Evaluation of Rangeland Grass Species Composition in Different Livestock Land use Systems in Marondera Zimbabwe

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Abstract— *This research work investigated that livestock land use systems influence grass species composition (Density and Biomass), and basal cover. A number of three livestock land use systems; communal livestock land use system, commercial livestock land use system and the resettlement livestock land use system each replicated thrice were assessed using the botanical sampling technique. Grass species density, species biomass and basal cover were measured using 50cm x 50cm quadrats. The collected data was analysed using Minitab version 17 at P≤0.05 significant level. The results revealed that grass species density, biomass and basal cover were lower in the communal livestock land use system than in resettlement and commercial systems. The prevailing grass species were dissimilar where more unpalatable grasses were found dominating in communal areas than in other systems. The invasive and increaser species were found in the communal livestock land use system than in the commercial and resettlement system. Furthermore, the basal cover was lower in the communal grazing lands than in the resettlement and commercial land use systems. Lack of knowledge, high stocking densities as well as poor grazing strategies were ascribed to these results. As a measure against rangeland degradation, there is a need to devise a monitoring scheme or strategy for early recognition of changes as some grass species maybe vanished. The basal cover changes require close attention and monitoring as very low percentages of basal cover might reduce the production potential of the rangeland.*

Keywords— Increaser species, Unpalatable, Invasive species, Stocking density, Species composition.

I. INTRODUCTION

Livestock production is one of the main essential enterprises in Zimbabwe. As of the year 2005 livestock industry contributed 15 to 25% of the total value of agricultural output (Sibanda, 2007). Cattle, goats and sheep are the chief important ruminant species kept, cattle being the most essential while donkeys, pigs and poultry are also reared. Natural grazing remains the principal source of animal feed (Gambiza and Nyama, 2000). Degradation and the unproductiveness of rangelands have been a major problem under this sector. This is relatively accompanied with some drastic losses of vegetation and decline in forage quality, reduced ground cover and above ground biomass production. The current shortage of forage is to some extend hinged to improper veld management practices and lack of knowledge. The ever increasing need for more cropping and settling land has led to the decrease of land left for grazing. Exceeding carrying capacities increased grazing pressure, grazing severity and overgrazing overall posing a great challenge in the livestock production sector. Veld condition can be defined as the state of the veld in relation to its position in plant succession as modified by some disturbance (Westoby *et al*., 1989). Measurement and interpretation of parameters like species composition, basal cover, litter cover, bush encroachment, plant vigour, and soil compaction and erosion compound to veld condition assessment (Westoby *et al*., 1989). Grass species diversity is a good indication of veld condition because different species react differently to grazing pressure. The increaser and decreaser grass species have been used as indicators to appraise veld condition. Categorising these species and monitoring their relative abundance is an essential step for sustainable veld management (Van Rooyen, 2002). The resettlement farming system established through the land reform program by the Zimbabwean government brought some changes to the already existing rangelands (Sibanda, 2007). The program came with the land fragmentation 2 following the handover takeover processes which brought about changes in land management systems. There could be changes in veld species composition due to change in the farming systems from commercial subsectors to the resettlement farming systems. Knowing the changes brought by the difference in management is of essence in making recommendations for monitoring and managing veld condition for maximum production. The farming system influences species richness, species diversity, bush encroachment and biomass yield (Gusha and Mugabe 2013). From the previous research, species richness and diversity were lower in the communal farming system than in the small and large scale commercial farming system (Mugabe and Gusha 2013). According to Mugabe and Gusha (2013), there were notable differences in species composition among farming systems. Invasive, more wiry and weedy grasses were more dominant in the communal farming system than in the large and small scale farming sectors. Poor grazing strategies and high stocking densities were suggested to have attributed to these veld conditions. Considering the great influence of climate and some edaphic factors on the structure and state of vegetation within a veld, there is a need to study relatively similar concepts in a different climate. The veld degradation has been estimated to be 73% in dry land areas of Zimbabwe (Bai *et al*., 2008). This is, however, an attribute of management which is also a major factor under different farming systems. Quantification of species losses occurring in these rangelands needs to be done to mitigate the losses. Understanding the existing forage resources for stock production is an imperative to know type of supplementation for efficient stock production. This provides the basis for persistent monitoring into species alterations happening in communal, resettlement and commercial farming systems. It is as well important in generating information for government policy makers and formulating regulations helpful in preserving or mitigating veld degradation problems as well as monitoring veld for different farming systems. Through information generation, the research can also be helpful to some researchers for further studies under the same subject. Knowing the species composition within the veld is of great importance in calculating the carrying capacities of different rangelands. It allows the farmer to allocate the animals to grazing areas considering the quality and quantity available to the animal. Thus improving the animal condition as well as lowering the veld deterioration rate. This study therefore aimed at evaluating the effect of different management practices on grass species biomass, density and cover in different livestock land use systems.

