Decreaser grasses encompass palatable perennial grass species whose abundance serves as an indicator of rangeland condition. Monitoring the presence of deceiver grasses is crucial, especially during assessments of rangeland condition, as their numbers typically decline under selective overgrazing. Therefore, one of the primary objectives of this study is to closely track the abundance of deceiver grasses.

Analysis of the table above reveals an increase in the composition of deceiver grasses by 16.7% over five years (from 15.2% in 2019 to 32% in 2024). Moreover, the number of deceiver grass species has risen from nine to fourteen during the same period. The three species exhibiting the most significant increases are *Andropogon appendiculatus* (3.1%), *Leersia hexandra* (2.5%), and *Helictotrichon turgidulum* (2.1%).

Increaser 2 grasses

The only other group demonstrating an increase is the Increaser 2b group, albeit at a modest rate of 1.7%. Within this group, only one species, *Bromus catharticus*, was identified. This grass species, commonly known as Rescue grass, is a palatable naturalised forage species.

Conversely, the highest level of decrease (-12%) is observed in the Increaser 2a group. While certain species within this group experienced an increase, notably the robust species *Eragrostis curvula*, most species, particularly smaller ones such as *Eragrostis chloromelas* and *Setaria sphacelata* var. *torta*, have declined in number. Interestingly, despite the decrease in the proportion of Increaser 2a's, the number of recorded species has increased from eight to twelve.

Increaser 3 grasses

The second-highest decrease is observed in the Increaser 3 group, which consists of grasses that typically increase during selective overgrazing. Within this group, the notoriously unpalatable species *Aristida junciformis* exhibits the highest rate of decline (-8.2%). Despite its decline, *Aristida junciformis* still constitutes a significant portion of the composition, accounting for 20%. Observations have indicated that this brittle grass species is particularly susceptible to the short-term heavy trampling associated with non-selective-grazing, resulting in reduced tuft sizes and limited seed production. Although the proportion of this group has decreased, the number of recorded species has increased.

Increaser 1 grasses

A decrease (-2.4%), albeit relatively low, was also recorded in the Increaser 1 group, consisting of grasses that typically increase during underutilisation and lack of fire. The most prevalent species within this group is the large-tufted and highly unpalatable turpentine grass *Cymbopogon dieterleniae*. This grass species is frequently subjected to heavy trampling

during non-selective-grazing. Its persistence, despite this pressure, may be attributed to the long resting periods (effectively one full year) to which this group is well-adapted.

4.1.2. Other grass guilds

The table below presents the average grass species composition (%) for the 2019 and 2024 assessments at the non-selective-grazing sites, categorised into groups based on growth habit, plant size, grazing value, plant succession groups, and photosynthetic pathway.

Table 4: Grouping of grass species composition for 2019 and 2024 grouped into various categories. Green cells in the variance column indicate the largest increase and red cells the largest decrease during the five-year study period.

Growth form	2019	2024	Variance
Tufted	65.4	52.8	-12.7
Tufted + prostrate	19,0	23.7	4.6
Tufted + rhizomes	8.1	18.1	10.1
Creeping grasses	7.5	5.4	-2.0

Plant size	2019	2024	Variance
Large	43.8	46.5	2.7
Medium	46.9	47.0	0.1
Small	9,3	6.5	-2.8

Grazing value	2019	2024	Variance
High	13.8	25.8	12.0
Moderate	36.4	29,2	-7.1
Low	49,8	45.0	-4.8

Plant succession	2019	2024	Variance
Climax (strong perennials)	59,8	68.2	8.4
Subclimax (short-lived perennials)	39,2	29,3	-10.0
Pioneer (annuals)	1.0	2.5	1.6

Photosynthesis pathway	2019	2024	Variance
C3 (%)	1.0	13.8	12.9
C3 (number of species)	3.0	8.0	5.0
C4 (%)	99,0	86.2	-12.9

From the table above, it is evident that grasses with a purely tufted growth habit have significantly decreased, giving way to tufted grasses with rhizomes and those with the ability to grow prostrate during grazing. When rhizomatous and prostrate grasses are combined, the

increase is almost 15%. Remarkably, all these species are relatively large and palatable. Conversely, creeping or mat-forming grasses, typically comprising small species, have decreased in number (-2%).



Figure 14: Palatable large tufted grass species which also develop rhizomes have shown the highest level of increase during the five-year study period.

There has been a decrease in small grasses in favour of larger species in terms of leaf height and tuft size. This trend is likely attributed to the increased availability of natural resources (e.g., nutrients, moisture, and light) facilitated by non-selective-grazing, enabling larger species to thrive and outcompete smaller ones.

When grasses are grouped according to grazing value (high, moderate, low), there has been a 12% increase in the proportion of grasses with a high grazing value accompanied by decreases in both moderate and poor grazing value groups.

Grouping grasses according to their position in the secondary plant succession process reveals an 8.4% increase in the number of climax grasses, primarily in favour of subclimax species. This suggests a shift towards a more stable ecological state, likely indicating an improvement in soil health as part of plant succession progression.

An intriguing observation is the increase in C3 (cool-season) grasses during the study period. These species, which typically provide quality grazing during the early growing season, have increased from 1% to 14% and by five species. Their resurgence may be attributed to the likelihood that they were historically heavily grazed, particularly during the early growing season, leading to their decline. However, during the five years of non-selective-grazing, these grasses were protected from selective grazing, resulting in their reappearance.

4.1.3. Veld condition and grazing capacity

The veld condition and grazing capacity for the initial (2019) and latest (2024) assessments at the non-selective-grazing sites were determined using the benchmark method, which relies on the grazing values (GV) ranging from 1 to 10 assigned to various grass species in the respective compositions.

