Effect of soil type on herbaceous species composition and distribution in community property association projects of Bela-Bela municipality, South Africa

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Information on species composition and distribution is vital in assessing rangeland condition and mitigating its deterioration in Community Property Associations (CPAs) projects. Herbaceous vegetation composition, biomass and basal cover was compared in three CPAs projects varying in soil type and grazing pressure (Mashung Matlala-sandy loam, Mawela-clay loam, and Bela-Bela-clay) in Bela-Bela municipality. Mawela and Mashung Matlala were severely grazed. Two camps were selected per farm and three transects (500m) were used to collect data on species composition, distribution, biomass and basal cover. Species were grouped according to life form, palatability, ecological status and abundance. Variation in measured parameters was explored through a GLM analysis of variance procedure of SAS. Clay soil had higher levels ($P < 0.05$) of nutrients compared to sandy and clay loam. *Panicum maximum* was common in clay-loam and clay soil and dominant in sandy-loam. *Eragrostis curvula* and *Urochloa mosambicensis* were dominant in clay-loam and common in clay soil. Clay soil had the highest ($P < 0.05$) biomass (711.84 kg/ha) compared to the other two. Clay soil had higher ($P < 0.05$) basal cover (38.0%), and sandy-loam had the highest ($P < 0.05$) percentage of forbs (6.4%). There is an invasion of forbs and pioneer grasses in heavily grazed sites of Mashung Matlala and Mawela CPA farms, which adversely impact livestock production. Grazing management intervention should be guided by information on species composition and biomass, which reflects past management, and variation in soil type. Practical grazing plans should aim to reduce pressure on clay and sandy-loam areas.

Keywords: Soil types, overgrazing, livestock, natural resources, soil minerals, basal cover

Rangelands are regarded as the main nutrient source for livestock in Southern Africa. This creates a continuous interaction between livestock and plants within the rangelands ecosystems (McNaughton 1979). Even though rangelands rarely meet the nutrient requirements of livestock, particularly during the dry season, forages such as grasses in particular, provide the bulk of the feed to cattle and sheep and are also an important source of minerals throughout the year (Gwelo et al. 2015). The rangeland health condition is normally measured by soil condition, grass species composition, abundance and acceptability to grazing herbivores (Snyman 1998). Overgrazing is the major problem faced by communally-owned grazed areas such as communal rangelands (Lesoli 2008; Kwaza 2013) and commonages (Masiteng et al. 2003). The South African government, through its land reform programme, has pursued a policy of re-distributing land to empower landless people and decongest communal areas so as to reduce land degradation resulting from overstocking. Some of these farms have been allocated to a group of farmers to jointly utilise, and some are characterized by high stocking rates and poor rangeland management practices, mostly overgrazing (Munyai 2012). Grazing by domestic livestock can vary in

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intensity and frequency and it is the main anthropogenic disturbance of natural grasslands (Liu et al. 2012), often exceeding the functional capacity of grasslands to recover from overuse (Delgado-Balbuena et al. 2013). This normally results in a significant reduction of plant vigour ((Heitschmidt et al. 1987), a loss or poor establishment of palatable grass cover (Medina-Roldan et al. 2008) and an increase in subordinate and non-palatable species (Aguado-Santacruz and Garcia-Moya 1998). All these may lead to change in species diversity and soil nutrient properties (Amiri et al. 2008). Many studies have reported that long-term heavy grazing can result in soil degradation (Amiri et al. 2008; Gwelo et al. 2015; Warren and Khogali 1992) where most of nutritious topsoil is lost due to runoff caused by overgrazing. Enhancement of soil fertility and plant vigour is virtually guaranteed if grazing pressure is reduced within a grazing system (Dadkhah and Gifford 1980). Soil type has an influence on the agricultural potential and the nutrients in the soil influence the plant succession and growth of vegetation in an area (Viljoen 2012). A better understanding of the rangeland condition in the community property associations will shed some light on the impacts of inherent grazing management practices in these areas. In addition, their interaction with soil type will assist in customising rangeland management intervention strategies in specific areas. Such information is important for the development of efficient and sustainable rangeland utilization strategies, and thus productivity of ruminant livestock, an income source for most of the farmers. Thus, the objective of the study was to compare the herbaceous vegetation composition, biomass and basal cover in various soil types of some Community Property Associations projects in Bela-Bela local municipality. It was hypothesized that herbaceous vegetation, biomass and basal cover will vary among different soil types.

