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THE EFFECT OF LAND-USE ON HERBACEOUS PRODUCTION AND GRAZING CAPACITY IN THE MOLOPO DISTRICT OF THE NORTH WEST PROVINCE, SOUTH AFRICA

Franci Jordaan[1+]
Jaco Van Rooyen[2]

[1,2]*Pasture Science Division, North West Dept. of Agriculture & Rural Development, Potchefstroom, South Africa.*
[1]*Email: fjordaan@nwpg.gov.za*
[2]*Email: jvanrooyen@nwpg.gov.za*

(+ Corresponding author)

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ABSTRACT

There are three main types of rangeland management systems in South Africa, namely commercial livestock farming, communal livestock farming and game farming. In commercial farming you normally find one manager/owner with a specific management plan, whilst communal farming is characterized by numerous land users with no specific management plan. The communal areas are also normally overstocked and this overstocking leads to rangeland degradation. In this study the effect of two land-uses (commercial and communal) on herbaceous production and grazing capacity were studied. It was clear from the results that the herbaceous production of the communal rangelands was lower than that of the commercial rangelands. The grazing capacity figures showed that sustainable farming practices were also not possible if the communal rangeland is in a poor condition – this was not even possible in good rainfall years.

Contribution/Originality: This study is one of very few studies which have investigated herbaceous production and grazing capacity in the Molopo district of the North West Province of South Africa. The paper's primary contribution is finding that broad extrapolations between commercial and communal farming is scientifically incorrect.

1. INTRODUCTION

Approximately one third of the earth's land surface is occupied by grazing land ecosystems (Delgado et al., 2011; MEA Millennium Ecosystem Assessment, 2005; Teague, 2017). 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). It is believed that many of the world's rangelands are degraded as a result of excessive livestock grazing (Gamouna, Pattonb, & Hanchi, 2015).

Three main types of rangeland management systems can be found in South Africa: commercial livestock farming, communal livestock farming and game farming. These management systems differ in: (1) management structure, (2) animal diversity, (3) management of grazing resources, and (4) products (De Lange, 1994; Smet & Ward, 2005). The commercial farming enterprise is a well-developed industry in South Africa and is practiced on approximately 86 million hectares of farm land (DAFF (Department of Agriculture Forestry & Fisheries), 2017; De Lange, 1994; Smet & Ward, 2005). In a commercial livestock farming system, the grazing system determines the pattern of movement. Commercial producers usually make long-standing choices regarding livestock type and grazing system, but they may alter animal numbers year by year. Vegetation management is concerned with decisions on resting (in effect animal movement), fire regime, and the interaction between fire and grazing (planted pastures are not considered) (O'Connor, Kuyler, Kirkman, & Corcoran, 2010). In a commercial livestock enterprise you will normally find a single manager/owner, who farms with one or at the most two cattle species, the management of the grazing resource is through rotational grazing on uniform vegetation units and the product produced is a high quality single product for domestic and international markets (Smet & Ward, 2005).

The second rangeland management system is communal livestock farming – this is done on approximately 15million hectares of farmland (DAFF (Department of Agriculture Forestry & Fisheries), 2017). These areas are, however, increasing due to land reform and land restitution (Vetter, 2013). Communal rangelands are areas that are not privately owned, but belong to entire communities whose members have equal access to free resources (Scogings, De Bruyn, & Vetter, 1999). Communal land in South Africa is subject to a variety of tenure systems but most of the South African, and specifically the communal areas of the North West Province in South Africa, is now open-access rather than being managed as common property, with decreasing commitment to natural resource management (O'Connor et al., 2010; Peden, 2005). In a communal livestock enterprise there are thus many managers who farm with many different cattle species, the management of the grazing resource is continuous grazing on diverse vegetation and the products are a high quantity and a big diversity of products mostly for personal use (Smet & Ward, 2005).

The objectives of communal rangeland users differ markedly from those of commercial rangeland users (Peden, 2005). The objective of commercial farmers is marketing of the cattle to be economically sustainable. In communal rangelands cattle support multiple livelihood strategies and are used for milk, traction, bride-wealth, investment, manure, ceremonial slaughter and transport (Hall & Cousins, 2013; Peden, 2005). Cattle sales are thus generally low and this leads to communal areas being overstock which in turn leads to overgrazing and ultimately to rangeland degradation. In this paper degradation is defined as a deleterious change in the rangeland for livestock production, encompassing a range of changes, including a shift in species composition from desirable to unpalatable species, a decline in basal cover of perennial grasses, an increase in the density of woody shrubs/trees, a decline in water use efficiency, a decline in net primary production, and an increase in soil erosion (Palmer & Bennett, 2013). Rangeland degradation in the communal areas may manifest as a permanent decrease in primary productivity and a concomitant reduced ability of the rangeland to support livestock (Todd & Hoffman, 2000). Hoffman, Todd, Ntshona, and Turner (1999) found that communal areas in South Africa were, on average, stocked 1.9 times higher than commercial areas.