The table below displays the species, their assigned grazing values, the percentage of species occurrence, and the species contribution scores for both assessment periods. Additionally, the table includes the veld condition score (VCS), veld condition score percentage (VCS% at a benchmark score of 800), and the estimated grazing capacity for both years. These calculations are based on a long-term average rainfall of 665 mm per annum.

Table 5: The grass species, the grazing values (GV) used, the species occurrence (%) and species contribution scores for both years. It further shows (bottom of the table) the veld condition score (VCS), veld condition score percentage and the estimated grazing capacity for both years. Grass species are arranged alphabetically.

Species name	GV (1 - 10)	2019		2024	
		%	Score	%	Score
<i>Agrostis eriantha</i>	3	0.0	0.0	0.7	2.2
<i>Agrostis lachnantha</i>	4	0.0	0.0	2.2	8.7
<i>Andropogon appendiculatus</i>	8	0.6	4.4	3.6	29,1
<i>Aristida junciformis</i>	1	28.3	28.3	20.1	20.1
<i>Brachiaria serrata</i>	6	0.9	5.6	0.7	4.3
<i>Bromus catharticus</i>	5	0.5	2.3	2.2	11.0
<i>Cymbopogon dieterleniae</i>	1	10.6	10.6	8.1	8.1
<i>Cynodon dactylon/hirsutus</i>	5	0.5	2.5	0.4	1.8
<i>Digitaria eriantha</i>	9	0.0	0.0	0.7	6.5
<i>Digitaria tricholaenoides</i>	8	1.4	11.1	2.5	20.2
<i>Elionurus muticus</i>	2	1.4	2.8	3.3	6.6
<i>Eragrostis capensis</i>	4	0.9	3.7	0.7	2.9
<i>Eragrostis chloromelas</i>	4	9,4	37.7	5.8	23.4
<i>Eragrostis curvula</i>	6	0.5	2.9	4.1	24.8
<i>Eragrostis gummiflua</i>	1	0.0	0.0	0.4	0.4
<i>Eragrostis micrantha</i>	4	10.0	40.0	0.0	0.0
<i>Eragrostis plana</i>	4	9,5	37.9	8.7	35.0
<i>Eragrostis planiculmis</i>	1	0.0	0.0	1.4	1.4
<i>Eragrostis racemosa</i>	3	0.0	0.0	0.7	2.2
<i>Festuca longipes</i>	6	0.0	0.0	1.1	6.4
<i>Festuca scabra</i>	6	0.0	0.0	1.8	10.9
<i>Fingerhuthia sesleriiformis</i>	3	0.0	0.0	0.7	2.2

<i>Harpochloa falx</i>	7	2.3	16.2	2.9	20.4
<i>Helictotrichon turgidulum</i>	5	0.5	2.5	2.6	12.8
<i>Hemarthria altissima</i>	7	0.0	0.0	0.4	2.5
<i>Heteropogon contortus</i>	5	1.9	9.7	1.1	5.4
<i>Koeleria capensis</i>	3	0.0	0.0	0.8	2.3
<i>Leersia hexandra</i>	8	0.0	0.0	2.5	20.3
<i>Panicum coloratum</i>	6	1.1	6.7	0.4	2.2
<i>Paspalum dilatatum</i>	7	6.1	42.8	7.7	53.6
<i>Pennisetum sphacelatum</i>	5	3.3	16.7	3.3	16.3
<i>Setaria nigrirostris</i>	7	0.5	3.2	1.5	10.2
<i>Setaria sphacelata torta</i>	5	7.0	34.9	2.2	11.0
<i>Themeda triandra</i>	9	1.9	16.7	3.6	32.6
<i>Tristachya leucothrix</i>	5	0.9	4.6	1.1	5.5
Veld condition score (VCS)		343.7		423.1	
Veld condition score percentage (VCS%)		43		53	
Grazing capacity (ha/LSU/year)		4.2		3.6	
Assessment year		2019		2024	

From the table above, it is evident that the veld condition score percentage has increased from 43% in 2019 to 53% in 2024, signifying a 10% improvement in veld condition over the five-year study period. Additionally, the estimated grazing capacity has enhanced by 0.6 ha/LSU/year during the same period. What renders this improvement particularly significant is that the stocking density during this study averaged 1.2 ha/LSU/year, which is 3.3 times higher than the departmental guideline for the region, set at 4 ha/LSU/year.

4.2. Non-selective-grazing vs. selective-grazing

In this section, the data for the two grazing management approaches included in the study are compared. The analysis combines data from the last two assessment periods (2023 and 2024). The comparison encompasses grouping the grasses into their respective ecological index groups, categorising them into various additional guilds, comparing veld condition scores and estimated grazing capacities, comparing forb species, and evaluating water infiltration capacity as well as grass biomass production.

4.2.1. Grasses and ecological index groups

The table below shows the proportion of ecological index groups based on the grass species composition for each grazing management approach at the end of the study period.

Table 6: The proportion (%) of ecological index groups based on the grass species composition for each grazing management approach at the end of the study period.

Ecological index	Non-selective-Grazing		Selective-grazing	
	%	Spp.	%	Spp.
Decreasers	30.7	14	10	6
Increaser 1's	12.3	2	1.7	1
Increaser 2a's	29,6	13	70.2	11
Increaser 2b's	1.5	1	1.1	3
Increaser 3's	25.8	5	17.1	3
Total grass species	34		24	

The ecological index status of grasses pertains to the response of a specific grass species to varying levels of grazing pressure (refer to Table 2). Of particular importance is the "decreaser" group of grasses, comprising palatable species favoured by grazers, which decline in abundance during periods of overgrazing or undergrazing.

Decreaser grasses

From the table above, it is evident that the proportion of decreaser grass species recorded at the end of the study was highest at the non-selective-grazing sites, comprising 31%. A total of 14 decreaser species were documented at these sites.