Material and methods

Study site

The study was conducted in three selected CPA sites of Bela-Bela municipality, Waterberg district in Limpopo province. The three selected areas were Mashung Matlala (Ecca-Sandy-loam), Mawela (Hutton-Clay-loam), and Bela-Bela (Hutton-Clay) CPAs. The CPAs were 20 km apart (Table 1). The sites were selected because of field visual observations that revealed variation in grazing management practices (Mashung Matlala, and Mawela were heavily grazed, whereas Bela-Bela CPA was moderately grazed) and had different soil types (texture) (DoA 2018) (Table 1). In this paper, comparison between CPAs would be mainly through their difference is soil type. The rainfall of the areas varies from 500 to 600 mm/annum. The mean daily temperature ranges from 5 - 35°C throughout the year. The vegetation type of the areas is Springbokflakte thornveld composed of open to dense low thorn savannah dominated by acacia species or shrubry grassland with low shrub layer (Mucina and Rutherford 2006). The geology of the area shows vertic soils with high calcium carbonate content and Gilgai micro-relief (Musina and Rutherford 2006). The average grazing capacity in Limpopo province ranges from 4-25 ha/LSU (van Oudtshoorn 2007). All farms were geo-referenced using a GPS.

Table 1: Profile of the selected CPA farms in Bela-Bela municipality

	Mashung Matlala	Mawela	Bela-Bela
Year obtained	2007	2008	2002
Farm size (ha)	3404	1457	308
No. of camps	5	16	5
Soil type	Ecca-Sandy loam	Hutton-Clay loam	Hutton-Clay
Altitude(m)	1100	1069	1121
Coordinates	25^0 13’ 13.00” S 28^0 24’ 07.05” E	24^0 55’ 43.99” S 28^0 10’ 34.48” E	25^0 05’ 10.93” S 28^0 14’ 27.28” E
Current number of animals kept	905	400	33
Previous GC (ha/LSU)	6ha/LSU	6.5ha/LSU	5.4 ha/LSU

GC: grazing capacity; LSU: livestock unit; ha: hectare

Biomass determination and calculation of grazing capacity

Three transects (500 m), which served as replicates, were established in three camps (average size of 60 ha/camp) on each farm. The three transects were placed 50 m away from each other. Along each transect, points were marked at 100 metre intervals to create plots of 1 m^2 (Tefera et al. 2007 and 2010). The above-ground portions of plants were collected from the 1 m^2 plots using clippers. They were weighed, dried for 24 hours at 80°C , cooled in a desiccator jar, and reweighed (dry weight) to determine the biomass production.

The equation used to calculate biomass was:

Kg ha^{-1} *= 1000 * (10,000 * dried weight of sample)*

The biomass method prescribed by Moore and Odendaal (1987) and adopted by van Oudtshoorn (2014) was used to determine grazing capacity.

The equation used for grazing capacity was:

$$Y = d \div \frac{(\mathrm{DM})}{\mathrm{r}};$$

Where:

Y = grazing capacity;
d = number of days in the year;
DM = dry matter (biomass) in kg/ha;
and r = daily dry matter required by one grazing animal (2.5% body weight).

Identification of grass species

Identification of grass species was conducted on three transects (500 m), which served as replicates. At every 50m marked point, species were identified and counted within a 10 cm radius. The basal cover was estimated using the method prescribed by van Oudtshoorn (2015). A distinction was made between hit (the point directly onto the base of plant) and nearest plant, the basal cover was estimated using the total hits expressed as a percentage. Turf height and diameter of the tuft were recorded. Species were grouped according to their life form, grazing value and ecological status. The species density (frequency of occurrence of each grass species) was also recorded by converting the species data into percentage (van Oudtshoorn 2015). Grass species were classified as dominant (D) (>13%), C=common (>3-13%), R=rare (1-3%) and P= present (<1%).