The spatial extent of the North West Province in South Africa is 102 881km^2 (NWREAD (North West Department of Rural Environment and Agricultural Development), 2014). The total land used for commercial agriculture in this province is 5 324 000 hectares of which 3 475 000 hectare (±65%) is rangeland (Stats, 2020). The main livestock profile for the commercial farmers is 60% cattle, 25% sheep, 8% pigs and 7% goats (DAFF (Department of Agriculture Forestry & Fisheries), 2017). In the communal sector 3 312 873ha is farmland 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 (Department of Agriculture Forestry & Fisheries), 2017). The total number of farms or farming units in the commercial sector are 4 920 whilst the number of farming units in the communal sector are 147 400 (DAFF (Department of Agriculture Forestry & Fisheries), 2017; Stats, 2020). 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 North West Province is almost three times higher in communal farming areas that in commercial farming areas.

A study is done in the North West Province of South Africa where the effect of communal and commercial land-use on herbaceous production and grazing capacity, amongst other things, is studied. The aim of this paper is not to compare commercial and communal rangeland systems with each other in order to see if one is better than the other, but it is purely to evaluate what the effect of the two systems (land-uses) on the herbaceous biomass and grazing capacity of the rangeland was. Since the geology, soil, vegetation type and rainfall of both the commercial and communal areas are the same or comparable, changes in the measured variables can mostly be attributed to land-use.

2. MATERIALS AND METHOD

2.1. Study Area

The study area falls within the Eastern Kalahari Bushveld (Mucina & Rutherford, 2006) of the North West Province Figure 1 of South Africa. This vegetation type falls within the Savanna Biome. This Biome is characterized by a grassy ground layer and a distinct upper layer of woody plants (Low & Rebelo, 1998).

Figure-1. Orientation of the North West Province in South Africa.
Source: North West Department of Rural Environment and Agricultural Development (2014).

The geology and soils is Aeolian Kalahari sand of Tertiary to Recent age on flat sandy plans and the soils are more than 1.2m deep (Mucina & Rutherford, 2006). The study area receives summer rainfall, whilst the winters are very dry. The mean annual precipitation (MAP) is approximately 350mm to the west and ±450mm to the east (Mucina & Rutherford, 2006). The bulk of the rainfall in the study area is between January and March. The study area is characterized by great seasonal and daily variations in temperature. Mean monthly maximum and minimum temperatures are 35.6°C and -1.8°C in November and June, respectively (Mucina & Rutherford, 2006). The absolute maximum temperatures range up to 42°C (Low & Rebelo, 1998) with the absolute minimums ranging between-8.3°C and -9.7°C (Coetzee, 2006; Mangold, Kalule-Sabiti, & Walmsley, 2002).

As was mentioned, the study area has well developed tree and shrub layers and a grassy ground layer (Low & Rebelo, 1998). Rangelands in good condition are normally dominated by grass species like *Anthephora pubescens*, *Schmidtia pappophoroides* and *Brachiaria nigropedata*, whilst the rangelands in poor condition are dominated by grass species like *Aristida stipitata*, *Schmidtia kalahariensis* and *Pogonarthria squarrosa* (Acocks, 1988; Coetzee, 2006; Mucina & Rutherford, 2006).

2.2. Experimental Outlay

The study area falls within the Kagisano-Molopo municipal district (agricultural area). Within this area three (3) commercial land-users and three (3) communal villages were identified Figure 2.