Conversely, at the selective-grazing sites, the percentage of decreaser species constituted 10%, with a total of 6 species recorded. Among these sites, the most prevalent decreaser species was the non-indigenous but palatable grass *Paspalum dilatatum* (4.7%). Additionally, the palatable species *Themeda triandra* was recorded at 1.7%. Interestingly, this species was primarily observed within protected areas, such as dense clumps of the highly unpalatable *Aristida junciformis*.

Increaser 1 grasses

The proportion of Increaser 1 grass species, indicative of under-utilisation, was lowest at the selective-grazing sites, amounting to a mere 1.7%, while it peaked at the non-selective-grazing sites, reaching 12.3%. A slight decrease of -2.4% was observed in the Increaser 1 group at the latter sites.

Predominantly, the most abundant species in this group is the large-tufted and highly unpalatable turpentine grass *Cymbopogon dieterleniae*. This grass species is frequently subjected to heavy trampling during non-selective-grazing. The prolonged resting periods, effectively one full year, to which this group is well-adapted, may contribute to its persistence.

Increaser 2a grasses

At the end of the study period, Increaser 2a species, indicating moderate overgrazing, were most prevalent at the selective-grazing sites, comprising a very high proportion of 70.2%. At the non-selective-grazing sites, increaser 2a grasses accounted for 29.6%.

Increaser 2b grasses

The highest proportion of Increaser 2b's was documented at the non-selective-grazing sites, constituting a low of 1.5%. The presence of these grasses can be attributed to factors other than overgrazing. Their proliferation is likely facilitated by intensive trampling and high levels of non-selective-grazing during UHDG, creating favourable conditions for the emergence of these annual grasses. However, the subsequent long periods of veld rest and regrowth of perennial grasses, coupled with heightened competition for resources, likely account for the low proportion of this group in the overall composition.

Conversely, at the selective-grazing sites, the occurrence of Increaser 2b's was also minimal, representing only 1.1%. The characteristic dense yet low cover provided by the lawn-forming grasses common to these sites, combined with undisturbed patches of unpalatable grasses, which offer limited space for new propagules, likely explains this limited occurrence. Additionally, as most Increaser 2b species are palatable, such as *Digitaria sanguinalis* and *Urochloa panicoides*, the frequent grazing at the selective-grazing sites likely restricts the full establishment of these annual grasses.

Increaser 3 grasses

Surprisingly, Increaser 3 grasses, indicative of selective overgrazing, were most abundant at the non-selective-grazing sites, comprising 25.8% of the composition. This proportion primarily consists of the unpalatable *Aristida junciformis*, accounting for 19%. Despite experiencing an 8% decrease over the 5-year study period, this grass species demonstrated remarkable persistence. Observations have revealed that *Aristida junciformis* is significantly impacted by trampling, with individual tufts suffering severe damage and exhibiting minimal seed production.

Aristida junciformis is arguably the single species that detrimentally affects grazing capacity the most in high-rainfall regions of South Africa. It is hypothesized that this species will continue to decline in number. These gradual changes in grass species composition underscore the significance of long-term research efforts.

Conversely, at the selective-grazing sites, Increaser 3's accounted for 17% of the composition at the end of the study period. In these sites, this grass species remains largely ungrazed or undisturbed.



Figure 15: At the non-selective-grazing sites the Increaser 3 grass *Aristida junciformis* was, although slowly decreasing during the 5-year study, still relatively high at 19%, albeit heavily trampled (photo left). At the selective-grazing sites, it occurs at 17% and is undisturbed (photo right).

4.2.2. Grass guilds

In this analysis, we compare the grass species composition of the two grazing management approaches (non-selective-grazing vs. selective-grazing) when grouped into various ecologically related categories, with some overlap (see table below). For this analysis, the average grass species composition obtained during the last two assessments (2023 + 2024) was combined.

Table 7: Grouping of the grass species composition into various categories based on the average composition (%) of the last two assessments (2023 and 2024) combined. Green cells show the highest positive variance and red cells the highest negative variance between non-selective and selective-grazing in each category.

Growth form	Non-selective-grazing	Selective-grazing	Variance
Tufted	52.5	38.6	13.9
Tufted + prostrate	23.0	35.0	-12.0
Tufted + rhizomes	20.7	0.5	20.3
Creeping grasses	3.8	26.0	-22.2

Plant size	Non-selective-grazing	Selective-grazing	Variance
Large	47.9	22.2	25.7
Medium	47.6	50.8	-3.2
Small	4.5	27.0	-22.5

Grazing value	Non-selective-grazing	Selective-grazing	Variance
High	27.6	9,6	18.0
Moderate	24.8	39,4	-14.7
Low	47.7	51.0	-3.4

Plant succession	Non-selective-grazing	Selective-grazing	Variance
Climax (strong perennials)	67.9	26.0	41.9
Subclimax (short-lived perennials)	30.4	58.3	-27.9
Pioneer (annuals)	1.7	15.7	-14.0

Grass growth form

The table above illustrates that both grazing management approaches are predominantly characterised by tufted grasses. The second most prevalent group shared between the two approaches consists of tufted grasses with the ability to grow prostrate.

A notable difference (with a variance of 22%) in this category is the relatively higher proportion of smaller creeping grasses observed at the selective-grazing sites compared to the non-selective-grazing sites. These grasses are typically forming grazing lawns, interspersed with patches of tall unpalatable species, which are easily identifiable at the selective-grazing sites. The three most common grass species in this group within lawns are *Cynodon dactylon*, *Setaria sphacelata* var. *torta*, and *C. hirsutus*.

In contrast, larger tufted grasses with rhizomes are more prevalent at the non-selective-grazing sites (with a variance of 20%). Over the five-year study period, this group of grasses, all comprising palatable species, has experienced a 10% increase in composition at these sites.