Soil sampling and analysis

Soil samples were collected at each 100 m interval in all three transects at the depth of 0-15 cm for chemical analysis. The sample were air-dried, grounded to pass through 2 mm sieve and analysed for pH as described by McLean (1982), soil organic carbon as described by Walkey and Black (1934). Soil samples were also analyzed for macro and trace minerals following the guidelines provided by the Agri-Laboratory Association of Southern Africa (AgriLASA 1998).

Statistical analysis

One way analysis of variance (SAS 2010) was used to test the effect of soil type in all measured parameters in studied farms. The following model was used for statistical analysis:

$$Yi_{ij} = \mu + S_i + \varepsilon_{ij}$$

Where *Yij* was the dependant variable, μ was the overall mean, S was the effect of soil type, and ε was the random error associated with observation ij assumed to be randomly distributed. Statistical difference was declared at P ≤ 0.05.

Results

Grass species composition and distribution

The results of grass life form, palatability and abundance in three soil types are presented in Table 2. A total of 27 species were identified across study areas, and 24 were perennial species. There was equal distribution of grass species in terms of grazing value, with 33% classified to be of low grazing value and the same percentage in both medium and high grazing value.

Grass species composition (%) based on the frequencies of occurrence of dominant and common grass species in all soil types

A species is considered dominant when its average frequency is exceeding 13 % in the site, and is classified as common when the average frequency ranges between 3 and 13 %. In line with this definition, *Eragrostis curvula* was dominant (P < 0.05) in clay-loam and common in clay and sandy –loam soil types, these latter two sites did not differ significantly from each other (Table 2, 3). *Urochloa mosambicensis* was dominant in clay-loam and common in clay soil types. *Panicum maximum* was common in clay-loam and clay soil types and dominant in sandy-loam soil type. *Themeda triandra* was rare in clay-loam and sandy-loam soil types and found to be common in clay soil type. *Aristida congesta* was found to dominate (P < 0.05) in clay and sandy-loam when compared to clay-loam soil type. *Digitaria eriantha* was dominant more (P < 0.05) in sandy-loam (16.70%) than in clay-loam soil type (0.29 %).

Table 2: Life form, grazing value and abundance of grass species in three soil types (clay-loam, clay, sandy-loam)

Species	Common name	Life form	ES	GV	Clay Loam	Clay	Sandy loam
Cymbopogon plurinodis	Giant Turpentine	Per	Inc i	LGV	C	+	-
Cymbopogon caesius	Turpentine	Per	Inc iii	LGV	+	R	-
Eragrostis curvula	Weeping love grass	Per	Inc ii	HGV	D	C	C
Urochloa mosambicensis	Bushveld signal grass	Ann	Inc ii	MGV	D	C	-
Heteropogon contortus	Spear grass	Per	Inc ii	MGV	C	D	+
Aristida congesta	Spreading Three-awn	Per	Inc ii	LGV	R	D	D

