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THE EFFECT OF CONTINUOUS GRAZING ON HERBACEOUS SPECIES COMPOSITION, BASAL COVER AND PRODUCTION ON THREE SOIL TYPES IN THE NORTH WEST PROVINCE, SOUTH AFRICA

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ABSTRACT

Rangeland health is normally measured by soil condition, grass species composition as well as its acceptability to grazing herbivores. The impact of grazing on community structure and ecosystem functioning is a key issue for rangeland management in order to maximize livestock production and sustainability of the operations. Year-round continuous grazing is the management strategy used in the communal areas of the North West Province of South Africa. In this study the effect continuous grazing on herbaceous species composition, basal cover and production on different soil types was tested. It was clear from the results that the effect of continuous grazing was the biggest on the andesitic soils (high clay), then the diabase soils (medium clay), whilst the effect on the quartzite soils was limited to even positive. The end result was that the different soil types in a continuous grazing system led to serious selective grazing in this study.

Contribution/Originality: The paper's primary contribution is finding that continuous grazing on different soil types has a definite influence on herbaceous species composition, basal cover, and production. The clayey soils are more negatively influenced than the sandy soils.

1. INTRODUCTION

Approximately one third of the earth's land surface is occupied by grazing land ecosystems (Delgado et al., 2011; MEA, 2005; Teague, 2017; Wang, Teague, Park, & Bevers, 2018). At least 1 billion rural and urban people depend on these ecosystems for their livelihoods, often through livestock production, or for ecosystem services that affect human well-being (Ragab & Prudhomme, 2002; Teague, 2017) Grasslands or rangelands cover approximately 40% of the earth's land surface and represent about 70% of the agricultural area (Abdalla et al., 2018; Conant, 2012; Wang & Fang, 2009). Rangelands are regarded as the main nutrient source for livestock (Khuliso, Moyo, Mmbi, & Silinda, 2021) and this creates a continuous interaction between livestock and plants within the rangeland's ecosystem (McNaughton, 1979). However, it is believed that many of the world's rangelands are degraded as a result of excessive livestock grazing (Gamouna, Pattonb, & Hanchi, 2015). The rangeland health condition is normally measured by soil condition, grass species composition and abundance as well as its acceptability to grazing herbivores (Snyman, 1998). The impact of grazing on community structure and ecosystem functioning is a key issue for rangeland management in order to maximize livestock production and sustainability of the operations (Jacobo, Rodríguez, Bartoloni, & Deregibus, 2006) In the short term, grazing can influence the structure of plant communities by removing plant tissues and, in the long term, by changing botanical composition and species diversity through selective grazing (Jacobo et al., 2006; Teague & Dowhower, 2003). Overgrazing of grassland typically decreases tall and more palatable perennial grass species to shorter, unpalatable perennial grass species (Teague & Dowhower, 2003). This is often followed by an increase in prostrate grasses (Mitchley & Grubb, 1986), annuals (Teague & Dowhower, 2003), forbs (Bullock et al., 2001) and finally bare ground (Teague & Dowhower, 2003).

However, overgrazing not only changes the structure and composition of the vegetation, but it also affects the soil structure as well as the relationship between water and the microclimate (Gamoun, 2013). According to Snyman and Du Preez (2005); Taboada, Rubio, and Chaneton (2011) soil compaction and soil temperature increase as degradation increase due to an increase in grazing intensity. Water infiltration decreases and water run-off increases in most soil types as the grazing intensity increases, whilst the organic matter content decreases with overgrazing (Ahmed, Schuman, & Hart, 1987; Snyman & Du Preez, 2005; Taboada, Rubio, & Chaneton, 2001). Grazing intensity not only has the potential to modify soil structure, function, and capacity but also to store organic carbon (OC) and could significantly change grassland C stocks (Abdalla et al., 2018). According to these authors recent studies have suggested that intensive livestock management has led to C losses from many grasslands around the world and therefore, grassland soils could potentially become a source rather than a sink for greenhouse gas (GHG) emissions.

Year-round continuous grazing is the management strategy used in the communal areas of the North West Province (NWP) of South Africa. This type of continuous grazing is well known to result in severe loss of plant basal cover, serious changes in the herbaceous species composition and herbaceous production (Hawkins, 2017; Jordaan, Van Rooyen, & Strydom, 2019; Jordaan & Van Rooyen, 2020). The communal areas in the North West province are all open-access systems, in other words there is little to no control over the animal numbers in the area, whilst the commitment to natural resource management is little to none (Jordaan & Bareki, 2018; Peden, 2005). According to (Hardin, 1968) the 'tragedy of the commons' reasons that it is more profitable for an individual to overstock the 'commons' (i.e. communal lands) because he derives the entire benefit from each additional animal, but the cost is shared by all. Due to this phenomenon, a growing number of livestock will populate the rangeland and will eventually exceed its ecological carrying capacity, which will lead to rangeland degradation. It is a known fact that the communal areas in the NWP are 200% to 600% overstocked (Jordaan & Bareki, 2018). A comprehensive study was done in 367 magisterial districts of South Africa in 1999, where experts of these districts had to give inputs, amongst other things, about the rangeland condition, soil condition, and reasons for the status of the rangelands and soils in these districts (Hoffman, 1999). Results from this study showed that the mean values, for the severity of rangeland degradation in the NWP was almost three (3) times (63%) higher in the communal areas than in the commercial areas (Hoffman & Todd, 1999). The mean values for the severity of soil degradation in the NWP the was four (4) times (±80%) higher in the communal areas than in the commercial areas.

The spatial extent of the NWP in South Africa is 105 703.4km^2 (DEDECT, 2018). The total land used for communal farming is 3 312 873ha of which 2 360 898ha (±62%) is rangeland. The main livestock profile for the communal farmers is 45% goats, 40% cattle and 15% sheep (DAFF, 2017). The total number of farming units in the communal sector are 147 400 (DAFF, 2017). The communal sector is thus characterized by a high number of people and animals on small farming units. This might be the reason why Garland, Hoffman, and Todd (1999) and Hoffman and Todd (1999) indicated that both soil and rangeland degradation in the NWP is almost three to four times higher in communal farming areas that in commercial farming areas.