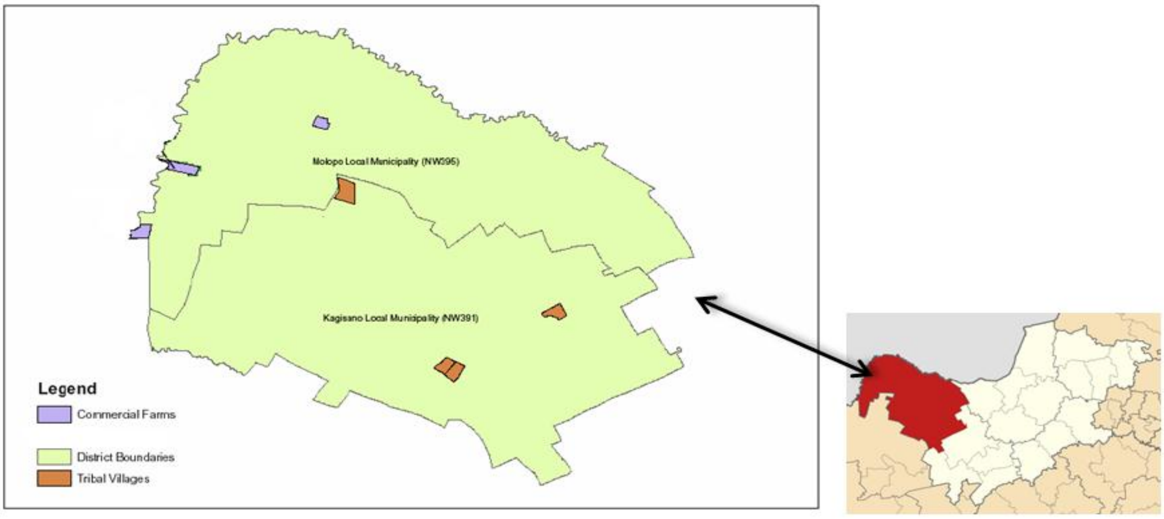


Figure-2. The study area in the Kagisano-Molopo municipal district (red part). Tribal Villages = Communal farming areas.
Source: Coetzee (2006).

The three communal villages were specifically chosen because the tribal authorities gave their permission for and cooperation with the project. They have also promised to put measures in place to ensure that the fencing material of the benchmark sites was not stolen. On each of the commercial farms rangeland in good and poor condition was identified. The identification of good and poor rangelands in the study area was based on the expert knowledge of researchers, technical staff, extension personnel and farmers of the area.

On each farm eight (8) survey sites were identified - three sites in good rangeland; three sites in poor rangeland and one benchmark site in good condition and one benchmark in poor condition. The same rational was followed in the communal villages. The size of a benchmark site was 120m x 30m. In total 48 survey sites were identified - 12 benchmark sites (6 in communal land and 6 in commercial land) and 36 sites (18 in communal land and 18 in commercial land) outside the benchmark sites (will further be referred to as *grazed sites*).

2.3. Data Sampling and Data Analysis

2.3.1. Herbaceous Production

Above ground phytomass (production) of the herbaceous layer was determined in autumn (May) in the grazed as well as in the benchmark sites. 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. In the grazing areas as well as the benchmark sites 30 x 1m^2 quadrates were randomly placed. Each quadrate was sub-divided into four smaller quadrants – a total of 120 points were thus surveyed in each plot. 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.

2.4. 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). The total production (kg/ha) was calculated for each group using the results of the DWRM. These results were then used in the following formula to obtain the grazing capacity (ha/LSU) for each survey plot:

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.

Although this is an ongoing project, herbaceous species composition data from the 2003/2004 to the 2019/2020 seasons (data of 17 years) will be discussed in this paper.

3. RESULTS

3.1. Rainfall

The results of the rainfall data for the 2003/04 to 2019/20 are shown in Figures 3 and 4. The mean average rainfall for the commercial and communal areas was 357±120mm and 456±150mm respectively. These averages correspond well with long term rainfall figures obtained from the farmers of these two areas - a figure of 350mm was given by the framers for the commercial areas and 440mm for the communal areas. From these figures it is further clear that eight (8) seasons can be described as receiving below average rainfall and nine (9) seasons receiving above average rainfall. Although seasons 2006/07 and 2014/15 in the communal areas Figure 4 appeared to be average rainfall years, the distribution of the rainfall throughout the seasons was very erratic - in both seasons the active growing period (January - March) received below average rainfall and was thus identified as 'dry' years. The same tendency occurred during the 2017/18 season in both areas Figures 3 and 4 as well as the 2018/19 season in the communal areas Figure 4. From these figures it appears that above average rainfall occurred, but again below average rainfall was received during the growing season in both areas.