II. MATERIALS AND METHODS

2.1 Study site:

The study was carried out in Marondera District in three different livestock land use systems. The area is in natural region 2b which receives about 700mm-1000mm rainfall per year. Marondera experiences wet and dry season. The wet season starts from late October to March whereas the dry season extends from April to October. Temperature ranges from 5, 5-28 degrees Celsius. The communal area is located in Magorimbo under Svosve communal lands. A common rangeland site was randomly selected from all the sites in this area. Rangelands which are being used for grazing were sampled. The resettlement area selected is located in Masomera area and is partitioned into villages as well as some individual farms. Machangara grazing land was randomly selected from all these to represent the resettlement livestock farming system. A list of a number of commercial farms in Svosve area was compiled and Gwaai Farm was randomly selected from this list to represent the commercial livestock farming system. The research sites are in close proximity interlinking with each other with resettlements in between them, their land use, management and management regime being different. The communal grazing is often a shared possession with no grazing management in place. Commercial and resettlement farming systems had some similar attributes and tenure conditions but differed in veld control, management systems, resource base and disturbance regimes.

2.2 Grass species sampling and measurements:

Only top land rangelands portions were used, vleis or swamps and arable lands were excluded in this study. This was to exclude the biased effect of topography and artificial manipulation of the rangelands of grasses. Within each division a diagonal transect line was established using a 100m tape measure. The quadrat sampling method was used to carry out the research on grass species composition of the three farming systems represented in the study area. Three homogeneous stands were chosen within a farming system. Sampling was done in 30m x 30m square plots situated on top land grazing sites being used as grazing lands. A diagonal transect was stretched in each plot marked by pegs. Along the transect chain a quadrat was dropped after every 8 mitres determining each sampling point. Five quadrates for each plot in respective subdivisions were worked on for grass species composition for every farm unit. A total of 15 quadrats were sampled representing each farm unit as well as the respected farming system. Species identification was done at the field and verified with the experts. Fresh biomass was cut at a height of around 5 cm above the ground and dry matter weights were then attained by weighing using a digital scale after drying the samples in oven at 70 ^{0}C to a constant weight (mostly 24 hours) in khaki pockets. The data was collected thrice with a one week interval. The basal cover was evaluated following the same sampling procedures to complement the species composition outcomes as well as giving a general view of the rangeland condition.

2.3 Statistical analysis:

Qualitative statistical analysis was done, where different herbaceous species were identified and taken note of. The data was transformed using the formula √×+0.5. The data was then subjected to ANOVA (analysis of variance) at 95 % significance level. Fisher's least significant difference test was used for separation of means. Both ANOVA and separation of means were done using Minitab 15. Summary statistics was done using Microsoft excel.

III. RESULTS

3.1 Species density:

Generally, species density was highest in commercial areas and lowest in communal areas. Table 1 shows summarises findings on species density.

TABLE 1
SPECIES density / m^2

	Commercial	Resettlement	Communal
Mean	30	26	20
Maximum	37	29	22
Minimum	25	21	17

3.2 Total species density:

The commercial livestock land use system had the highest total species density/m^2 with about 33 total grass plants/m^2 followed by the resettlement livestock land use system. The communal livestock land use system had the lowest total grass plant species/m^2 with an average of 23 grass plants/m^2 (Fig 1). However, there was no significant difference in the total species density/m^2 between the commercial and resettlement livestock land use system. Furthermore, there was also no significant difference in the total species density between the resettlement and communal systems. A significant difference in the total species density/m^2 existed between the commercial and communal livestock land use system (Fig 1).