Certain communal areas, especially in the western parts of the NWP, are characterized by homogeneous geology and soil type. However, most of the communal areas in the NWP are characterized by different geological parent rocks and soil types in one area. It is a known fact that soil type has an influence on the palatability or acceptability of grass. A study was done on a farm of the Department of Agriculture and Rural Development

(DARD) of the NWP to mimic a communal area that consists of different geological parent rocks and thus soil types. The hypothesis put forward was that differences in palatability or acceptability in the grasses would occur as a result of difference in the soil types and that this would lead to certain areas being over-utilized while others were under-utilized.

2. MATERIALS AND METHOD

2.1. Study Area

The study area falls within the Dry Highveld Grassland (Mucina & Rutherford, 2006) of the North West Province Figure 1 of South Africa. This vegetation type falls within the Grassland. Characteristics of this Biome is that it is dominated by grasses and that it has a semi-arid climate (Low & Rebelo, 1998).

Figure-1. Orientation of the North West Province in South Africa.

The geology of the study area is mainly andesitic lavas of the Allanridge Formation and diabase of the Ventersdorp Supergroup whilst quartzite of the Pretoria Group is to a lesser extent, also present (Mucina & Rutherford, 2006). The soil originating from andesite is dark grey to black in color with a clay content of 47 – 50%. The soils originating from diabase are dark reddish brown in color with a clay content of ±30% whilst the quartzite soils are shallow and rocky with a clay content of between 15 – 20%. Both the andesite and diabase soils are slightly alkaline whilst the base status is relatively high (Szymański & Szkaradek, 2018). The palatability or acceptability of the grasses on these soils is relatively high. Quartzite soils are normally slightly to strongly acidic, whilst the base status is normally moderate to low – the palatability of the grasses on this soil is normally moderate to low (Neely & Barkworth, 1984).

The study area receives summer rainfall, whilst the winters are dry. The mean annual precipitation (MAP) is approximately 573mm (Mucina & Rutherford, 2006). The bulk of the rainfall in the study area is between December and March. The study area is characterized by great seasonal and daily variations in temperature. Mean monthly maximum and minimum temperatures are 29°C and 2°C in January and June, respectively (Mucina & Rutherford, 2006). The absolute maximum temperatures range up to 39°C (Low & Rebelo, 1998), with the absolute minimums ranging between -9.1°C and -10.2°C (Weatherbase, 2021).

As was mentioned, the study area is dominated by a well-developed grass layer (Low & Rebelo, 1998). Some of the dominant grass species on the andesite and diabase soils are *Themeda triandra*, *Setaria sphacelata*, *Cymbopogon pospischilii*, *Panicum coloratum*, *Digitaria argyrograpta*, *D. eriantha*, *Eustachys paspaloides* and *Eragrostis curvula*. The quartzite soils are characterized by grass species like *Andropogon schirensis*, *Schizachyrium sanguineum*, *Diheteropogon* *amplectens*, *Triraphis andropogonoides* and *Tristachya rehmannii* (Acocks, 1988; Mucina & Rutherford, 2006).

2.2. Experimental Outlay

The study area falls within the Tlokwe municipal district (agricultural area). The farm of DARD is situated just outside the town of Potchefstroom. In Figure 2 the DARD farm with the specific area allocated for the continuous grazing trial is indicated.

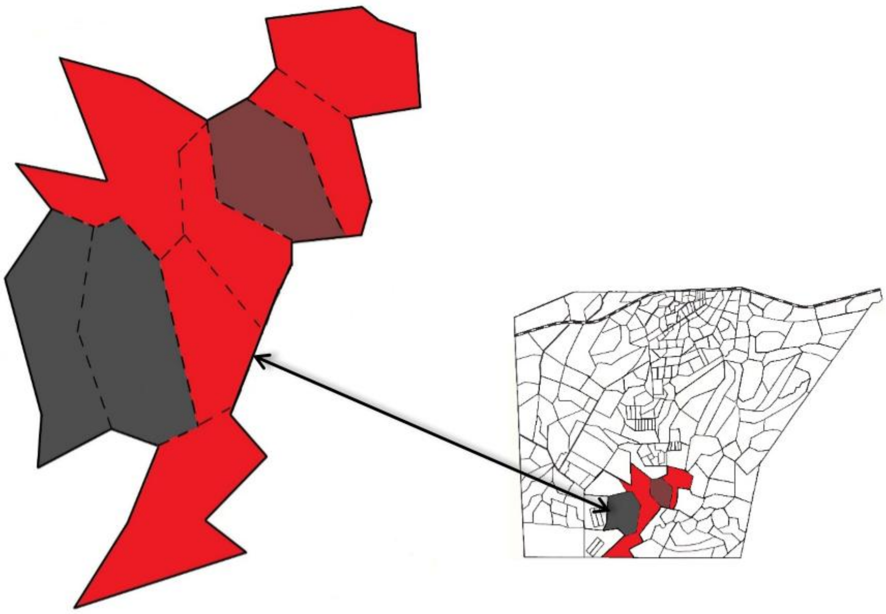

Figure-2. The farm of DARD with the identified area of the trail (dotted lines = original fence lines removed) (black = andesite soil; red = diabase soil; brown = quartzite soil).

The area originally consisted of nine paddocks. After removing the inner fence lines a paddock of 197ha was formed. Within this paddock124.1 ha (62.9%) was on diabase, 52.8 ha (26.8%) was on andesite and 20.2 ha (10.2%) was on quartzite. The treatment applied was year-round continuous grazing (no rest periods) and the area was stocked according to the norm of the area which was ±6ha/LSU. Single bull mating was done in a limited mating season during the summer. Calves were weaned at seven months and removed from the trial. Culling and replacement were done at the same time. A replacement rate of 20% was applied. The cows received a dicalcium phosphate salt lick in the summer and a rumen stimulating lick during the winter. Water points and licks were placed on all soil types to ensure possible even distribution of the animals - if animals occurred more on one soil type than the other it should not be due to the uneven distribution of the water points and licks.