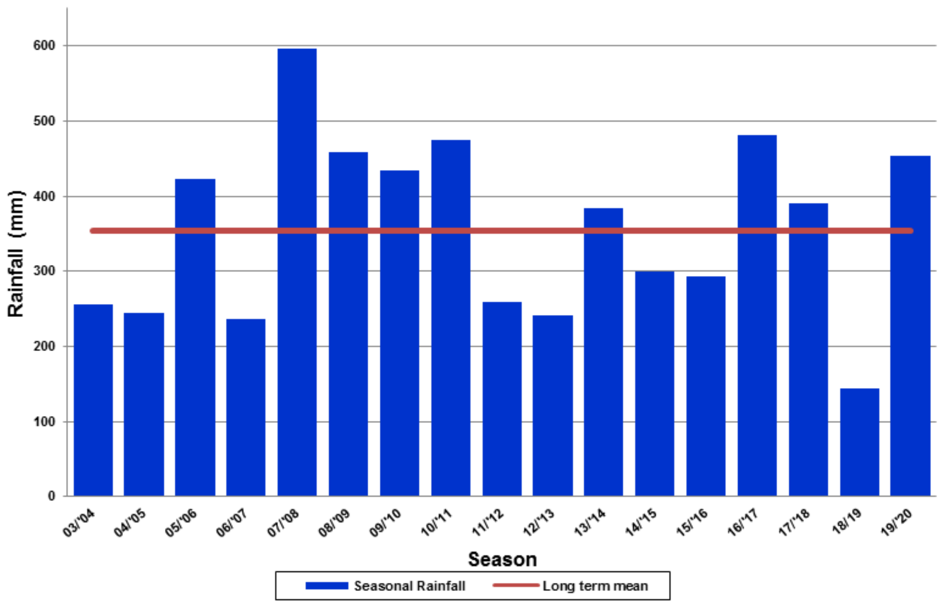


Figure-3. Rainfall for the commercial areas for the period from 2003/04 to 2019/20.

3.2. Herbaceous Production

The results of the herbaceous production for the benchmark and grazed sites are indicated in Figures 5 (a & b). From Figure 5(a) it is clear that the good commercial benchmark site differed significantly from the poor commercial and poor communal benchmark sites, whilst the good communal benchmark sites differed significantly