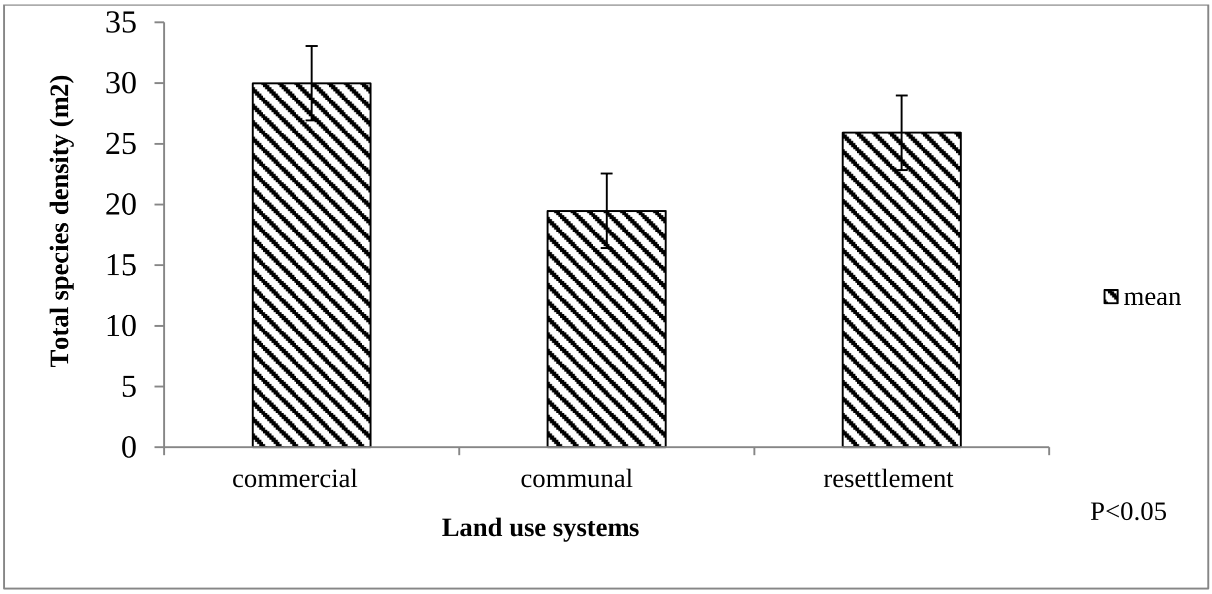

FIGURE 1: Total grass species density across land use systems

3.3 Categorised species density across farming systems:

The commercial livestock land use system had increasers with the highest species density/m^2 (around 14/m^2) followed by the invasive species and lastly the decreaser species which had the lowest species density of around 12 species/m^2 (Fig 2). However, there was no significant difference in species density between the relative categorised species within the system. The resettlement livestock land use system was found with the decreaser species having the highest density of above 14 grass plants/m ^{2} followed by the increasers which showed figures slightly above 12 grass plants/m^2. The invasive species had the lowest species density in this system following an average of at 10 grass plants/m^2 (Fig 2). However, there was no significant difference in terms of species density between the increaser and the decreaser species category. A significant difference existed between the invasive and the decreaser species category. Furthermore, a significant difference was found existing between the invasive and increaser species category in terms of density/m^2. In the communal livestock land use system, the increaser species had the highest species density/m^2 (average of 13 plants/m^2) followed by the decreaser species category and lastly the invasive species with the lowest species density of around 8 species/m^2 .Nevertheless, there was no significant difference existing between the invasive species density and the decreaser species density. A significant difference existed between increaser species and the invasive species density. Furthermore, between the increaser species and the decreaser species density/m^2 exist a significant difference (Fig 2).

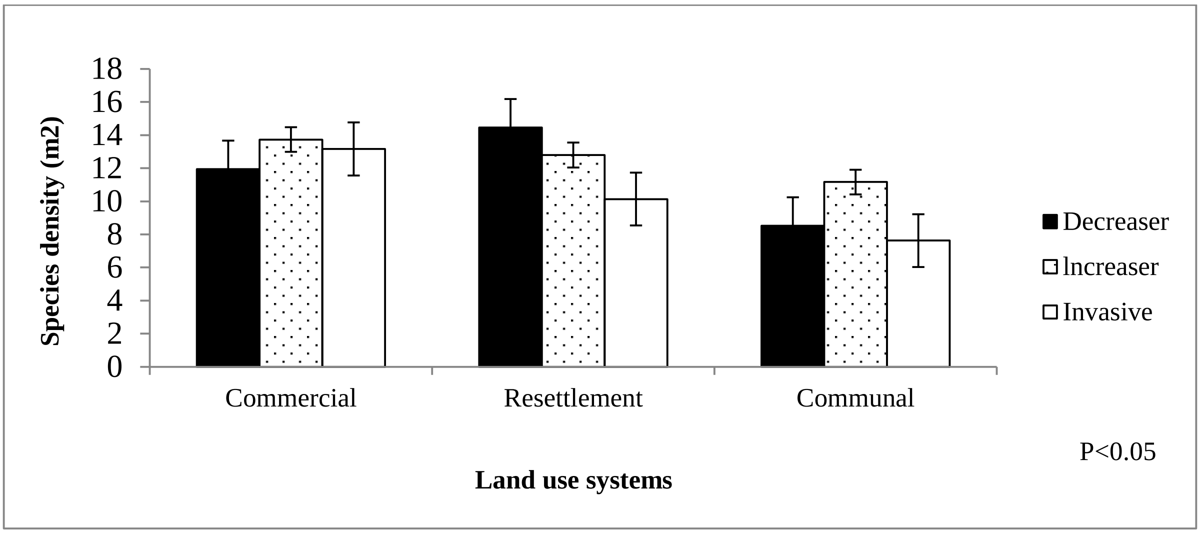

FIGURE 2: Relative density for the categorised species across land use systems.

3.4 Species dominance (density/m^2):

Decreaser species were more dominant in the resettlement system, followed by the commercial system in relation to increaser and decreaser species however more increaser species were found in the communal system as compared to all the systems. Table 2 shows summarises findings on relative species dominance.

TABLE 2
RELATIVE SPECIES DOMINANCE (density/m^2)

S.No.	Commercial	Resettlement	Communal
1	Egyptian crowfoot grass *(decreaser)*	*Hyparrhenia filipendula (decreaser)*	*Eragrostis curvula (increaser/invasive)*
2	*S. pyramidalis (increaser/invasive)*	*Panicum repens (decreaser/invasive)*	*Heteropogon contortus (increaser)*
3	*Eragrostis curvula (increaser/invasive)*	*S. pyramidalis (increaser/invasive)*	*Setaria sphacelata (decreaser)*
4	*Eragrostis aspera (increaser/invasive)*	*Panicum maximum (decreaser)*	*Melinis repens (increaser/invader)*
5	*Themeda triandra (decreaser)*	*Setaria sphacelata (decreaser)*	
6		*Melinis repens (increaser)*	

3.5 Species biomass:

Generally, species biomass was highest in commercial areas and lowest in communal areas. Table 3 shows summarises findings on species density.