Two fixed transects of 1500m were placed on each soil type where all the data capturing took place. There were thus six monitoring sites (2 x andesite; 2x diabase; 2 x quartzite).

2.3. Data sampling

2.3.1. Rainfall

Rain gauges were erected at the test site. Rainfall figures were recorded directly after a rainstorm.

2.3.2. Herbaceous Species Composition and Basal Cover

The botanical composition and basal cover were done biennially using the wheel point method of Tidmarsh and Havenga (1955). The nearest grass species within a radius of 30cm from each point was noted. If an annual plant was the closest to the point, the nearest perennial plant within the 30cm radius was noted. If no grass occurred within this radius of 30cm, it was noted as bare ground. Bare ground was thus recorded as a "vegetation species", and equates to the lack of herbaceous cover within that point (radius of 30 cm for this study) (Coetzee, 2006; Leggett, Fennessy, & Schneider, 2003). Point observations were done on the fixed transects; the points were spaced at 1 m intervals and 1 500 points were surveyed per transect. 3 000 Points were thus done biennially on each soil type. This data was not only used to detect the changes, if any, in the herbaceous species composition, but it was also used to calculate the rangeland condition.

2.3.3. Herbaceous Production

Above ground phytomass (production) of the herbaceous layer, and thus available grazing material, was determined at the beginning of the growing season (November) and at the end of the growing season (May). The Dry Weight Rank Method (DWRM) of Mannetje and Haydock (1963) as adapted by Kelly and McNeill (1980) and Barnes, Odendaal, and Beukes (1982) and described by Kirkman (1999) were used. 50 x 1m^2 quadrates were placed alternately along the permanently marked transects at the beginning and at the end of the season. Care was taken that an area was not cut twice in one season as well as not in subsequent seasons, to eliminate the cutting effect on the production capacity of the grass species. Each quadrate was sub-divided into four smaller quadrants – a total of 200 points were thus surveyed at each transect on each soil type. As there were two fixed transects per soil type it means that 400 production points were done at the beginning of the season on a soil type and again at the end of the season on that same soil type. In total there were 1 200 herbaceous production datapoints done at the beginning of the season and again at the end of the season (3 x soil types x 400 points).

However, before the production estimates and ranking of the species are done in the quadrants, each surveyor harvested a proportion of the quadrats so that a regression could be established between the estimates and the corresponding actual mass of the material in the harvested quadrats. It is important to note that calibration is specific to each operator, and calibrations are necessary on each sampling occasion (Kirkman, 1999). The herbaceous material was dried for 48 hours at 70°C, left for one day to stabilize after which it was weighed, and the herbaceous production calculations were done.

2.3.4. Grazing Capacity

The average grazing capacity of the rangeland for each soil type was calculated using the herbaceous production data. The formula used for this calculation is shown in the paragraphs where the data analysis is discussed.

2.3.5. Utilization Percentage

The utilization percentage for each soil type over the duration of the study was calculated.

2.4. Data Analysis

2.4.1. Rainfall

Daily rainfall figures were recorded in an Excel spreadsheet. The monthly rainfall was calculated and from these monthly figures the seasonal rainfall was calculated. A season runs from July to June.

2.4.2. Herbaceous Species Composition and Basal Cover

The first step in the data analysis of the species composition data was to use different ordinations within the CANOCO 4.5 package (Ter Braak & Smilauer, 2002) in order to determine if differences did occur in the species composition between the three different soil types.

For the calculation of the rangeland condition index the classification of the grasses for this paper was based on the quantitative climax method of Dyksterhuis (1949) and adapted according to the ecological information for the arid to semi-arid regions of South Africa (Foran, Tainton, Booysen, & De, 1978; Gibbs Russell et al., 1990; Tainton, Edwards, & Mentis, 1980; Van Oudtshoorn, 2002; Vorster, 1982). For this paper the species were classified according to the grazing-index and rangeland condition scores were calculated to convey multivariate information about the current state of the vegetation at a site. Classification according to the grazing-index grouped species into: (i) highly desirable species (HD), (ii) desirable species (DE), (iii) less desirable species (LD), (iv) undesirable species (UD) and bare ground (BG). The grouping of the species was also verified with specialists' knowledge for the particular survey area. Each class was given a relative index value: highly desirable species = 10; desirable species = 7; less desirable species = 4 and undesirable species = 1 (Vorster, 1982). The range condition index was calculated by summing the percentage composition of grass species in each class, after which the sum for each class was multiplied by its relative index value.

The basal cover was calculated by dividing the number of "hits" per species by the total number of points on the transect. A "hit" was noted when the tip of the spoke of the wheel point apparatus fell into the center (base) of a living grass plant.

2.4.3. Grazing capacity

The herbaceous species were classified according to the grazing-index and were grouped as (i) highly desirable and desirable species (HD + DE), (ii) less desirable species (LD), (iii) undesirable species (UD) as discussed in point 2.4.2. The total production (kg/ha) was calculated by the DWRM (Kirkman, 1999). These results were then used in the following formula to obtain the grazing capacity (ha/LSU) for each survey area on each soil type (Moore & Odendaal, 1987):

10/((Production of HD+DE*0.35) + (Production of LD*0.20) + (Production of UD*0.05))*365

Where:

10 = kg DM needed per LSU/day.

0.35; 0.20; 0.05 = utilization factors.

365 = one year.

2.4.4. Utilization Percentage

The utilization percentage was calculated using the following formula:

$$\frac{\text{Total herbaceous biomass beginning of season} - \text{total herbaceous biomass end of season}}{\text{Total herbaceous biomass beginning of season}} \times 100$$

The trial started during the 1996/1997 season and ended during the 2010/2011 season – a duration of 15 years.