Table 2 continued…

Species	Common name	Life form	ES	GV	Clay Loam	Clay	Sandy loam
Aristida stipitata	Long-awned grass	Per	Inc ii	LGV	-	+	+
Aristida diffusa	Iron grass	Per	Inc ii	LGV	-	-	+
Panicum maximum	Guinea Grass	Per	Dec	HGV	C	C	D
Cynodon dactylon	Couch Grass	Cre Per	Inc ii	HGV	R	-	+
Melinis repens	Natal Red Top	Per	Inc ii	LGV	+	R	R
Eragostis rigidior	Curly leaf	Per	Inc ii	MGV	C	C	R
Themeda triandra	Red grass	Per	Dec	HGV	R	C	R
Hyparrhenia filipendula	Fine Thatching grass	Per	Inc i	MGV	+	D	-
Schmidtia pappophoroides	Sand quick	Per	Inc i	HGV	-	+	R
Inschaemum fasciculatum	Hippo grass	Per	Inc i	MGV	-	R	-
Hyperthelia dissoluta	Yellow Thatching grass	Per	Inc i		-	+	-
Perotis patens	Cat's tail	Ann	Inc ii	LGV	-	-	C
Setaria sphacelata	Bristle grass	Per	Dec	HGV	-	-	R
Digitaria eriantha	Finger grass	Per	Dec	HGV	+	-	D
Eragrostis Lehmanniana	Lehmann's love grass	Per	Inc ii	MGV	+	+	C
Tragus berteronianus	Carrot-seed grass	Per	Inc ii	LGV	-	-	+
Pogonarthria squarrosa	Herringbone grass	Per	Inc ii	LGV	+	-	+
Eragrostis superba	Saw-tooth love grass	Per	Inc ii	MGV	+	-	-
hyparrhenia hirta	Thatching grass	Per	Inc i	MGV	-	-	+
Poa Annua	Annual bluegrass	Ann	Inc ii	HGV	+	-	-
Enneapogon cenchroides	Nine-awned grass	Per	Inc ii	MGV	-	-	+
Forbs					C	+	C

Per= perennial, Cre Per= creeping perennial grass, Inc i= increaser i, Inc ii= increaser ii, Inc iii= increaser iii, Dec= decreaser, LGV=low grazing value, MGV=Medium grazing value, HGV=High grazing value, D=dominant (>13%), C=common (>3-13%), R=rare (1-3%), P= present (<1%)

Table 3: Grass species composition (%) based on the frequencies of occurrence of dominant and common grass species in all soil types

	Soil type			
Species	Clay-loam	Clay	Sandy-loam	SE
C. plurinodis	6.85[a]	0.40[b]	-	0.40
E. curvula	15.67[a]	4.95[b]	3.94[b]	3.94
U. mozambisens	34.54[a]	4.44[b]	-	3.89
H. contortus	11.65[b]	27.12[a]	0.91[c]	0.91
A. congesta	3.34[b]	18.43[a]	24.44[a]	3.34
P. maximum	12.18[a]	8.34[b]	30.61[a]	8.34
E. rigidor	7.54[a]	4.95[a]	2.66[a]	2.21
T. triandra	2.84[a]	6.37[a]	2.47[a]	2.72
H. filipendula	0.26[b]	16.56[a]	-	0.26
P. patens	0.29[b]	-	4.06[a]	0.91
D. eriantha	0.29[b]	-	16.68[a]	0.30
E. lehmanniana	0.26[b]	0.32[b]	6.32[a]	0.26

[abc] :Shared lower-case superscripts letters within a row indicate a non-significant difference in abundance among soil types (P > 0.05).
SE: standard error

Biomass production, basal cover, forbs distribution, frequency of desirability groups and grazing capacity of grass layer under three different soil types

The results of grass species composition (common and dominant species) based on frequency of desirability groups, biomass production, basal cover, forbs distribution and grazing capacity of grass layer under three different soil types are presented in Table 4. The clay soil had higher (P < 0.05) percentage of basal cover (38.00%) than the clay-loam (13.90%) and the sandy-loam (8.10%) soil types which did not differ significantly from each other. Sandy-loam had the highest (P< 0.05) percentage of forbs (6.40%). The clay-loam soil type had a similar (P>0.05) percentage of forbs as clay and sandy-loam soil types. The clay soil type had the highest (P<0.05) biomass production (711.84 kg/ha) compared to clay-loam and sandy-loam soil types which did not differ significantly from each other.