TABLE 3
SPECIES BIOMASS (grammes/m^2)

Parameter	Commercial	Resettlement	Communal
Mean	342	179	85
Maximum	373	195	91
Minimum	231	106	30

3.6 Total species biomass across land use systems:

The commercial livestock land use system had the highest total species biomass (g/m^2), around 340g/m^2 followed by the resettlement land use system (250g/m^2). The communal livestock land use system had the lowest total biomass (g/m^2), having an average of 75g/m^2. Nevertheless, there was a significant difference between the commercial and resettlement livestock land use system in terms of total biomass g/m^2. A significant difference was also found to exist between the commercial and the communal system; however, there was no significant difference in biomass between the resettlement and the communal livestock land use system (Fig 3).

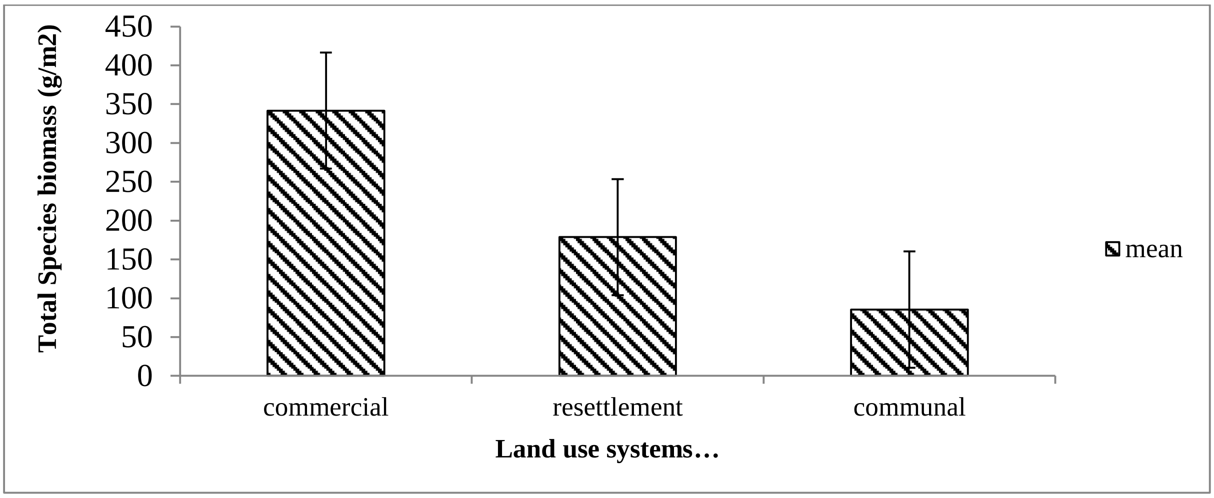

FIGURE 3: Total grass species biomass across land use systems

3.7 Categorised species biomass across land use systems:

The commercial livestock land use system had the decreaser species category having the highest biomass (g/m^2) of an average of 170g/m^2. This was followed by the increaser species having around 110g/m^2 and lastly the invasive species category had the lowest amount of biomass 100g/m^2 (Fig 4). A significant difference existed between the decreaser and the increaser species category as well as with the invasive species. However, there was no significant difference between the increaser and invasive species biomass (g/m^2). For the resettlement livestock land use system, the decreasers had the highest amount of biomass (130g/m^2). This was followed by the increaser species which has a biomass composition of around 100g/m^2. The invasive species category had lowest species biomass composition across all the categories in this system with biomass below 50g/m^2. A significant difference was found between the decreaser and invasive species. However, there was no significant difference between the decreaser and increaser species biomass composition in the resettlement system. A significant difference existed between increaser and invasive species in terms of biomass composition (g/m^2) in the resettlement system. In the communal livestock land use system, the invader species had the highest amount of biomass (Fig 4). The increaser category had the second highest species biomass composition slightly below the amount by the invader species. The lowest biomass composition was found with the decreaser species below 50g/m^2. Conversely there was no significant difference in species biomass composition across all the categories in this system.