3. RESULTS

3.1. Rainfall

The result of the rainfall data for the 1996/97 to 2010/11 is shown in Figure 3. The 54-year long-term mean rainfall for the study area 586.7mm. From the rainfall figures it is clear that eight (8) seasons can be described as extremely wet receiving between 132mm and 492mm more rainfall than the long-term average, with the last two seasons of the study being the wettest. The 2009/10 and 2010/11 seasons received 1079mm and 1073mm respectively. Three (3) seasons can be described as wet, receiving between 23mm and 87mm more rainfall than the 54-year long-term mean for the area Figure 3. Only one (1) season (2004/05 season) can be described as a normal rainfall year. It is further evident from this figure that three (3) seasons can be described as dry years. The driest season was the 2003/04 season where only 395mm of rain was recorded. This is approximately 192mm less rain that the 54-year long-term mean for the study area.

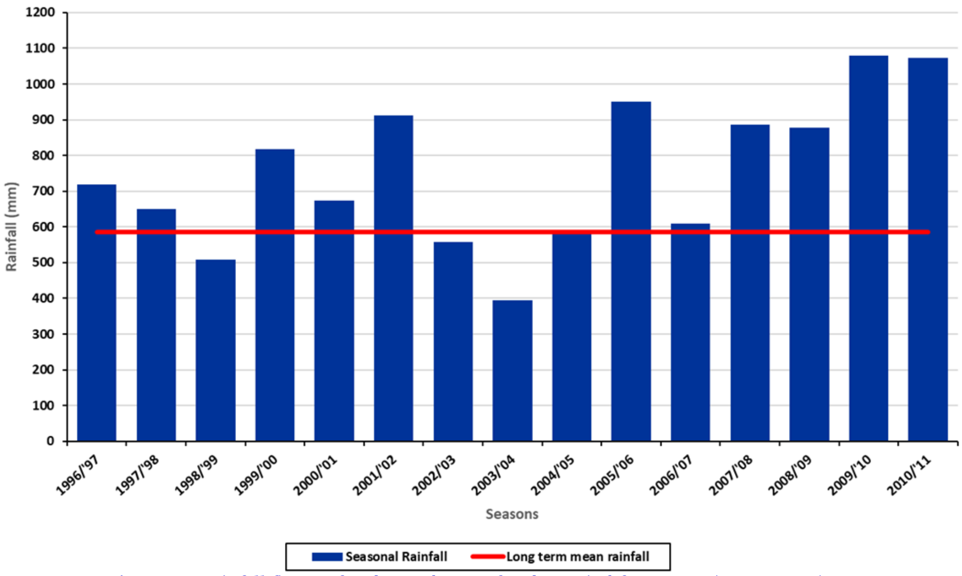

Figure-3. Rainfall figures for the study area for the period from 1999/97 to 2010/11.

3.2. Herbaceous Species Composition and Basal Cover

The ordination results of the Detrended Correspondence Analysis (DCA) of the herbaceous composition data of the three soil types are shown in Figure 4.

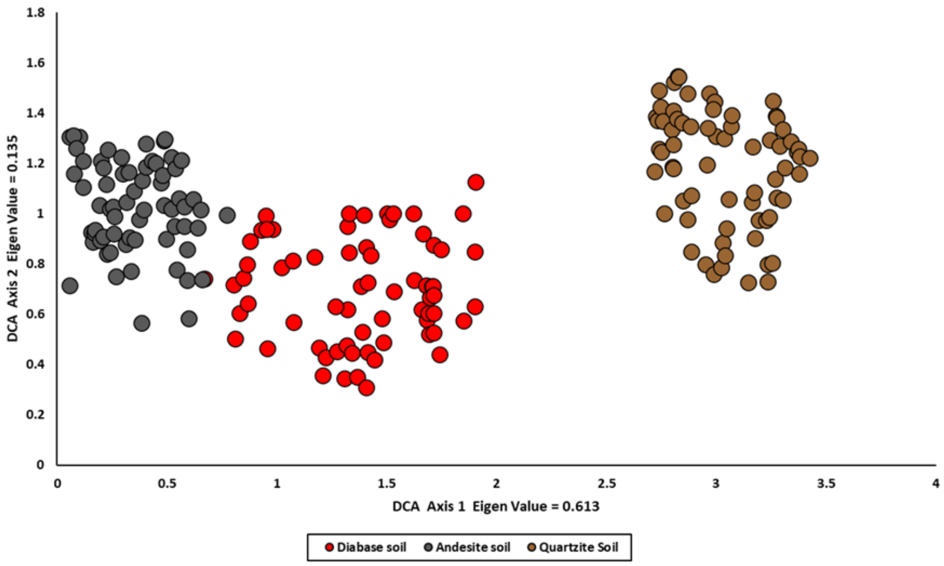

Figure-4. A DCA ordination of the herbaceous species composition data on the three soil types.

From this figure it is clear that the herbaceous species composition of the three soil types differed from each other. However, the compositions of the andesite and diabase soils were more comparable with each other than with the quartzite soils. Both the andesite and diabase soils are deep and relative clayey soils (clay % > 30%) whilst the quartzite soils are shallow, stony with less than 20% clay. Both the andesite and diabase soils are dominated by *Themeda triandra*, whilst *Setaria sphacelata* and *Digitaria argyrograpta* are more in abundance on the diabase soils than the andesite soils. *Digitaria eriantha* and *Setaria nigrirostris* are more abundant on the andesite soils than the diabase soils. *Eustachys paspaloides* and *Sporobolus fimbriatus* were present on the diabase soils but totally absent on the andesite soils.The quartzite soils were characterized by the abundance of species like *Diheteropogon amplectens*, *Schizachyrium sanguineum*, *Triraphis andropogonoides*, *Trachypogon spicatus* and *Tristachya rehmannii*. The grazing value of all these species is moderate to very low (Van Oudtshoorn, 2002).

The rangeland condition calculated from the species composition is indicated in.