Table 4: Grass species composition (%) (common and dominant species) based on frequency of desirability groups, biomass production (kg/ha), basal cover (%) and forbs distribution (%) and grazing capacity (ha/LSU) of the grass layer in the three different soil types

	Soil type			
Parameters	Clay-loam	Clay	Sandy-loam	SE
LGV	3.52^{c}	6.28^{b}	9.50^{a}	3.52
MGV	7.08^{b}	10.78^{a}	2.77^{c}	0.79
HGV	12.46^{a}	4.79^{b}	12.44^{a}	1.81
Biomass	219.05^{b}	711.84^{a}	309.35^{b}	54.82
Basal cover	13.90^{b}	37.96^{a}	8.10^{b}	3.28
Forbs	3.04^{ab}	0.47^{b}	6.38^{a}	0.98
GC	18.75^{a}	5.77^{b}	13.27^{a}	1.75

^{ab}: Means in the same row with different superscripts are significantly different (P<0.05). LGV: low grazing value, MGV: medium grazing value, HGV: high grazing value GC: grazing capacity; SE = Standard error

The sandy-loam had the highest (P < 0.05) low grazing value species compared to the same species in other soil types (Table 3). The clay soil type had the highest (P < 0.05) percentage (10.80%) of medium grazing value species. The sandy-loam had the least (P<0.05) percentage of medium grazing value species (2.80%). The clay soil type had the lowest (P < 0.05) high grazing value species (5.00%) when compared to clay-loam and sandy-loam which did not differ significantly.

Height and diameter of dominant and common grass species

The results of grass height of dominant and common grass species in three soil types are presented in Table 5. *Cymbopogon plurinodis* in the clay soil type was the tallest (P<0.05) (104.30 cm) compared to its growth in the clay-loam soil type (48.40 cm). *Panicum maximum* grew taller (65.10 cm) in clay soil type (P <0.05) compared to its growth in clay-loam and sandy-loam soil types which were similar. *Themeda triandra`s* growth was similar (P > 0.05) in clay and sandy-loam soils. *Heteropogon contortus* grew significantly (P < 0.05) taller (106.50 cm) in clay-loam than in clay and sandy-loam soil types. *Heteropogon contortus* was shortest (32.60 cm) in clay soil type (P<0.05). *Eragrostis rigidior* grew well in sandy-loam compared to its growth in clay-loam and clay soil types. *Eragrostis rigidior* in clay loam had the lowest height (18.65 cm).

Grass diameter (tuft) of dominant and common grass species in three soil types

The results of grass diameter (cm) of dominant and common grass species in three soil types are presented in Table 6. *Cymbopogon plurinodis* in clay-loam had the largest (P<0.05) diameter (14.30 cm) compared to the clay soil type (2.70 cm). *Urochloa mosambicensis* in clay soil had larger (P < 0.05) diameter (9.70 cm) than in clay-loam soil type (3.40 cm). *Aristida congesta* (3.80 cm) and *E. lehmanniana* (11.10 cm) in the sandy-loam soil type had larger (P<0.05) diameter than in the clay-loam and clay soil types which did not differ significantly from each other. *Eragrostis rigidior* in sandy-loam had the largest (P<0.05) diameter (4.00 cm) when compared to the same species in clay-loam and clay soil types. *Panicum maximum* in clay soil type had the same diameter as clay-loam and sandy-loam soil types. *Hyparrhenia filipendula* in clay soil type had the highest (P <0.05) tuft diameter value (10.10 cm) compared to clay-loam soil type.

Table 5: Grass height (cm) of dominant and common grass species in three soil types

Species	Clay-Loam	Clay	Sandy-Loam	SE
C. plurinodis	48.40^{b}	104.3^{a}	-	5.3
E. curvula	45.00^{a}	38.7^{a}	42.0^{a}	11.4
U.mosambicensis	25.1^{a}	41.2^{a}	-	9.2
H. contortus	106.5^{a}	32.6^{c}	79.5^{b}	32.6
A. congesta	36.3^{a}	38.2^{a}	46.9^{a}	10.5
P. maximum	35.1^{b}	65.1^{a}	34.2^{b}	34.2
E. rigidior	18.7^{c}	44.4^{b}	74.5^{a}	7.4
T. triandra	100.0^{a}	100.7^{a}	89.3^{a}	13.5
H. filipendula	32.7^{b}	99.4^{a}	-	0.5
P. patens	-	-	45.5^{a}	
Digitaria spps	-	-	63.7^{a}	
E. lehmanniana	25.38^{b}	31.00^{b}	64.33^{a}	3.49

Shared lower-case superscript letters within a row indicate a non-significant difference between soil type (P > 0.05). SE: standard error.