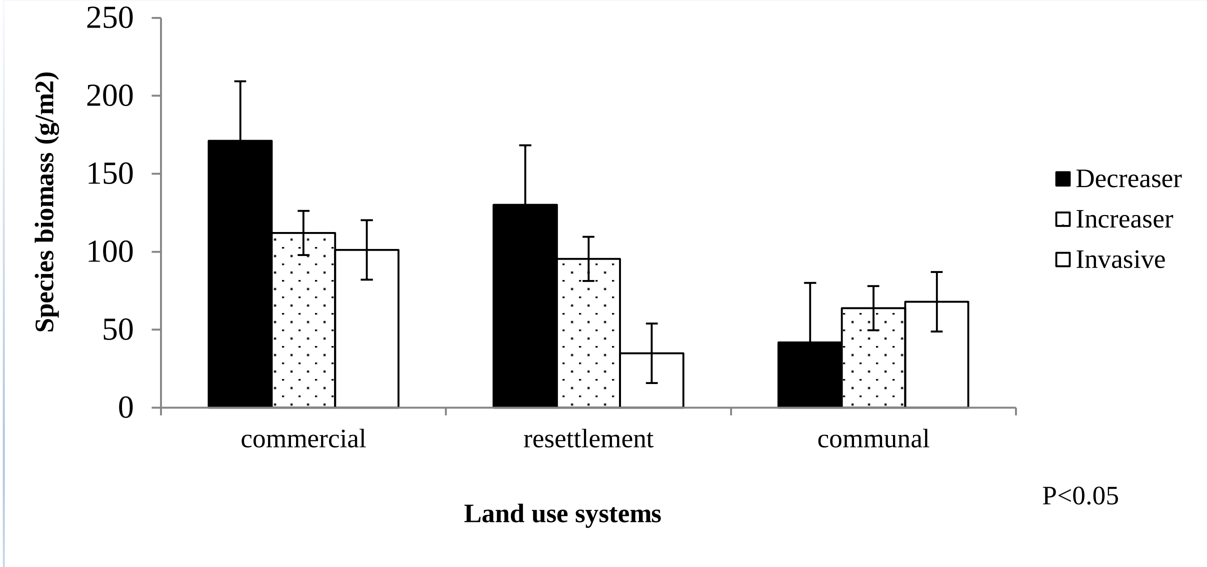

FIGURE 4: Species biomass for the categorised species across land use systems

3.8 Basal cover:

The commercial livestock land use system had the largest basal cover (92, 6%), followed by the resettlement (73%) and lastly the communal (46, 3%) system with the lowest basal cover.

3.8.1 Resettlement grazing land:

The basal cover was normally distributed statistically across the grazing land. The largest portion of the grazing land was 70% covered followed by areas which were 80% covered. It was the smallest proportion which was 60% or 90% and over covered (Fig 5). However, the results reveal that there was no significant difference between different portions of the resettlement grazing land in terms of basal cover.