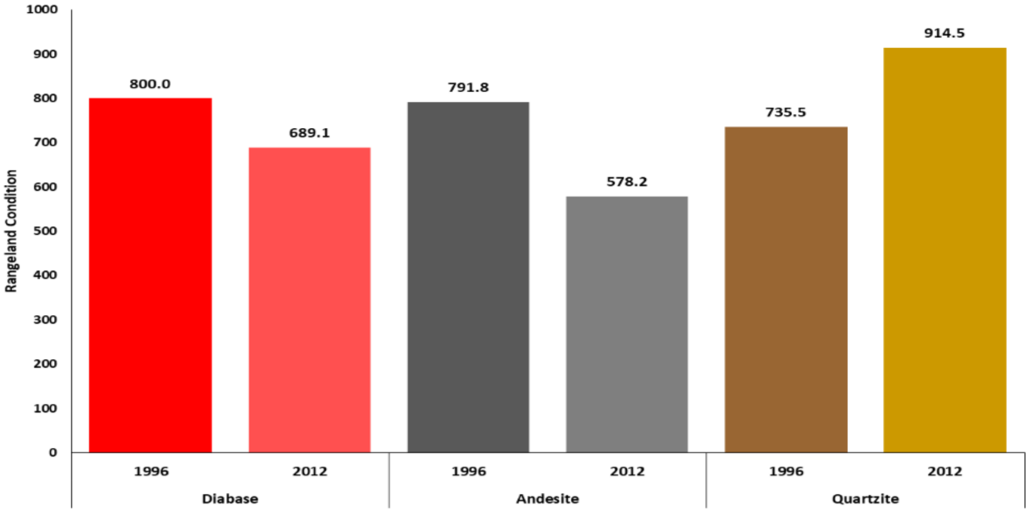

Figure-5. The rangeland condition scores of the three soil types.

From this figure it is clear that the rangeland condition of both the diabase and andesite soils decreased whilst that of the quartzite soils increased. In the andesite soils the decrease was from 791.8 to 578.2 which is a 27% decrease. In the diabase soils the decrease was approximately 14% - from 800 to 689.1. However, the rangeland condition of the quartzite soils increased from 735.5 to 914.5 which is an increase of approximately 24%. The decrease in rangeland condition is related to the abundance of the highly desirable and desirable grass species. Figure 6 shows the changes in abundance of the highly desirable and desirable herbaceous species over the study period on the different soil types. In the diabase soils the percentage abundance in the highly desirable and desirable grass species decreased steadily over study period from 65.9% (1996) to 40.9% in 2012. It was mainly the abundance of *Themeda triandra*, *Digitaria eriantha* and *Eustachys paspaloides* which decreased, whilst the abundance of *Setaria sphacelata* (desirable species) increased. In the andesite soils the decrease in the highly desirable and desirable species was from 63.9% (1996) to 22% (2012). This decrease can be mainly attributed to the decrease in percentage abundance of *Themeda triandra*. This species made up 61.6% of the composition in 1996 while its occurrence was only 1.9% in 2012. The opposite trend occurred in the quartzite soils – the highly desirable and desirable species increased from 25.2% in 1996 to 61.3% in 2012. This increase was mainly due to an increase in the abundance of *Setaria sphacelata* (from 16% in 1996 to more than 50% in 2012). The decrease in abundance of the highly desirable and desirable species in 2004 on all three soils types can be attributed to the extremely low rainfall (395mm) that was received.

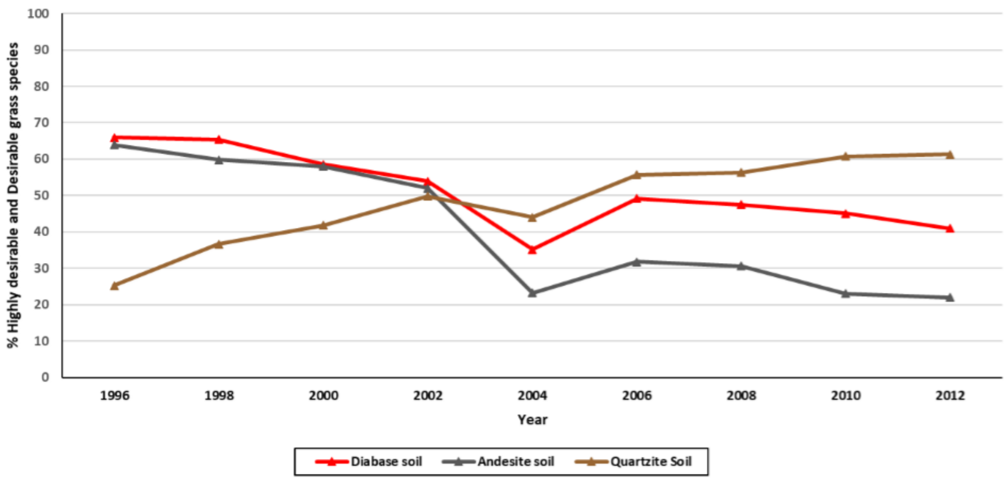

Figure-6. Change in abundance of the highly desirable and desirable grass species on the tree soil types.

The results of the effect of the grazing system on the three soils types on the basal cover are shown in Figure 7.

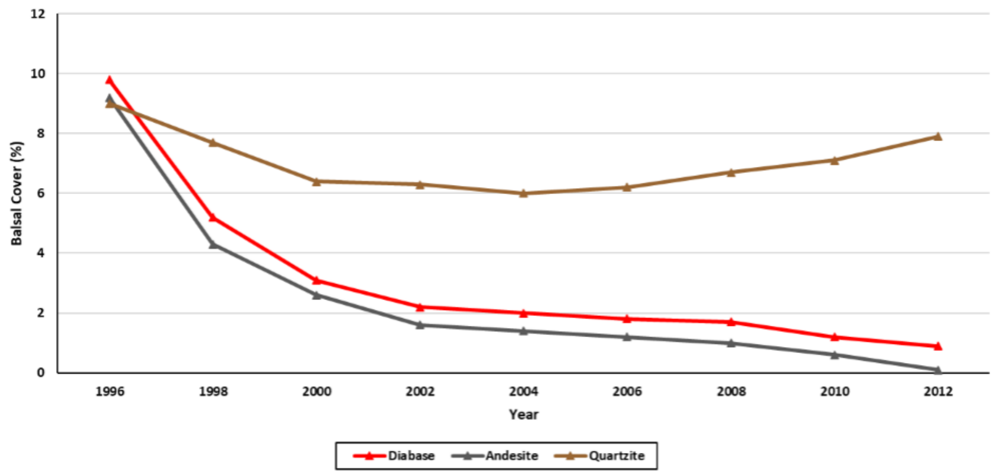

Figure-7. Change in the basal cover on the tree soil types.