Table 6: Grass diameter (cm) of dominant and common grass species in three soil types

Species	Clay-loam	Clay	Sandy-Loam	SE
C. plurinodis	14.25^{a}	2.67^{b}	-	2.10
E. curvula	2.50^{a}	3.80^{a}	3.05^{a}	0.40
U. mosambicensis	3.40^{b}	9.65^{a}	-	3.40
H. contortus	10.09^{a}	8.00^{a}	4.00^{b}	4.00
A. congesta	2.75^{b}	2.53^{b}	3.77^{a}	0.21
P. maximum	3.88^{b}	6.25^{ab}	10.52^{a}	3.90
E. rigidior	2.75^{b}	3.83^{a}	4.00^{a}	0.13
T. triandra	6.89^{a}	7.38^{a}	7.33^{a}	6.89
H. filipendula	1.25^{b}	10.07^{a}	-	0.22
P. patens	-	-	4.17	-
D. eriantha	-	-	8.53	-
E. lehmanniana	0.75^{b}	1.75^{b}	11.13^{a}	1.13

^{abc}: Shared lower-case superscript letters within a column indicate a non-significant difference between soil types (P > 0.05). SE: standard error

Table 7: Soil pH, carbon (%) and mineral concentration (mg/kg) in three soil types

	Clay-Loam	Clay	Sandy-Loam	SE
pH	5.70^{b}	6.40^{a}	4.90^{c}	0.050
C	0.98^{b}	1.64^{a}	0.32^{c}	0.082
P (Bray1)	0.95^{b}	1.01^{b}	2.25^{a}	0.085
K	350.40^{b}	359.80^{a}	177.90^{c}	0.146
Ca	699.30^{b}	925.10^{a}	73.30^{c}	0.503
Mg	345.80^{b}	347.90^{a}	28.30^{c}	0.123
Na	4.915^{a}	4.98^{a}	3.25^{b}	0.088
Fe	8.85^{b}	11.56^{a}	11.00^{a}	0.372
Cu	2.36^{b}	4.79^{a}	0.24^{c}	0.039
Zn	0.64^{b}	1.23^{a}	0.32^{c}	0.0258
Mn	42.65^{a}	23.10^{b}	15.64^{c}	0.293

^{abc}: Shared lower-case superscript letters within a row indicate a non-significance difference in height of a grass species ($P < 0.05$). SE: standard error.

Soil pH and mineral concentration in three soil types

The results of soil pH and mineral concentration in three soil types are presented in Table 7. Soil type influenced the mineral concentration in all sites. The clay soil type had higher ($P<0.05$) pH (M ± SE=6.4 ± 0.05) than all other soil types. The sandy-loam had the least ($P < 0.05$) pH (4.7 ± 0.05). The clay soil type had higher ($P<0.05$) carbon percentage (1.6 ± 0.082%) than all other soil types. Phosphorus concentration (2.25 ± 0.085 mg/kg) in sandy-loam soil type was higher ($P<0.05$) compared to clay (1.01 ± 0.085 mg/kg) and clay-loam (0.95 ± 0.085 mg/kg) soil types which did not differ significantly from each other. The clay soil type had higher ($P<0.05$) calcium concentration (925.1 ± 0.503 mg/kg) than all other soil types. Sandy-loam had the lowest ($P<0.05$) Ca concentration (73.3 ± 0.503 mg/kg). The clay and sandy-loam soil types had highest ($P<0.05$) iron concentration values (11.56 ± 0.372 mg/kg and 11.0 ± 0.372 mg/kg. respectively). The clay-loam had the least ($P < 0.05$) Fe value (8.85 ± 0.372 mg/kg). The clay soil had the highest ($P<0.05$) zinc concentration (1.23 ± 0.0258 mg/kg), followed by the clay-loam (0.64 ± 0.0258 mg/kg) and sandy-loam (0.32 mg/kg) soil types.