from the poor communal benchmark site during the good rainfall years. The difference in production between the good commercial benchmark sites and the good communal benchmarks sites during the good rainfall years is ±529kg/ha. However, the difference between the good communal benchmark sites and the poor commercial benchmark sites during the good rainfall years is only 153.8kg/ha Figure 5(a).

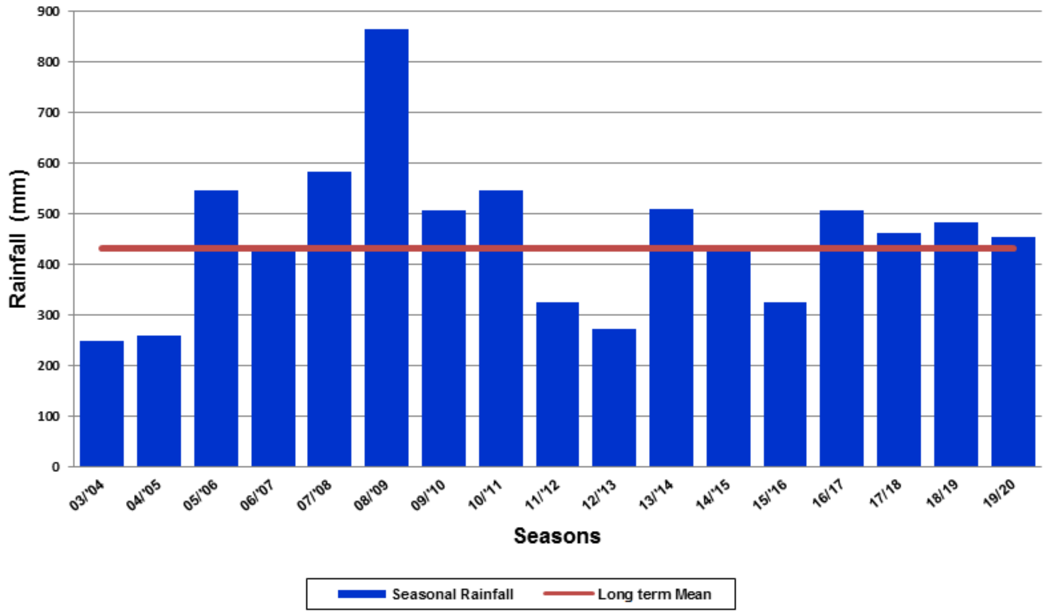
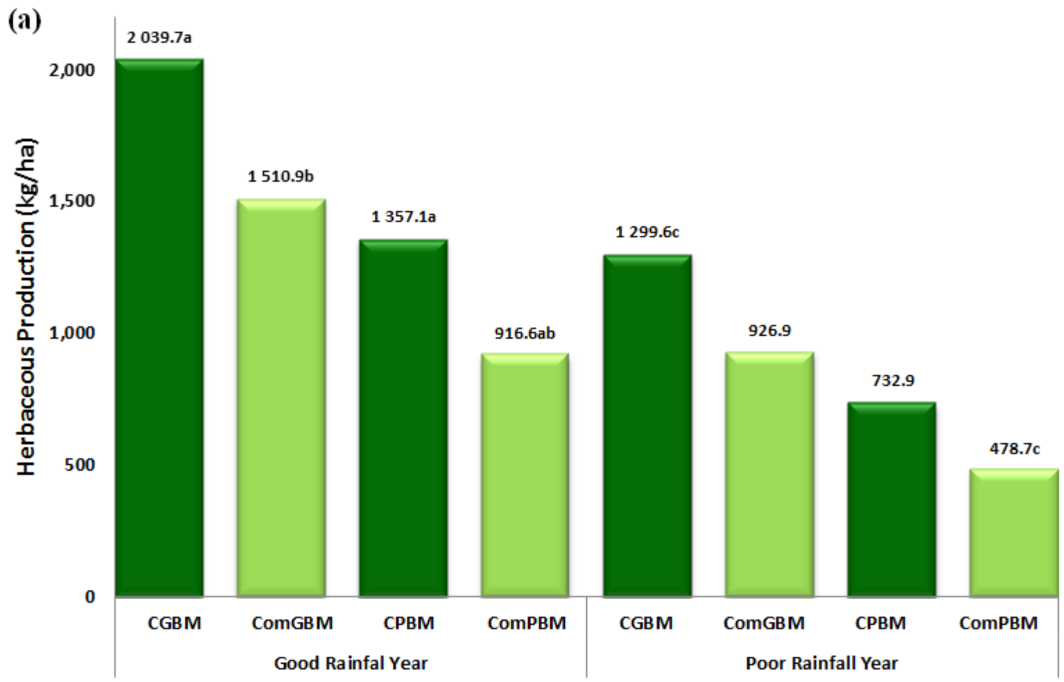