From this figure it is clear that the percentage basal cover of all the soil types was almost the same at the start of the study – 9.8% for the diabase soils; 9.2% for the andesites soils and 9% for the quartzite soils. It is further evident that the percentage basal cover decreased in both the diabase and andesite soils. In the diabase soils the decrease was from 9.2% (1996) to 1% (2012). In the andesite soils the percentage basal cover was 9.2% in 1996 and only 0.1% in 2012. The percentage basal cover in the quartzite soils decreased initially but increased steadily again from 2002 and was 7.9% in 2012.

3.3. Herbaceous Production

The herbaceous production results for the study period is indicated in Figure 8.

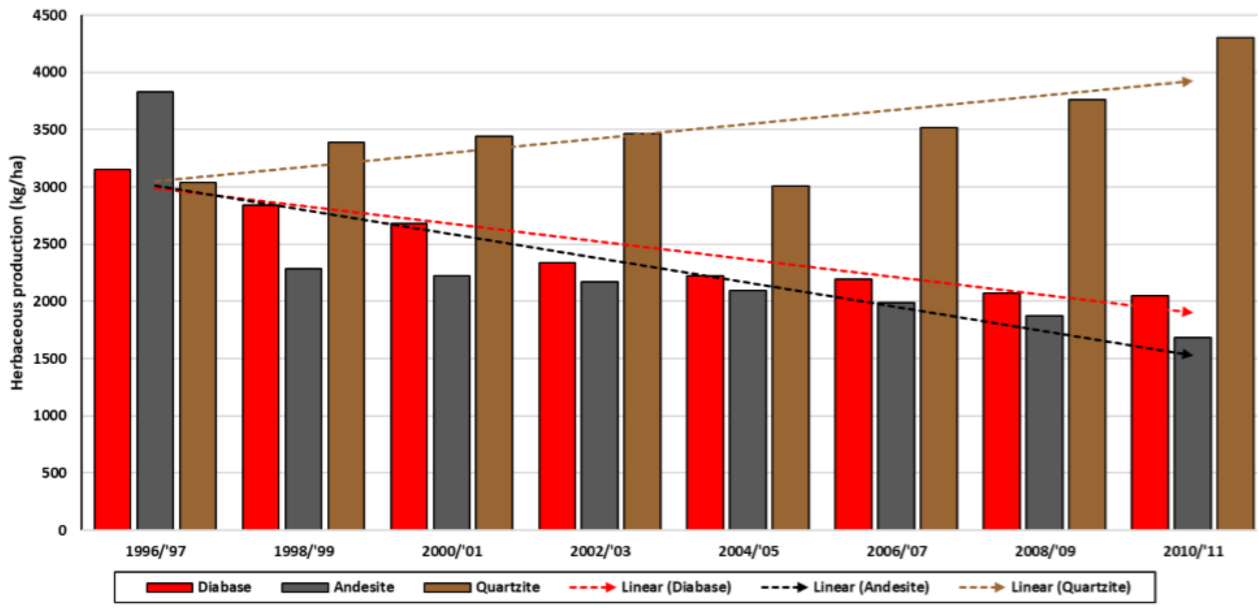

Figure-8. The herbaceous production on the three soils types for the study period.

From the trend lines it is clear that the herbaceous production in both the diabase and andesite soils decreased whilst it increased in the quartzite soils. The production on the diabase soils decreased from 3152.1kg/ha at the beginning of the study to 2048.9kg/ha at the end of the study – a decrease of 1103.2kg/ha or 35%. On the andesite soils the production decreased from 3833.1kg/ha to 1683.9kg/ha. This is a decrease of 56% in the herbaceous production. The production on the quartzite soils increased with almost 42% over the study period – from 3039.9ka/ha (1996/97) to 4305.3kg/ha (2010/11).

3.4. Grazing Capacity

The grazing capacity at the beginning and end of the study period is indicated in Figure 9. It is clear that the grazing capacity figures of the diabase (6ha/LSU) and andesite (5.7ha/LSU) soils were at the beginning of the study in line with the norm of the area which is 6ha/LSU. The grazing capacity of the quartzite soils was almost 2ha/LSU higher than the norm of the area. This can be attributed to the species composition of the quartzite soils which is characterized by grass species with low palatability of acceptability.

As the grazing capacity is linked to the herbaceous production it is no surprise that it increased for both the diabase and andesite soils whilst it was slightly better for the quartzite soils. In the quartzite soils the grazing capacity changed from 7.9ha/LSU (1996) to 6.3ha/LSU in 2012 – this change is mostly due to the increase in abundance of *Setaria sphacelata*. In the diabase soils the grazing capacity changed from 6ha/LSU to 10.2ha/LSU. This was mostly because the percentage abundance of species like *Themeda triandra*, *Eustachys paspaloides* and *Digitaria eriantha* decreased over the study period. The biggest change was in the andesite soils where the grazing capacity changed from 5.7ha/LSU to 15.7ha/LSU. As was mentioned the percentage abundance of *Themeda triandra* was more than 60% at the beginning of the study and only approximately 2% at the end of the study. Other palatable species like *Heteropogon contortus* and *Digitaria eriantha* also decreased in abundance of the andesite soils.