Grass plant size

When the grasses are categorised based on plant size, the most notable difference between non-selective and selective-grazing lies in the prevalence of large and small-sized grass species. Small-sized grasses were predominant at the selective-grazing sites, comprising 27% of the composition. This category includes the small-sized lawn-forming grasses mentioned earlier. The extended grazing cycles characteristic of selective-grazing sites likely promote the dominance of short grasses by maintaining a low grass sward, thereby reducing competition against taller species.

Conversely, the relatively lower proportion of small grasses at the non-selective-grazing sites can be attributed to the presence of a tall grass sward and high volumes of grass biomass. These conditions hinder the ability of short grasses to compete for resources. Such

unfavourable conditions for small species arise from the tall grass sward that develops during the prolonged resting cycles associated with non-selective-grazing.

Grazing value groups

When the dataset is organized based on grazing value classes (high, moderate, and low), the highest proportion of grasses with a high grazing value was observed at the non-selective-grazing sites, accounting for 28% of the composition. In contrast, the selective-grazing sites recorded only 10% in this category. This disparity marked the most significant difference between the two grazing approaches, with an 18% variance. At the non-selective-grazing sites, 11 grass species with a high grazing value were identified, whereas only four species were recorded at the selective-grazing sites.

Despite approximately 7 years of UHDG, the presence of species with a low grazing value remained relatively high at the non-selective-grazing sites, averaging 48%. These remnants of long-term historic selective-grazing are gradually diminishing, although at a slower pace than expected. While these large, unpalatable species persist, their impact and low seeding rate due to trampling and grazing are not fully reflected in the data. Nonetheless, this impact is evident in the field, suggesting a further decline in their numbers over time.

At the selective-grazing sites, the proportion of grasses with a low grazing value at the study's end was 51%. Among the common grass species in this category is *Aristida junciformis*, a medium to large-sized unpalatable grass that forms dense patches, as described by Fuls (1993). Grazers typically avoid these patches, while the intervening areas are frequently grazed and maintained as lawns. Due to the minimal herd impact on these *Aristida junciformis*-dominated patches, the grass grows undisturbed and produces optimal levels of seed. Consequently, it is anticipated that their numbers will remain stable or even increase over time.

These dense patches of unpalatable grass may offer limited palatable grazing, yet they serve a vital role as refuges for palatable grasses, particularly *Themeda triandra*, enabling them to grow relatively undisturbed and produce seeds. The spread of such palatable grasses beyond these refuges is however restricted due to the short periods of rest associated with this grazing approach.



Figure 16: Typical grass structure, with grazing lawns interspersed by dense patches of *Aristida junciformis*, at the selective-grazing sites.

Plant succession groups

When examining the plant succession groups, it becomes evident that the occurrence of climax grasses represents the most significant disparity between the two grazing management approaches, with a variance of 50%. At the non-selective-grazing sites, 68% of the grasses belonged to the climax group, whereas at the selective-grazing sites, this figure was only 26%.

Combining the pioneer and subclimax groups reveals that they are most prevalent at the selective-grazing sites, constituting 75% of the composition, compared to 32% at the non-selective-grazing sites.

These disparities in plant succession stages are likely attributed to the duration of grazing absence or rest periods. Longer periods of absence allow for more advanced plant succession progression, as evidenced by the high percentage of climax grasses at the non-selective-grazing sites.

Conversely, at the selective-grazing sites, where grazing is absent for only one month after a full month of grazing, plant succession is hindered from progressing beyond the subclimax stage to the climax stage. The data suggest that this brief rest period is however sufficient to progress beyond the pioneer stage (15.7%) to the subclimax stage (58.3%).

4.2.3. Veld condition score

The table below presents the veld condition score (VCS) and veld condition score percentage (VCS%) derived from the grazing value (0 – 10) assigned to individual grass species in the grass species composition for both grazing management approaches. Additionally, the table includes the grazing capacity computed based on the VCS% using the equation described for the benchmark method.

Table 8: The Veld Condition Score (VCS) and VCS% of the two grazing management approaches based on the grazing value (0 – 10) of grasses in the grass species composition. The VCS, VCS%, grazing capacity and number of grass species recorded are shown in the bottom rows. Grass species are arranged alphabetically.

Scientific name	Grazing value (1-10)	Non-selective-grazing		Selective-grazing	
<i>Agrostis eriantha</i>	3	0.4	1.1	0.0	0.0
<i>Agrostis lachnantha</i>	4	1.1	4.3	1.1	4.5
<i>Andropogon appendiculatus</i>	8	3.2	25.7	0.0	0.0
<i>Aristida junciformis</i>	1	18.7	18.7	16.4	16.4
<i>Brachiaria serrata</i>	6	0.8	4.6	0.2	1.2
<i>Bromus catharticus</i>	5	1.5	7.5	0.0	0.0
<i>Cymbopogon dieterleniae</i>	1	11.6	11.6	1.7	1.7
<i>Cynodon dactylon & hirsutus</i>	5	0.2	0.9	12.2	61.0
<i>Cynodon transvaalensis</i>	2	0.0	0.0	2.4	4.8
<i>Digitaria eriantha</i>	9	0.4	3.2	0.0	0.0
<i>Digitaria sanguinalis</i>	3	0.0	0.0	0.2	0.6
<i>Digitaria tricholaenoides</i>	8	4.0	32.3	0.0	0.0
<i>Elionurus muticus</i>	2	2.2	4.4	0.0	0.0
<i>Eragrostis capensis</i>	4	0.4	1.5	0.6	2.5
<i>Eragrostis chloromelas</i>	4	9,0	36.0	14.3	57.1
<i>Eragrostis curvula</i>	6	2.9	17.3	0.6	3.8
<i>Eragrostis gummiflua</i>	1	0.4	0.4	0.0	0.0
<i>Eragrostis plana</i>	3	11.3	33.8	28.0	83.9
<i>Eragrostis planiculmis</i>	1	1.3	1.3	0.2	0.2
<i>Eragrostis racemosa</i>	3	0.4	1.1	0.0	0.0
<i>Festuca longipes</i>	5	0.5	2.5	0.0	0.0
<i>Festuca scabra</i>	6	0.9	5.5	0.0	0.0
<i>Fingerhuthia sesleriiformis</i>	3	0.4	1.1	0.0	0.0
<i>Harpochloa falx</i>	7	4.3	29,8	0.0	0.0
<i>Helictotrichon turgidulum</i>	5	1.3	6.4	0.2	1.0
<i>Hemarthria altissima</i>	7	0.2	1.3	0.0	0.0
<i>Heteropogon contortus</i>	5	0.6	2.8	0.2	1.0
<i>Koeleria capensis</i>	3	0.4	1.1	0.0	0.0
<i>Leersia hexandra</i>	7	1.5	10.2	2.8	19,3
<i>Microchloa caffra</i>	1	0.0	0.0	1.5	1.5
<i>Panicum coloratum</i>	6	0.2	1.1	0.4	2.5
<i>Panicum schinzii</i>	5	0.0	0.0	0.2	1.1
<i>Paspalum dilatatum</i>	8	7.8	62.5	4.7	37.8
<i>Pennisetum sphacelatum</i>	5	3.1	15.7	0.5	2.3