Figure-4. Rainfall for the communal areas for the period from 2003/04 to 2019/20.

The same tendency is visible in the different benchmark sites during the poor rainfall years than that what was seen during the good rainfall years. The only significant difference ($P \leq 0.05$) was between the good commercial benchmark sites and the poor communal benchmark sites. Once again the difference in herbaceous production between the good communal benchmark sites and the poor commercial benchmark sites is relatively small (only 194kg/ha). When the good and poor rainfall years within the benchmark sites are compared to each other, it is clear that rainfall had a definite influence on the amount of biomass produced. In all the commercial and communal benchmark sites the herbaceous production during the poor rainfall years was substantially less than during the good rainfall years. The decrease in the commercial sites was 740kg/ha and 659kg/ha for the good and poor sites respectively whilst it was 584kg/ha and 438kg/ha in the good and poor communal sites respectively.



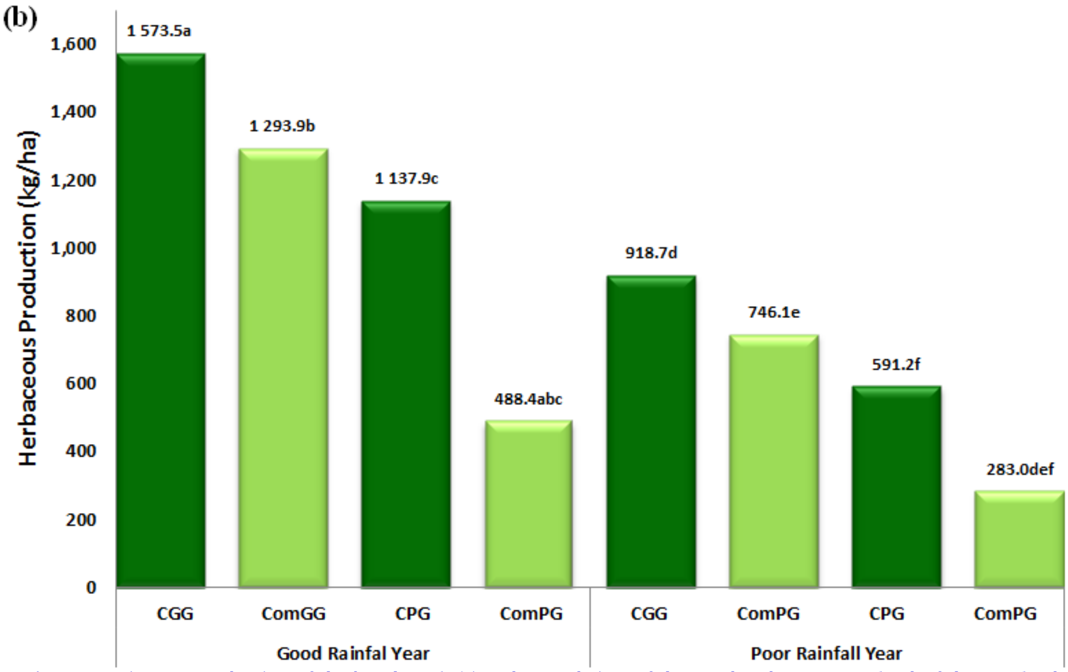
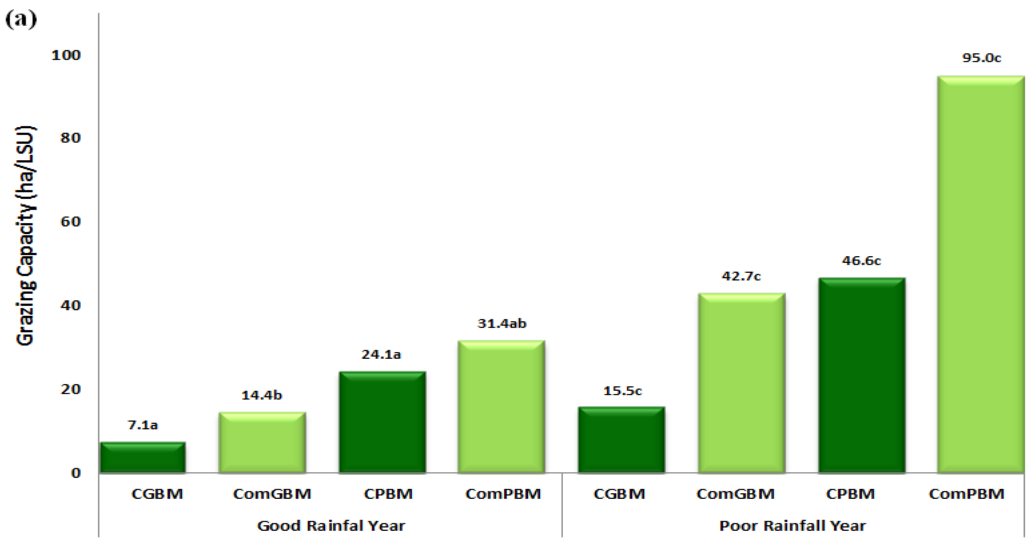


Figure-5. Biomass production of the benchmark (a) and grazed sites of the good and poor rangeland of the two land-uses (CGBM = commercial good benchmarks; ComGBM = communal good benchmarks; CPBM = commercial poor benchmarks; ComPBM = communal poor benchmarks; CGG = commercial good grazed sites; ComGG = communal good grazed sites; CPG = commercial poor grazed sites; ComPG = communal poor grazed sites) ($P \leq 0.05$).

In the grazed sites it is clear that the poor communal sites differed significantly from the good and poor commercial sites as well as the good communal sites during good rainfall years Figure 5(b). In all the other mentioned sites the herbaceous production was above 1000kg/ha whilst is was below 500kg/ha for the poor communal sites. As in the case of the benchmark sites rainfall, or the lack of it, had a huge influence on the herbaceous production. The herbaceous production in all the sites in both land-uses decreased during the low or poor rainfall years. Once again the poor communal sites differed significantly from the good and poor commercial sites as well as the good communal sites during the poor rainfall years.

3.4. Grazing capacity

The grazing capacity results are shown in Figures 6 (a & b).