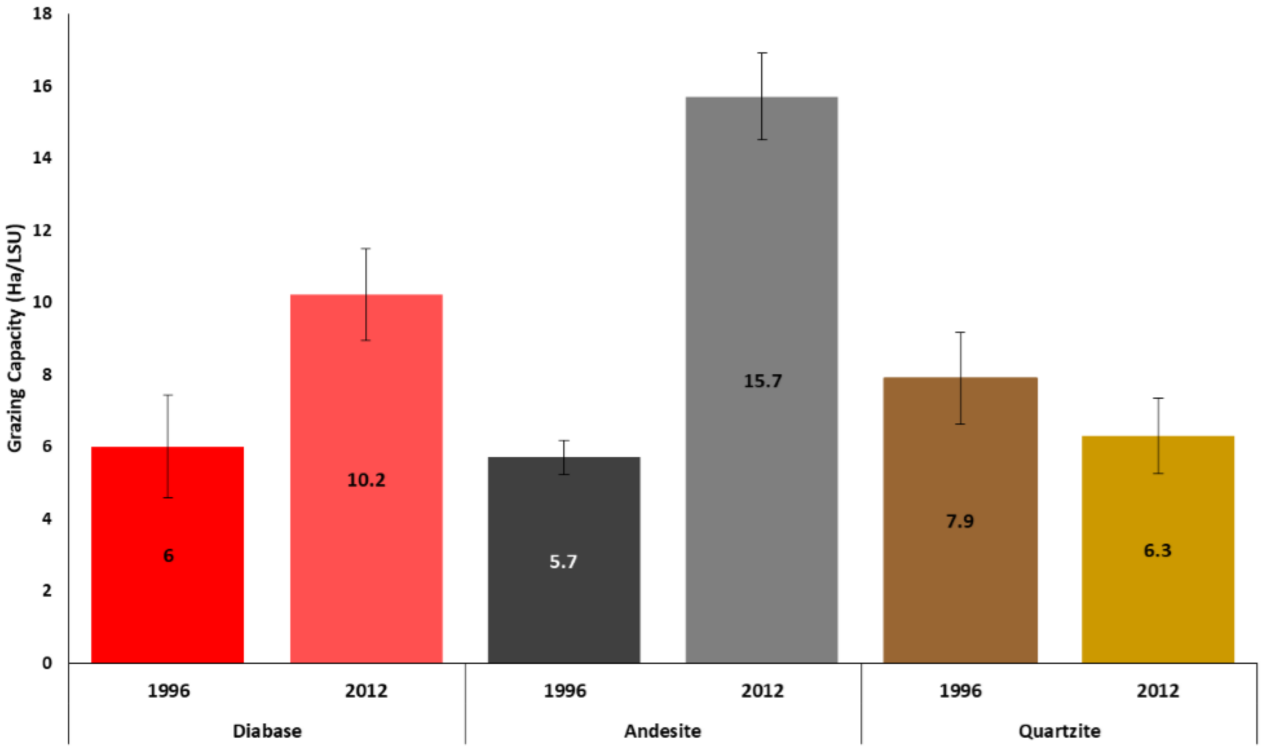

Figure-9. The grazing capacity figures at the beginning and end of the study period on the three soil types.

3.5. Utilization Percentage

The average utilization percentage of the grass species over the 15-year study period is indicated in Figure 10.

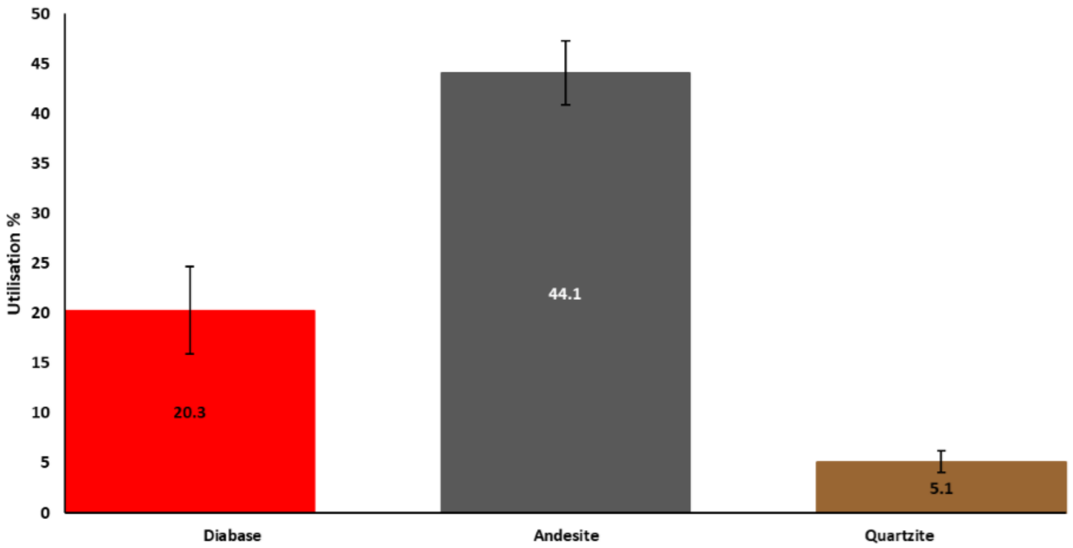

Figure-10. The average utilization percentage of the grass species over the 15-year study period.

The average utilization percentage of the herbaceous layer on the andesite soils was 44.1%, on the diabase soils 20.3% and on the quartzite soils only 5.1%. The utilization percentage on the andesite soils was twice as high as on the diabase soils and almost nine times higher than on the quartzite soils. The utilization percentage of the five most palatable species in the study area (*Themeda triandra*, *Setaria sphacelata*, *Digitaria eriantha*, *D. argyrograpta* and *Heteropogon* contortus) was also calculated and indicated in Figure 11.