<i>Setaria nigrirostris</i>	7	4.0	27.7	0.0	0.0
<i>Setaria sphacelata torta</i>	5	1.9	9,6	8.6	43.1
<i>Sporobolus africanus</i>	4	0.7	2.9	0.0	0.0
<i>Themeda triandra</i>	9	2.1	19,3	1.7	15.0
<i>Trichoneura grandiglumis</i>	3	0.0	0.0	0.6	1.9
<i>Tristachya leucothrix</i>	5	0.7	3.3	0.0	0.0
<i>Urochloa panicoides</i>	4	0.0	0.0	0.6	2.5
Veld condition score (VCS)		408.4		367.0	
VCS% (Benchmark = 800)		51.1		45.9	
Grazing capacity (ha/LSU/year)		3.7		4.0	
Number of grass species recorded		35		24	
Grazing management approach		Non-selective-grazing		Selective-grazing	

The table above illustrates that the VCS%, estimated grazing capacity, and number of grass species recorded are higher at the non-selective-grazing sites, reaching 51%, 3.7 ha/LSU, and 35 species, respectively.

These values only indicate veld in a moderate condition, and they are not significantly greater than those observed for the selective-grazing sites, which stand at 46%, 4 ha/LSU, and 24 species, respectively. However, it's worth noting that at the non-selective-grazing sites, the proportion of decreaser grasses has increased since the implementation of UHDG at a stocking density of 1.2 ha/LSU/year.

4.2.4. Forb species

Forbs, also known as wildflowers, constitute a diverse group of herbaceous plants encompassing various plant families, excluding grasses. In the grassland biome, forbs often represent a substantial portion of herbaceous plant species diversity, sometimes reaching up to 80%. Their presence and diversity are considered vital indicators of ecosystem health.

Forbs contribute significantly to grassland ecology, playing roles in insect associations and often serving as important fodder plants, particularly legumes, which enhance the quality of fodder. However, the effects of non-selective-grazing on forb diversity and composition remain poorly understood. The initial forb assessment took place in January 2022, followed by a subsequent assessment in January 2024. Below are the combined results of these evaluations.

4.2.4.1. Number and density of forb species

The table displays the total number of forb species and the average density of forb plants observed at two different grazing management approaches.

Table 9: The total number of forb species and average forb plant density.

Grazing management	No. of species recorded	Ave. plant density (plants/m ²)
Non-selective-grazing	99	47
Selective-grazing	71	77

The data illustrates that a greater total number of forb species, 99 in total, were documented at non-selective-grazing sites compared to 71 species at selective-grazing sites. However, despite this higher species count, the average density of these species was lower, recorded at 47 plants/m², in contrast to the selective-grazing sites where the average density reached 77 plants/m².

4.2.4.2. Common forb species

The table below presents the five most frequently encountered forb species documented for each grazing management approach, averaged across all sites within each approach. Additionally, it indicates the variance in occurrence between the two approaches.

Table 10: The five most common forb species recorded (%) for each grazing management approach and the variance of the two management approaches (arranged from highest to lowest variance). Highlighted cells indicate the highest occurrence per species.

Forb species name	Common name	Non-selective-grazing (%)	Selective-grazing (%)	Variance (%)
<i>Cyperus esculentus</i>	Yellow nutsedge	2.53	28.55	-26.02
<i>Seriphium plumosum</i>	Bankrupt bush/Slangbos	0.46	12.38	-11.92
<i>Delosperma herbeum</i>	Highveld vygie	0.00	7.60	-7.60
<i>Ajuga ophrydis</i>	Bugle plant	1.35	6.16	-4.81
<i>Hermannia depressa</i>	Rooiopslag	0.96	5.75	-4.79
Selective-grazing common forbs		5.29	60.43	-55.14
<i>Hypochaeris radicata</i>	Cat's-ear	4.47	1.52	2.95
<i>Ledebouria marginata</i>	African hyacinth	4.63	0.05	4.58
<i>Helichrysum krausii</i>	Straw everlasting	5.32	0.05	5.28
<i>Verbena bonariensis</i>	Purple top	8.03	2.28	5.75
<i>Rumex saggitatus</i>	Climbing sorrel	7.77	1.76	6.01
Non-selective-grazing common forbs		30.22	5.65	24.57

The data highlights a notable contrast in the composition of the five most prevalent forb species between selective-grazing and non-selective-grazing sites. While many species are shared between the two areas, there is a significant difference in their abundance.