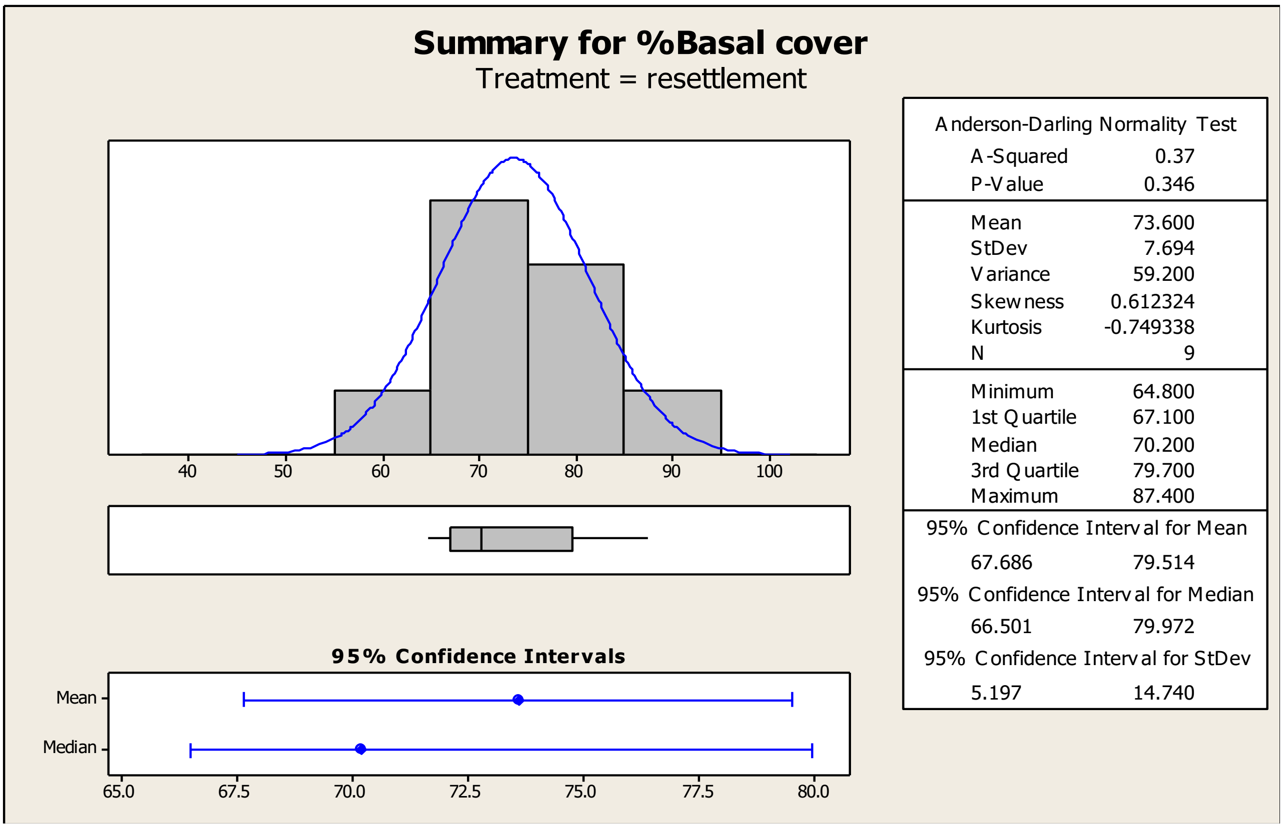

FIGURE 5: Basal cover distribution across the resettlement system grazing land

3.8.2 Commercial grazing land:

For the commercial grazing land, the largest portion of the land was 90% and above with very small portions below 90% cover. A considerable portion of the land even exhibited a cover of 100% (Fig 6). Nevertheless, the results showed no significant difference from this distribution across the commercial grazing land in terms of basal cover.

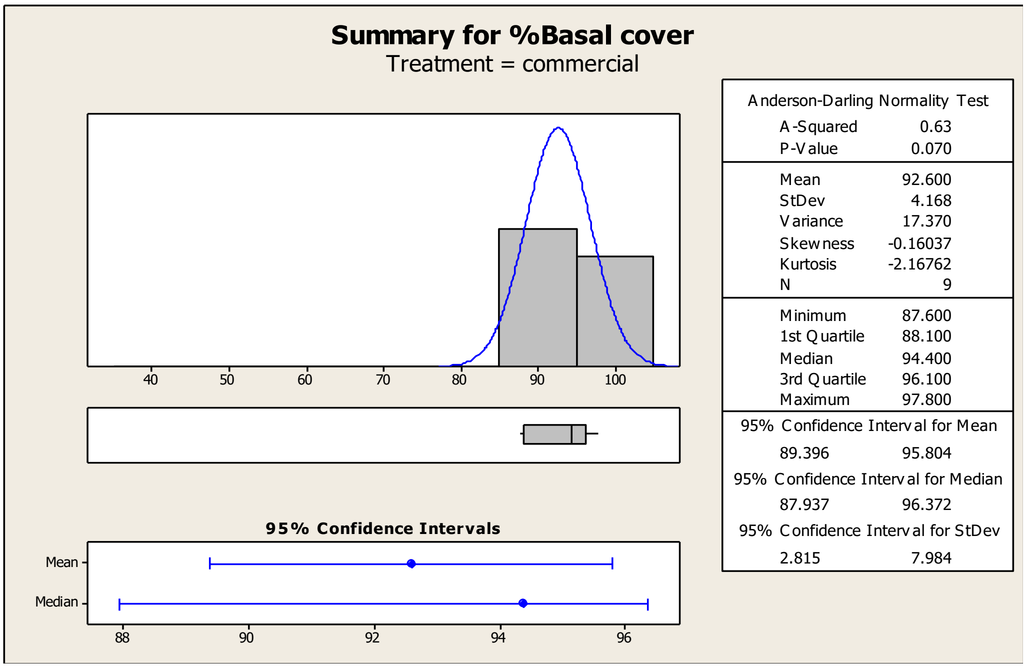

FIGURE 6: Basal cover distribution across the commercial system grazing land

3.8.3 Communal grazing land:

A considerable portion of the communal grazing land sites were below 50% cover averaging 40% followed by other portions of 50% percent cover. These percentage covers equally took up the greater portion of the communal grazing land followed by a relatively smaller portion which occurred with an average of 60% cover (Fig 7). Not even a considerable portion of the land existed with above 70% cover under this system (Fig 7). However, there was no significant difference in the cover distribution across the grazing land.