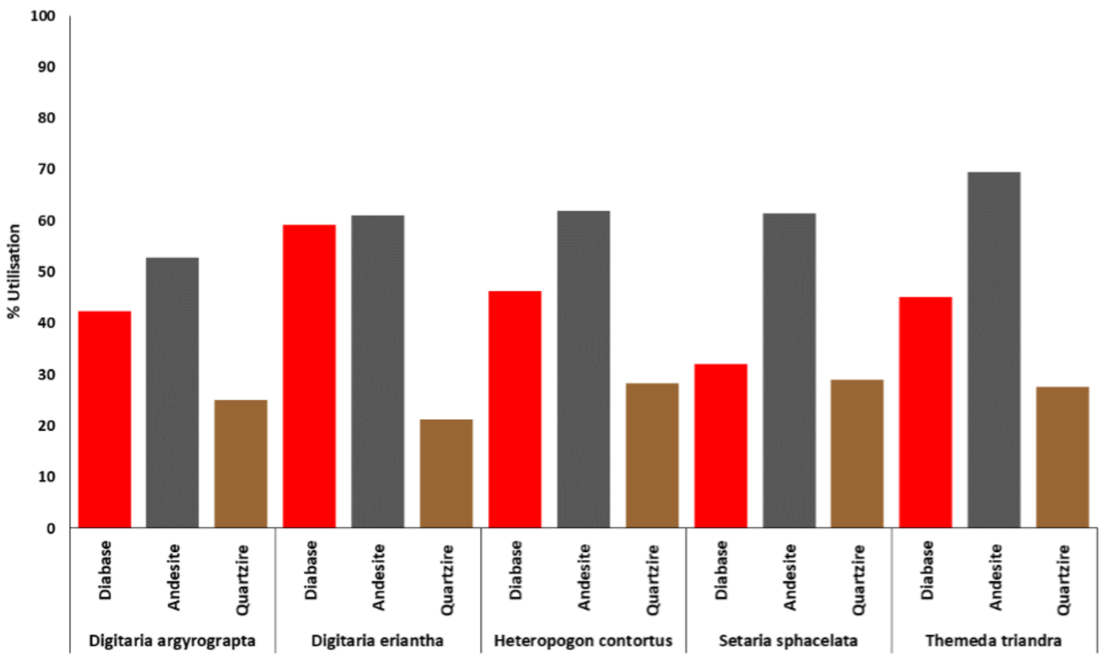

Figure-11. The average utilization percentage of the five most palatable grass species in the study area.

From this figure it is clear that the utilization percentage of the species on the andesite soils is all above 60% except for *D. argyrograpta* (52.8%). The species with the highest utilization percentage is *T. triandra* with 69.5%. The utilization percentage of these species on the diabase soils was mostly between 42% and 46% with the exception of *S. sphacelata* (32.1%) and *D. eriantha* (59.1%). The utilization percentage of these species on the quartzite soils was never above 30% and varied between 21% and 29%.

4. DISCUSSION

From the results presented in Figure 5 to Figure 11 it is clear that the andesite soils were affected the most by the continuous grazing system, whilst the diabase soils were affected to a lesser extent. According to Teague and Dowhower (2003); Kellner and Bosch (1992) and Norton (1998) patch-selective grazing normally occurs in large paddocks that are continuously grazed. From Figure 6 it is clear that there was a drastic decrease in the percentage highly desirable and desirable species on the andesite soils, especially since 2004, and to a lesser extent on the diabase soils. In Figure 7 it is also indicated that the basal cover of both the andesite and diabase soils decreased over the study period and was only 0.2% and 1% respectively at the end of the study. According to Sternberg, Gutman, Perevolotsky, and Kigel (2003) continuous grazing, and especially heavy grazing pressure, reduced seed bank densities of grasses. O'Connor and Pickett (1992) indicated that the removal of reproductive structures under heavy grazing may lead to situations in which seed banks become a limiting factor for recovery or persistence of the palatable vegetation. The results obtained in the mentioned studies therefore agree with the results of this study. From Figure 3, it is clear that the percentage incidence of the highly acceptable and acceptable species did not recover on the andesitic soils after the drought year, even though the last part of the study was characterized by above-normal rainfall. Figure 11 shows that the utilization rate of *Themeda triandra* was about 70% on the andesitic soils – this high utilization intensity led to this species virtually disappearing from the composition of these soils. As was mentioned, that the 2003/04 season was an extremely dry year. The combination of the drought together with the heavy grazing of the highly desirable and desirable species, especially during the growing season, might thus have led to a decrease in the seed bank densities of these species, especially on the andesite soils and to a lesser extent on the diabase soils.

From Figure 8 it is clear that there is a constant decrease in the herbaceous production of the diabase and especially the andesite soils. This decrease might be attributed to the following as described by Briske et al. (2008): Chronic, intensive grazing is detrimental to plants because it removes leaf area that is necessary to absorb photosynthetically active radiation and convert it to chemical energy. This reduction in energy harvest is manifest in all aspects of plant growth and function because photosynthesis provides the total energy and carbon source for growth. A chronic, intensive reduction in photosynthetic leaf area negatively impacts root systems by reducing energy available to support existing root biomass and new root production. Root mass, branch number, vertical and horizontal root distribution, and root longevity all may be reduced by chronic, intensive defoliation. This reduces the ability of severely grazed plants to effectively access soil water and nutrients that often limit plant growth and biomass production on rangelands. The decrease in above ground production in this study was the biggest on the andesite soils (56% decrease in production) and the diabase soils (35% decrease). Due to the fact that the animals naturally avoided the quartzite soils there was a 42% increase in the biomass production. Abdalla et al. (2018); Ahmed et al. (1987) and Taboada et al. (2011) also proved that heavy grazing and the trampling effect that accompanies it, increased the soil temperature and compaction and decreased water infiltration and thus water availability. This ultimately led to a decrease in plant community composition, above ground biomass, leaf area and light interception and thereby, net primary production.

5. CONCLUSION

According to Gamoun (2013) several authors have viewed heavy grazing as the major cause of rangeland degradation. This author also indicated that the most important factor affecting the structure of vegetation in an ecosystem is soil and soil type. The hypothesis put forward for this study was therefore proved true as it was clear that soil type had a definite influence on the herbaceous species composition, basal cover, and production in the continuous grazing system. These differences led to severe selective grazing. These results suggest that utilization of rangelands in communal areas needs to be improved through grazing management procedures that consider geological parent rock and thus ultimately different soil types occurring in these areas. Management strategies that consider vulnerable soil types (especially soils higher in clay) need to be implemented in communal areas of the North West Province of South Africa. If this is not done degradation and even total destruction of the rangeland will be the end result.

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