This discrepancy is also reflected in the variance among the most common species when their occurrence is combined. At the selective-grazing sites, these five species constitute a substantial 60% of the total forb composition, whereas at the non-selective-grazing sites, they comprise only 30%. Particularly, the selective-grazing sites exhibit a higher variance, indicating a lower level of evenness in species distribution compared to the non-selective-grazing sites.

Of notable mention are two species highly prevalent at the selective-grazing sites: yellow nutsedge (*Cyperus esculentus*) and bankrupt bush/Slangbos (*Seriphium plumosum*), accounting for 29% and 12% of the composition, respectively. Yellow nutsedge, a common cropland weed, appears well-grazed in these areas, while bankrupt bush, an encroacher species, is frequently found in South Africa's grassland biome.

4.2.4.3. Forb families

The table below shows the most common forb families, based on their percentage occurrence, for the two grazing management approaches. It also shows the number of species recorded at each approach, the total number of species in the data set and the average occurrence (%) of each family.

Table 11: The composition of common forb families in the dataset, arranged from the highest to lowest number of species recorded. Green highlighted cells indicate the highest occurrence (%) in each family.

Family	Common name	Non-selective grazing		Selective-grazing		Ave %	Total Spp.
		%	Spp.	%	Spp.		
<i>Asteraceae</i>	Daisy family	36.2	37	25.2	31	30.7	40
<i>Fabaceae</i>	Legume family	8.5	9	1.6	4	5.0	11
<i>Malvaceae</i>	Hibiscus family	2.5	5	5.9	3	4.2	5
<i>Hyacinthaceae</i>	Hyacinth family	4.9	3	0.1	1	2.5	3
<i>Verbenaceae</i>	Vervain family	8.3	2	2.3	1	5.3	2
<i>Oxalidaceae</i>	Wood sorrel family	3.9	2	6.1	2	5.0	2
<i>Scrophulariaceae</i>	Figwort family	6.9	2	2.9	1	4.9	2
<i>Commelinaceae</i>	Wandering Jew family	2.4	2	3.8	2	3.1	2
<i>Cyperaceae</i>	Sedge family	2.5	1	28.5	1	15.5	1
<i>Polygonaceae</i>	Knotweed family	7.8	1	1.8	1	4.8	1

From the table above can be seen that Asteraceae (Daisy family) and Cyperaceae (Sedge family) are the most prevalent forb families in the dataset, representing 31% and 15.5% of species, respectively.

Of particular interest are the indigenous legumes in the Fabaceae family, with nine species recorded at non-selective-grazing sites (8.5% occurrence) and four species at selective-grazing sites (1.6% occurrence). The overall distribution of forb families is relatively even, with 36 families represented at non-selective-grazing sites and 33 families at selective-grazing sites.

4.2.5. Herbaceous species diversity

Species diversity is a measure of not only the species richness but also the relative abundance of species within a particular composition. For species diversity, the data sets of both grasses and forbs were used (separate and combined) and analysed using the two most widely used diversity indices, namely the Shannon-Wiener index and the Simpson's index. The table below presents diversity indices for forb and grass species at each grazing management approach, along with the number of species recorded.

Table 12: Diversity indices for forb and grass species at each grazing management approach. The number of forb and grass species recorded at each grazing approach is additionally shown.

Index	Non-selective-grazing			Selective-grazing		
	Forbs	Grass	Ave	Forbs	Grass	Ave
Number of species	99	34	133	71	24	95
Shannon-Wiener index (H')	3.8	2.8	3.3	2.9	2.2	2.6
Simpson's index ($1/D$)	30.5	11.6	21.0	8.6	6.6	7.6
Average index value	17.2	7.2	12.2	5.7	4.4	5.1

The table above shows that, at non-selective-grazing sites, the Shannon-Wiener index (H') is 3.3 and the Simpson's index ($1/D$) is 21.0, resulting in an average index value of 12.2. In comparison, at selective-grazing sites, the Shannon-Wiener index (H') is 2.6 and the Simpson's index ($1/D$) is 7.6, with an average index value of 5.1. The results indicate a significantly higher species diversity at non-selective-grazing sites.

4.2.6. Water infiltration capacity

The capacity of soil to infiltrate water, known as soil permeability, refers to the quality of soil enabling it to transmit water and air through its pores. Soil permeability is influenced by soil texture, structure, and the amount of organic matter in the topsoil and on the soil surface. It plays a crucial role as it affects the supply of moisture, air, and nutrients available for plant uptake and microbial activity. High soil permeability typically results in increased phytomass production.

During the 2024 assessment, water infiltration was measured for the first time. The results, indicating the time it takes for 25 mm of water to fully infiltrate the soil, showed that water

infiltration at the non-selective-grazing sites averaged 5 minutes and 31 seconds, significantly higher than at the selective-grazing sites, where it averaged 13 minutes and 11 seconds.

This increased water infiltration capacity at the non-selective-grazing sites indicates an increased potential for grass biomass production. Conversely, the selective-grazing sites would experience higher rates of runoff during rainfall events, with less capacity to produce grass biomass.

4.2.7. Grass biomass production

Above-ground grass biomass production data was sampled during the 2021 (February) and 2024 (January) assessments. The table below shows the average biomass production (at the date of assessment), the biomass production per mm rain (received up to the assessment date) and the grazing capacity based on the biomass method.

Table 13: The average grass biomass production, biomass production per mm rain and the grazing capacity based on the biomass method for the three grazing management sites.

Biomass categories	Non-selective-grazing		Selective-grazing	
	2021	2024	2021	2024
Grass biomass production (kg DM/ha)	4 359	3 851	2 633	2 056
Grass biomass production (kg/mm rain)	8.8	10.6	5.3	5.6
Grazing capacity (ha/LSU/year)	2.9	3.0	6.2	6.1
Average grass biomass (kg DM/ha)	4 105		2 345	
Average grass biomass (kg/mm rain)	9,7		5.5	
Average grazing capacity (ha/LSU/year)	3.0		6.2	

The non-selective-grazing sites exhibited the highest average grass biomass production, recording 4,105 kg DM/ha (9.7 kg/mm rain), with an estimated grazing capacity of 3 ha/LSU/year. Conversely, the selective-grazing sites showed a lower level of biomass production, measuring 2,345 kg DM/ha (5.5 kg/mm rain), with an estimated grazing capacity of 6.2 ha/LSU/year. The difference in grass biomass production, and consequently grazing capacity, can largely be attributed to the substantial difference in water infiltration (as discussed above).