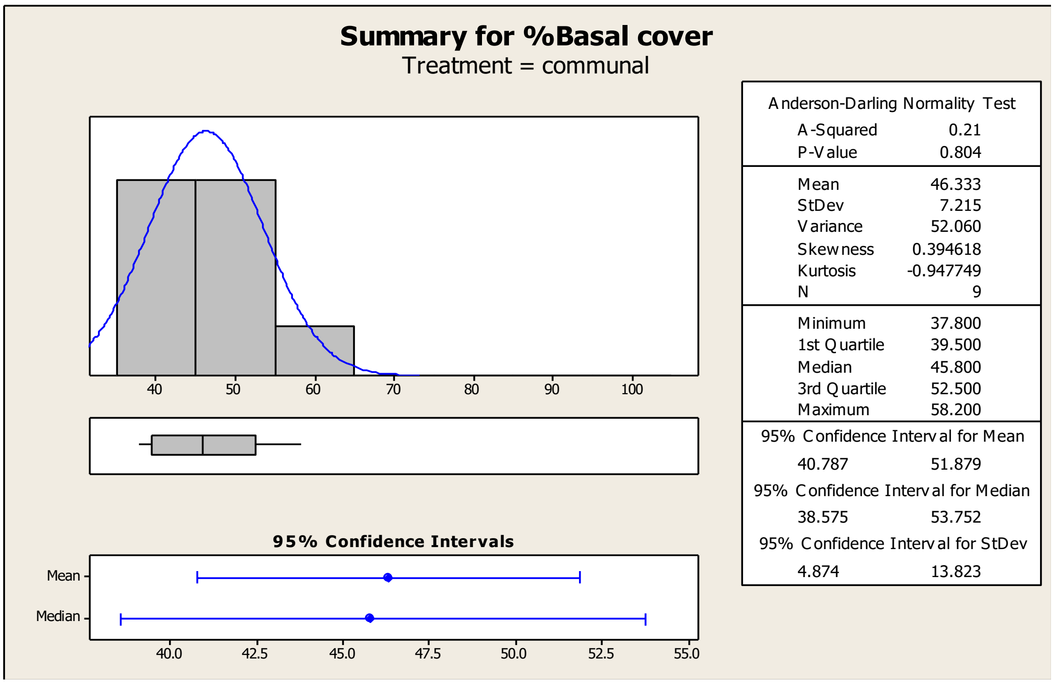

FIGURE 7: Basal cover distribution across the communal grazing lands

IV. DISCUSSION

4.1 Species density and biomass:

The outcomes point out that species density was low in communal than in commercial and resettlement systems in Marondera region 2b. This however might be a consequence of elevated stocking rates (Mavedzenge *et al*., 2005) as well as inappropriate supervision of the veld (Mugabe and Gusha. 2013). The general estimated stocking rate in the communal system was reported to be between 0.5 to 0.7LUs/ha units much higher than the proposed 0.3 to 0.34LUs/ha as reported by (Mavedzenge *et al*., 2005). Elevated stoking rates raise the intensity of grazing along with pressure on various palatable grasses. The transformation brought by this may possibly predict tragedy to communal producers who largely depend on livestock for draught power as well as dung. This is as a result of the declining capability intended for optimal production of herbage. The reduced forage production in communal rangelands has an effect on carrying capacity therefore the productivity per unit area. This as well reduces the amount of forage available to the foraging animals' hence poor livestock production (Mavengedze *et al*., 2005). The fraction of increaser/invasive species such as *Heteropogon contortus*, *Melinis repens* and unpalatable Eragrostis species was higher in the communal livestock land use system compared with other land use systems. This state could have been brought by preferential and selective foraging of more palatable grasses by the grazing livestock (Todd and Hoffman, 1999). These relative findings fell in the same line with the findings of Mugabe and Gusha (2013), Todd and Hoffman, (1999) and El-Keblawy (2003) backing that the grazing stoke reduce more palatable grass species for example decreaser species mostly recognised as perennials.

The increaser/invasive (unpalatable) grass species tend to increase density in relation to the palatable grasses dominating the grazing lands. This increase in less palatable grasses relate to the reduction in nutrient intake by the livestock as the animals are likely to be foraging on nutrients below the demands for maintenance (El-Keblawy ,2003). Therefore, the performance as well as the overall productivity of livestock reared under such rangelands deteriorates. Furthermore, the relative increase in abundance of unpalatable (increaser) grasses goes hand in hand with the weakly interactive model (MacDougall and Turkington, 2005). In the communal system the species dominant were rarely affected by the recruitment barrier together with the environmental stressors that are largely limiting when it comes to other grass species (Mugabe and Gusha, 2013). *Setaria sphacelata* with a good quality forage value was in limited amount and densities in the communal area showing a greater grazing severity. Following an uncontrolled grazing system in the communal livestock land use system where the livestock is left free to move around, decreaser (palatable) grasses are not given ample time to rejuvenate and replenish leading to overgrazing (Mugabe and Gusha,2013) and absolute elimination. Above optimal grazing intensity might shift the vegetation community stability paving way for the establishment of invasive and weed species. This however could be a reason for proportionally high biomass and densities of weedy and invasive grasses in the communal sector. Following the research by Gambiza *et al* (2009) in Zimbabwe wetter areas, there was no common trend viewed in relation to grass species density and biomass. Nevertheless, this was a different case with this study, the communal livestock land use system had the lowest species density and biomass that the resettlement and commercial farming system. The findings revealed a precise change in the dominant grass species adding up to the total biomass across all the livestock land use systems (communal, resettlement, 33 commercial). However, in this research study *Eragrostis curvula* was found occurring in both the commercial and communal livestock land use systems although it was considerably low in communal areas being insignificant to enhance livestock production. *Setaria sphacelata* and *Melenis repens* was also found in both the resettlement and communal systems but with relatively low densities and biomass in the communal areas. For the resettlement and commercial systems, the grasses of higher forage value (decreasers) were more dominant contrary to the situation found in communal areas. The fraction decreaser species were however insignificantly higher in the resettlement farming system than in the commercial farming system. However, this is in terms of grass density as the commercial areas conversely top in terms of biomass production (Mugabe and Gusha, 2013). This however could be more affiliated to the land use history over other factors such as overgrazing and stocking rates. The communal areas are very much associated with high population densities resulting in the overconsumption of the available resources. Higher level of bush infringement was observed in the communal livestock land use system more than in commercial and resettlement systems. This could be attributed to the lowered regularity as well as the fuel consignment of fire in the communal system. These results were therefore in agreement with the former findings by Trollope (1994) and Mugabe and Gusha (2013), stating that low biomass within a grazing land results in increased woody vegetation because of the reduced fuel load which reduces the intensity and frequency of fire. The grass biomass was higher in commercial than in the resettlement area which was also considerably higher than in communal grazing lands. This may be out of the factors such as the grazing pressure and the rate of grazing which was accountably elevated in the communal livestock land use system.