Discussion

From the livestock records obtained from the farms, Mashung Matlala CPA (Sandy-loam) grazed 905 cattle on 3404 hectares, Mawela (Clay-loam) grazed 400 on 1457 hectares and Bela-Bela (Clay) grazed 33 in 308 hectares. From the biomass values observed in this study, the current expected maximum stocking rate are 267 livestock units in Mashung Matlala, 78 livestock units in Mawela and 53 livestock units in Bela-Bela CPA. A visual veld assessment method prescribed by van Oudtshoorn (2007), suggests that Mashung Matlala and Mawela are heavily grazed, and this corroborates the high stocking rates from the farm records, and the calculated grazing capacity. This has impacted the soils and vegetation in these grazing areas.

The clay soil type had a better soil nutrient content compared to the sandy-loam and clay-loam soil types. Viljoen (2012) indicated that clay soil type had higher agricultural potential especially in dry land areas and they are suited for rehabilitation purposes for natural veld. Nutrients in the soil influence the existence and growth of vegetation in an area and its dynamics is due to cyclical processes of litter supply and vegetation cover. The clay soil type had a better pH (6.4) than the clay-loam and sandy-loam. The pH results from this study are alkaline and they are within the range reported by Viljoen (2012) (pH of 5.3 to 7.2). Depending on the type of species, soil pH of 5.2 to 8 is regarded as optimum for most grass species (Lake 2000). Soil pH affect nutrient translocation to the plants and interaction among nutrients which affect their individual availability to the plant. Londo et al. (2006) stressed that there is a relationship between plant growth as influenced by pH and the soil concentration of plant toxic minerals. When the pH is low, minerals such as P, Mg and Ca are less available to the plants, while other minerals may be more available to an extent that they become toxic to plants. The clay soil type had higher values of macro minerals (Ca, Na and Mg) than other soil types. Blank et al. (2007) highlighted that the overgrazed areas normally reduce availability of nitrates, C, Ca and Mg in the soil and negatively affect the nutritional status of the soil, and thus biomass of that particular area. FAO (2017) and Xie and Witting (2004) reported the significant contribution that C has on the maintenance of soil health status and plant productivity. Clay soil type had higher concentration of micro minerals than other soil types. Micro mineral also play an important role in plant growth and they are required in trace quantities (Munshower 1994). As highlighted by Blank et al. (2007), factors such as heavy grazing as it happened in sandy-loam and clay-loam soil type sites might have contributed to low mineral concentration in those sites.

Most of medium and high grazing value grass species such as *E. curvula, U mosambicensis*, *P. maximum*, *T. triandra, H. filipendula*, and *E. rigidior* were found to be common and dominant in the clay soil type. Rahim and Maselli (2004) stressed that the more moderate grazing, the more preferred and perennial species are increased and ultimately replace the unpalatable pioneer ones. The existence of high grazing value species such as *P. maximum* in sandy-loam and clay-loam as common and dominant might have been influenced by habitat of this species. This species is known to grow under trees where there is little or no access to herbivory (Roodt 2011; van Oudtshoorn 2014). The management practices through ungulate grazing influence grass species diversity and other plant community (Hickman et al. 2004). Heavy grazing normally results in change of vegetation structure and composition (Stern et al. (2002). Change in vegetation composition from high grazing value grass species to less grazing value grass species, had been reported in many areas (Cingolani et al. 2003; Zatout 2014; Koerner and Collins 2014), whereby most of high grazing species increase with decreasing grazing intensity (Deng et al. 2014). Bezuidenhout (2015) stressed that in order to have a long term improvement in veld condition that lead to a higher grazing capacity and livestock productivity, good management practices should be applied and the vigour of desirable species should be better than that of undesirable species.