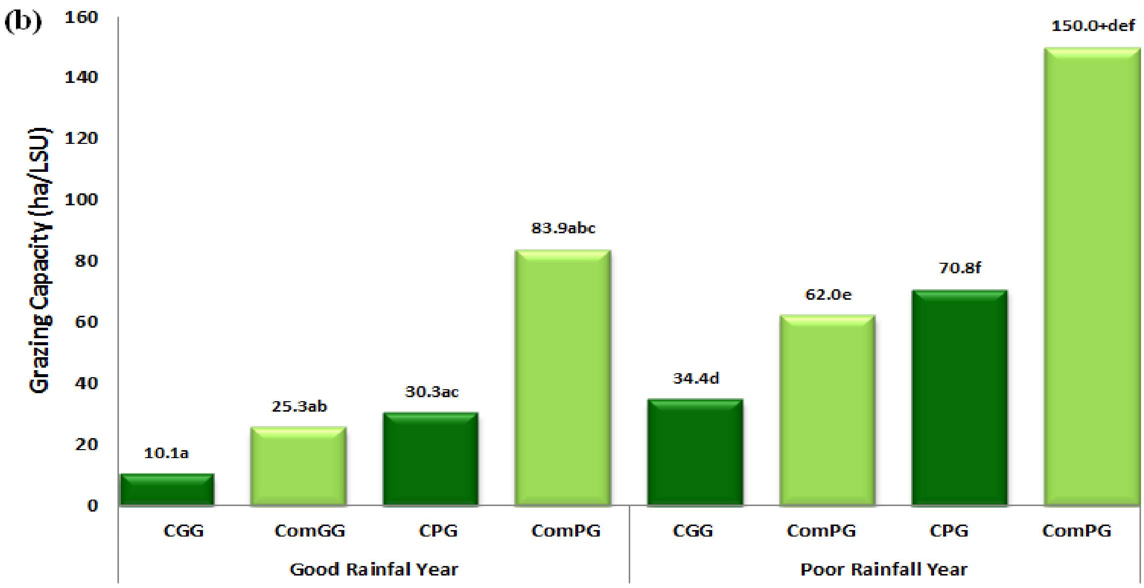


Figure-6. Grazing capacity of the benchmark (a) and grazed sites of the good and poor rangeland of the two land-uses (CGBM = commercial good benchmarks; ComGBM = communal good benchmarks; CPBM = commercial poor benchmarks; ComPBM = communal poor benchmarks; CGG = commercial good grazed sites; ComGG = communal good grazed sites; CPG = commercial poor grazed sites; ComPG = communal poor grazed sites) ($P \leq 0.05$).

The good commercial benchmark sites differed significantly from the poor commercial and poor communal benchmark sites whilst the good and poor communal benchmark sites also differed significantly from each other during the good rainfall years Figure 6(a). It is further evident that the difference between the good commercial and good communal benchmark sites is approximately 7ha/LSU – double the area is thus needed in the communal good rangeland to sustain a large stock unit (LSU) than in the commercial rangeland (good rainfall years).

As in the case of the herbaceous production, rainfall also had a huge influence on the grazing capacity in all the sites of the two land-uses. During low or poor rainfall years the grazing capacity figures of all the benchmark sites in the two land-uses either doubled (commercial sites) or tripled (communal sites). As in the case of the herbaceous production, the difference in grazing capacity between the good communal and poor commercial benchmark sites was not that big – this was especially visible during the poor rainfall years.

In Figure 6 (b) the grazing capacity figures for the two land-uses and the two rainfall scenarios are indicated for the grazed sites. From this figure it is clear that the grazing capacity figures of the good commercial grazed rangeland differed significantly from the good and poor communal as well as poor commercial grazed rangeland during wet years. It is further evident that although the grazing capacity figures of the good communal and poor commercial rangeland did not differ significantly from each other, they both differed significantly from the grazing capacity figure of the poor communal rangeland.

During the poor rainfall year the grazing capacity figure of the poor communal rangeland is indicated in Figure 6(b) as 150+ha/LSU – the actual grazing capacity figure for these rangelands is 519ha/LSU but for visibility purpose of the figure it was indicated as 150+ha/LSU. The grazing capacity figure of the poor communal rangeland differed significantly from the figures of the good and poor commercial and good communal rangelands.

When the two rainfall scenarios are compared it is clear that low or poor rainfall had a negative influence on the grazing capacity figures of both land-uses. All the grazing capacity figures increased which implies that larger areas are needed to sustain a large stock unit as during high rainfall years.