Additionally, due to intensive grazing at the non-selective-grazing sites, a substantial portion of this biomass (estimated at 75%) is consumed during grazing cycles. On the other hand, at the selective-grazing sites, approximately 30% of the surface area is covered by patches of the highly unpalatable grass *Aristida junciformis*, which are avoided by grazers, severely restricting overall biomass utilization.

4.2.8. Grazing capacity combined

To get a more accurate estimation of the grazing capacity at the end of the study period, the two methods used, the benchmark method and the biomass method, are combined in the table below.

Table 14: The estimated grazing capacity during the end of the study period based on the two methods used.

Method	Non-selective-grazing	Selective-grazing
Benchmark method (ha/LSU/year)	3.71	4.01
Biomass method (ha/LSU/year)	2.95	6.15
Average (ha/LSU/year)	3.3	5.1

The combined estimation of grazing capacity at the end of the study period suggests that the non-selective-grazing sites achieved an average capacity of 3.3 ha/LSU/year, while the selective-grazing sites reached 5.1 ha/LSU/year. Notably, the non-selective-grazing sites exceeded the long-term grazing capacity norm for the region, despite utilising a stocking density 3.3 times higher than the norm for the region.

4.3. Other results and observations

During the study, certain observations were made which are not part of the scope of the study or which do not directly or currently reflect in the data. These observations, which mainly focus on the non-selective-grazing portion of the study area, are discussed below.

4.3.1. Biomass removal

The rate at which above-ground biomass is removed (grazed and trampled) during non-selective-grazing cycles was added towards the end of the study. This was done by measuring biomass production before and after grazing cycles. Although only two surveys have been done so far, and much more data is needed to substantiate the results, it is included here (with recognition of its anecdotal status).

Table 15: Above-ground phytomass levels before and after a grazing cycle during non-selective (UHDG) grazing.

No.	Position in terrain	Biomass before (kg DM/ha)	Biomass after (kg DM/ha)	Biomass removed (kg/DM/ha)	Biomass removed (%)
1	Valley bottom	7 471	1 566	5 905	79,0
2	Footslope	4 799	1 380	3 419	71.2
Ave		6 135	1 473	4 662	76.0

The data indicates that a significant portion of above-ground phytomass is removed during non-selective-grazing cycles, with between 70% and 80% removed in a single cycle.



Figure 18: The level of grass biomass before and after a grazing cycle.

4.3.2. Bankrupt bush

Bankrupt bush (*Seriphium plumosum*), also locally known as Slangbos, is a common indigenous encroacher shrub in the grassland biome of South Africa. It is believed to increase during selective-grazing and may have severe implications, if not controlled, on grazing capacity and botanical diversity.

The observations regarding bankrupt bush, or Slangbos, suggest that while it may increase in areas subjected to selective grazing, it faces significant pressure in non-selective-grazing areas due to the trampling action during UHDG. This pressure leads to a reduction in its height, cover area, and growth vigour, potentially allowing space for the establishment of young grasses in its place.



Figure 19: It is observed that Bankrupt bush is impacted by trampling and new grasses established in areas previously occupied by it.

4.3.4. Impact on unpalatable grasses

The non-selective-grazing portion of the study area contains significant numbers of highly unpalatable perennial grasses, remnants of historic overgrazing and known for their persistence. Observations regarding the high levels of trampling on these unpalatable grass species, primarily *Aristida junciformis* and *Cymbopogon dieterlenii*, offer valuable insights into the dynamics of grassland ecosystems under non-selective-grazing.

Despite experiencing less trampling compared to Bankrupt bush, as discussed earlier, these unpalatable grasses still face considerable pressure. This pressure, not reflected in the assessment data, manifests as severely disrupted growth and low levels of seed production (see photos below).

Their persistence underscores their resilience to the impacts of non-selective-grazing. However, the emergence of broad-leaved grass seedlings within trampled tufts suggests potential shifts in vegetation composition over time. These observations underscore the complexity of interactions between different plant species and grazing regimes, emphasizing the necessity for ongoing monitoring and research to enhance our understanding of ecosystem dynamics and inform management practices.



Figure 20: It was observed that large tufted unpalatable grasses are light to moderately grazed (left) and often heavily trampled (right). In some instances, broad-leaved grass seedlings were seen growing in the centre of trampled tufts (photo centre).

4.3.5. Birdlife

The observation of diverse bird species in the non-selective-grazing area, particularly during summer, suggests a dynamic ecological interaction between grazing livestock, vegetation, and avian populations. The presence of various bird species, including Ibis, herons, ducks, geese, and lapwings, indicates a rich avian biodiversity within the study area.

The association of these birds with grazing cattle highlights their ecological dependence on grazing activities. Birds may follow cattle to forage on insects attracted to dung deposits or to capitalize on newly exposed vegetation and associated prey. This phenomenon underscores the interconnectedness of different trophic levels within the ecosystem.

Furthermore, the potential impact of bird activity, such as the deposition of guano, on soil fertility and nutrient cycling represents an intriguing area for further research. Understanding the role of birds in nutrient dynamics and ecosystem processes could provide valuable insights into the ecological functioning of grassland ecosystems under grazing regimes.

4.3.6. Dung beetles

The observed increase in dung beetle species following the implementation of UHDG presents an interesting ecological phenomenon worth further investigation. Dung beetles play a vital role in nutrient cycling and soil health by facilitating the decomposition of organic matter, including livestock dung.