The fraction of decreaser grass species (good forage value grasses) was significantly higher in the resettlement areas in terms of density as well as biomass. This was also exceptionally higher in the commercial areas. These systems however revealed a significant difference in terms of grasses with better forage value in comparison with the communal systems. This could therefore be attributed to the level of management across these systems. Rotational grazing system practiced in the commercial system allows for the decreaser species to recover and re-establish after grazing by reducing the grazing severity, allowing forage to perpetuate with higher densities and biomass (Mugabe and Gusha, 2013). Lower stocking rates, slightly lower than the recommended carrying capacities in the resettlement grazing lands, by default, allow for maintenance of decreaser species vigour through reduced grazing severity (Todd and Hoffman, 1999). This however results in accumulation of the moribund stuff (top hamper) which is on the contrary regularly controlled by occasional/seasonal fires. The results showed the commercial system had the highest range distribution (difference between maximum and minimum) in terms of grass density and biomass across the grazing land as compared to all other farming systems. This however shows the high degree of heterogeneity in grass composition across the landscape. This could be because of increased selective and preferential grazing, where animals continuously graze particularly on their preferred sites and species neglecting some areas

4.2 Basal cover:

The findings of this study show that the communal areas had significantly lower basal cover (46, 3%) than all other systems. This could be attributed to higher stocking densities, exceeding carrying capacities leading to overgrazing in the communal areas. The grazing intensity and frequency was too high in the communal system, giving less time for the grasses to grow and cover the land. Higher population densities also increase compactions destroying 35 some grass species, leaving the soil prone to all the agents of erosion reducing the chances by some species to germinate and re-establish hence productivity is lowered in the process. Low levels of biomass in the communal areas mean low organic matter as well as decomposed organic matter (humus) rendering the soil infertile to support much vegetation to cover the grazing land. The basal cover below 50% is categorised poor (Hungwe, 2014) as this acts as an indicator of the potential productivity by the rangeland as well as its susceptibility to erosion and level of degradation. The basal cover is positively correlated to the grass species composition in terms of biomass and density (Hungwe, 2014).

V. CONCLUSION

There was a significant difference in species composition (density and biomass) and cover across all livestock land use systems. Grasses with good forage value (decreasers) were observed to be highly concentrated in the commercial system followed by resettlement and lastly the communal system. The increaser/invasive species were significantly more in the communal set up than in all other systems. In addition, the commercial system had the highest basal cover followed resettlement with the lowest basal cover in communal systems.

VI. RECOMMENDATIONS

Rangeland rehabilitation and maintenance takes a long and patient process, where in the mix are annual rainfall and dry spell uncertainties. However, in the face of a degraded rangeland it is important to initially restore the soil fertility. To bare soils with little cover rangeland thatch packing practices can be implemented to aid in water penetration reduce surface runoff; provide shading and aid to detritus build up. This remedial practice must therefore be practiced for several seasons necessary. As a soil remedial practice, it is also important to shape contours channelling water and prevent lateral erosion as well as tilling for aeration and seeding. Bush packing can also be done following the observation of new growth to avoid overutilization of such grasses during their early or establishing stages. To increase grass biomass as well as density, selective bush thinning can be useful as this will give support to grass competition. Decreaser (palatable) grass species losses could be solved by reinforcing the grazing land by planting relatively palatable grasses with some grazing resistance and quick establishment characteristics. Amongst these are *Panicum repens* and *Digitaria diagonalis* which under optimum conditions have high prolific rates, density, and biomass and are tolerant to grazing. This will in turn increase the carrying capacities of communal grazing lands. However, the major problem leading to low production potential and level by the communal grazing lands is management related. This is mainly due to lack of knowledge. Therefore, an increase in government extension services and educational campaign enriching people with communal grazing management knowledge can be a long-lasting solution. Government legislation and policies in control and monitoring of rangelands also need to be enforced with increased patrols and assessment. This encompasses the judicious burning legislations, where uncontrolled fires may lead to an accelerated species loss (decrease in biomass and density) as well as basal cover. Indicators and continuous monitoring should be set in place to scrutinize alterations much earlier. To minimize species loss, increasing grass biomass and density, holistic management practices ought to be promoted in the communal livestock land use system. The evaluation of species composition under this study was done over a short period of time. A similar research over an extended period of a season or year might be more relevant in assessing seasonal species composition change.

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