4. DISCUSSION

From the results presented in Figures 5(a & b) it is clear that there are definite differences in the herbaceous production between the two land-uses (benchmark and grazed sites – good and poor rainfall years) and these differences had a distinct influence on the grazing capacity figures of the benchmark sites (good and poor rainfall) as well as of the grazed sites (good and poor rainfall). De Bruyn, Goqwana, and Van Averbeke (1998); Todd and Hoffman (2000) and Palmer and Bennett (2013) indicated in their studies that communal rangelands are normally overstocked and this overstocking does not only have an influence on the species composition of an area but it increases erosion, it decreases water use efficiency and it decreases net primary production. It is a known fact that the communal areas that were studied in this study are approximately 300% overstocked. The differences in herbaceous production between the commercial and communal rangelands (in both the benchmark and grazed sites) are thus an indication of the effect of this overstocking. In both the benchmark and grazed sites (good and poor rainfall) the difference in herbaceous production between the good communal and poor commercial rangeland was relatively small Figures 5(a & b). This phenomenon might be attributed to the herbaceous species composition of the different rangelands. The dominant species in the good communal sites are *Aristida stipitata*, *Stipagrostis uniplumis* and *Eragrostis lehmanniana* whilst *Schmidtia pappophoroides* and *Digitaria eriantha* (formerly known as *Digitaria pentzii*) are also present. The dominant species of the poor commercial rangelands are also *Aristida stipitata*, *Stipagrostis uniplumis* and *Eragrostis lehmanniana* whilst the opportunistic pioneer, *Schmidtia kalahariensis*, is also present in these rangelands. In both the benchmark and grazed sites it as also clear that the good commercial rangelands had a higher herbaceous production than the all the other sites. The good commercial rangelands are dominated by climax species like *Anthephora pubescens*, *Brachiaria nigropedata*, *Panicum kalahariensis*, *Centropodia glauca* and *Schmidtia pappophoroides* – these species are not only extremely palatable but also mostly highly productive species (Van Oudtshoorn, 2012). The decline in the above ground herbaceous production of especially the good and poor communal areas is not only a result of the species composition but may also be attributed to the following, as explained 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 on rangelands.

The reduced ability of the grass plants to produce grazeable material was also portrayed by the grazing capacity figures of the benchmark and grazed sites Figures 5(a & b). From this figure it was clear that sustainable farming is impossible in poor communal areas, even in good rainfall years. During good rainfall years the grazing capacity in the poor grazed communal rangeland was almost 90ha/LSU and this figure was more than 500ha/LSU during drought years. The species composition of the poor communal rangelands consists mostly of low producing annual species which is almost totally absent during drought years. Herbaceous production as low as 25kg/ha was obtained during drought years in the poor communal rangelands – during drought years the rangelands are mostly bear with only a few *Tribulus terrestris* plants. During prolonged drought periods 30% to 50% livestock deaths were reported in the communal areas that were studied. From Figure 6 (b) it is clear that even the poor commercial areas pose sustainability problems – in this case it is because the opportunistic annual grass species, *Schmidtia kalahariensis*, is absent during drought years in the commercial poor sites whilst it is present during good rainfall years. Although the mentioned species is an annual, it provides excellent fodder, especially during the winter (Van Oudtshoorn, 2012). The question that arises from these results is: Can this situation of low herbaceous production and unsustainable grazing capacity figures, especially in poor rainfall years, be reversed, and can it either be done by merely reducing the animal numbers in the communal land-use, or imposing commercial land-use management strategies on these communal areas, especially those practices done in the good commercial rangelands? The answer to the question is NO. Coetzee (2006) and Jordaan, Van Rooyen, and Strydom (2019) found that the good rangeland of the communal land-use is a new stable state with a different species composition than the good rangeland of the commercial land-use. There is a clear indication that a threshold or limit of resilience has been surpassed (state-and transition model) and that the communal rangelands have moved into a new domain of attraction due to prolonged overstocking and mismanagement of the rangeland. In the new stable state of the communal land-use (good rangeland), climax species like *Anthephora pubescens*, *Brachiaria nigropedata*, *Panicum kalahariensis* and *Centropodia glauca* are totally absent whilst the abundance of *Schmidtia pappophoroides* is constantly reducing. These species are mostly replaced in the communal land-use by other climax, sub-climax and pioneer species with a lower production and grazing value (Jordaan et al., 2019).

5. CONCLUSION

It is clear from the results of this study that land-use had a definite influence on the herbaceous production and grazing capacity in the study area. It is further clear that broad extrapolation in terms of management principles cannot be made between different land-uses due to the fact that unique ecosystems have developed out of a specific land-use. It is further evident that more efforts are required by government to monitor and try to prevent further degradation of new 'communal' lands that are part of the land redistribution program (Palmer & Bennett, 2013). Proper training of communal farmers using applicable training methods and material for their unique situations is also something that needs urgent attention (Peden, 2005). Lastly it is evident that policy for the development and sustainable management of the rangeland commons currently lacks a coherent vision and is misaligned with the realities of life in the rural areas (Vetter, 2013). In formulating policies for South African rangelands, it is thus important to recognize that both humans and their livestock are important agents of land-use. Recognition of the ecological and socio-economic diversity in communally used rangelands is thus crucial for appropriate policy formulation. Lastly should policy formulation also be based on actual evidence, rather than general perceptions or unsubstantiated notions (Scogings et al., 1999).

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