The absence of certain dung beetle species before UHDG suggests that the management practice may have created favourable conditions for their establishment and proliferation. Factors such as increased dung availability, altered vegetation structure, and reduced disturbance levels could have contributed to this phenomenon.

Comparing dung beetle populations between different grazing management approaches, such as non-selective-grazing and selective-grazing, could provide valuable insights into the impact of grazing intensity and pattern on dung beetle diversity and abundance. Longitudinal studies assessing changes in dung beetle communities over time would help elucidate the dynamics of this ecosystem component in response to grazing management practices. Additionally, investigating the functional role of dung beetles in nutrient cycling and soil ecosystem services would further enhance our understanding of their ecological significance in grassland ecosystems.

4.4. Summary of results

Below is a synthesis of the findings from our five-year study, starting with the changes observed between 2019 and 2024 at the non-selective-grazing sites, followed by a comparative analysis of results between these sites and the selective-grazing sites at the end of the study period.

Non-selective-grazing sites 2019 to 2024:

- The number of grass species increased from 23 in 2019 to 34 in 2024.
- The proportion of decreaser grasses increased by 16.7%, from 15.2% in 2019 to 32% in 2024, with the number of decreaser species increasing from nine to fourteen.
- Grasses with a purely tufted growth habit decreased in favour of tufted grasses with rhizomes and those capable of prostrate growth, marking a 15% increase, comprising mostly large and palatable species.
- Smaller-sized grasses decreased in favour of larger species.
- A notable 8.4% increase in climax grasses occurred, predominantly over subclimax species.
- The composition of C3 (cool-season) grasses increased from 1% to 14%, encompassing five additional species.
- Veld condition score percentage increased from 43% in 2019 to 53% in 2024.
- Grazing capacity improved by 0.6 ha/LSU/year. This improvement was achieved at an average stocking density of 1.2 ha/LSU/year (3.3 times the departmental norm of 4 ha/LSU/year).

Non-selective-grazing sites vs. Selective-grazing sites (end of the study period):

- Non-selective-grazing sites exhibited a higher proportion of decreaser grass species, constituting 31% and 14 decreaser species, while selective-grazing sites recorded 10% and 6 species.
- Both management approaches predominantly featured tufted grasses, with selective-grazing sites showing a 22% higher proportion of smaller creeping grasses.

- Non-selective-grazing sites displayed a greater prevalence of larger tufted grasses with rhizomes (a 20% variance), while selective-grazing sites favoured small-sized grass species, accounting for 27% of the composition.
- Non-selective-grazing sites boasted a 28% proportion of grasses with a high grazing value, contrasting with 10% at selective-grazing sites, reflecting the most significant difference between the two approaches.
- Non-selective-grazing sites identified 11 grass species with high grazing values compared to four at selective-grazing sites.
- The presence of species with low grazing value remained relatively high at both grazing management approaches, with non-selective-grazing sites at 48% and selective-grazing sites at 51%.
- Climax grasses showed a substantial disparity between the two management approaches, with non-selective-grazing sites comprising 68% and selective-grazing sites 26%.
- Selective-grazing sites exhibited a higher prevalence of pioneer and subclimax grasses, constituting 75% of the composition compared to 32% at non-selective-grazing sites.
- While non-selective-grazing sites had higher veld condition scores, estimated grazing capacity, and number of grass species, the differences were not significant compared to selective-grazing sites.
- Non-selective-grazing sites documented a greater total number of forb species (99 vs. 71), albeit with lower average density.
- Nine indigenous legume species, at 8.5% occurrence, were recorded at non-selective-grazing sites compared to four species, at a low 1.6%, at selective-grazing sites.
- Botanical diversity, indicated by Shannon-Wiener and Simpson's indices, was notably higher at non-selective-grazing sites (average index of 12.2), compared to the selective-grazing sites (average index of 7.6).
- Water infiltration capacity, indicated in the time it takes for 25 mm of water to fully infiltrate the soil, was significantly higher at non-selective-grazing sites at 5' 31'', compared to 13' 11'' at the selective-grazing sites.
- Grass biomass production was higher at non-selective-grazing sites, at an average of 4,105 kg DM/ha (9.7 kg/mm rain), compared to selective-grazing sites, measuring 2,345 kg DM/ha (5.5 kg/mm rain).
- The estimated grazing capacity, based on the biomass method, was significantly higher at the non-selective-grazing sites at 3 ha/LSU/year. Conversely, at the selective-grazing sites, it was 6.2 ha/LSU/year.

Conclusion

At the conclusion of this five-year study, several encouraging outcomes were observed at the non-selective-grazing sites. These include notable increases in the number of grass species, the abundance of good grazing grasses, climax grasses, and C3 (cool-season grasses), as well as improvements in overall veld condition and grazing capacity.

In comparison to the selective-grazing sites, the non-selective-grazing sites demonstrated superior performance across all criteria, albeit to varying degrees. The most significant variances favouring non-selective-grazing included the proportion of good grazing grasses, botanical diversity, water infiltration capacity, and estimated grazing capacity based on the grass biomass method.

Conversely, the smallest disparities between the two grazing management approaches were observed in the veld condition score and grazing capacity, both assessed using the benchmark method. These minor differences primarily stem from the remarkable resilience of a few strongly perennial, unpalatable grass species to the impact of non-selective-grazing. Notably, these species include Ngongoni three-awn (*Aristida junciformis*), Threat-leaved turpentine grass (*Cymbopogon dieterleniae*), and Tough love-grass (*Eragrostis plana*). While these species persist longer than anticipated in the data sets, evidence of significant trampling damage and a gradual decline in their numbers are recorded. These slow changes underscore the importance of long-term research, particularly in the mesic grassland biome, where botanical composition alterations occur at a notably slow pace.

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The End

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