Cymbopogon pospischilii was more common on clay-loams whereas *Perotis patens* was common on sandy-loams. *Cymbopogon pospischilii*`s presence in grazing areas is an indication of selective grazing, animals avoid it because of a bitter taste from some inherent essential oil (van Oudtshoorn 2014), and its woody structure (Roodt 2011). *Perotis patens* is regarded as a pioneer, and a handy indicator species which survives well in poor sandy soil and its abundance is an indicator of mismanagement and overgrazing in an area (Roodt 2011).

The clay soil type had the highest biomass production when compared to clay-loam, and sandy-loam soil types. Climatic condition, edaphic and management practices are known to be the main factors in grass growth. The effects of these factors and their interaction need to be understood. These areas are based within the same altitudes (1069-1121) and also receive equal amounts of rainfall. Soil and management practices might have influenced the biomass production which is in agreement with the findings from de Araujo et al. (2018).

Through grazing, grass species can decrease in abundance or disappear completely which may lead to the reduction of biomass in many grazing areas (McNaughton 1979) and this decreases the grazing capacity as observed in this study.

There was a relationship between biomass and soil chemical constituents of the study sites (Table 4 and Table 9). The soil nutrient characteristics play an important role in biomass accumulation. The fertility status of the clay soil type area was better than that of the other soil types, and that might have contributed to the observed high biomass. Poor soil fertility and overgrazing might have contributed negatively to biomass production in the other soil types (Papadopoulos et al. 1993, Tessema et al. 2011). Ohmunn (1981) emphasized that significant decrease in dry matter yield in sandy-loam and clay-loam soil types is a reflection of the impacts of low P and K observed in these sites.

Sandy-loam and clay-loam had higher percentages of forbs when compared to clay-soil type. Areas such as sandy-loam and clay-loam sites when overgrazed can create a breeding ground for pioneer species and forbs to germinate (van Oudtshoorn 2014). Less forbs were expected in clay soil type when compared to clay-loam and sandy-loam soil types due to moderate grazing in these areas. Forbs such as *Conchorus tridens* L., *Sida cordifolia* L., *Amaranthus spinosus* L., Aloe spp and *Tragia rupestris* song were the most common species found in clay-loam and sandy-loam. *Aloe* spp is known to be used as efficient barrier for retention of eroded sediments and superficial runoff, stabilising the soil and increase soil humidity by improving infiltration and soil structure (WOCAT 2018). *Aloe vera* species, if left unattended, can be invasive to the forage available to livestock. Many studies suggest that application of proper grazing management is important (Biondini et al. 1998) as it improves livestock productivity due to proper management of grass growth.

Cymbopogon pospischilii, *P. maximum*, *H. filipendula* in clay soil type had higher height values when compared to the same species on other soil types. These species heights were within the range reported by van Oudtshoorn (2014). Though there were no significant differences observed, species such as *U. mosambicensis*, and *T. triandra* in clay soil reflected higher values when compared to the same species on other soil type. The value of *C. pospischilii* was higher and similar to the ones reported by Ravhuhali (2018) and Ravhuhali et al. (2019). With genotype-set limits, most of growth of the tiller were influenced by environment (Laude 1972). The height of the plant assists in the accumulation of biomass that could provide necessary protection against top soil leaching and increase soil organic matter content, hence there will be an increase in soil nutrients and improvement in the structure of the soil for moisture retention (Dahl 1995).

Urochloa mosambicensis, *H. contortus* and *H. filipendula* in clay soil type and *P. maximum* in sandy-loam soil type had the high tuft diameter values when compared to the same species in other soil types. Numbers of tillers determine tuft diameter. Even though *C. pospischilii* is known to accumulate many tillers under adaptive environments (Shackleton 1990, Ravhuhali et al. 2019), the opposite was observed in clay soil type. Competition for the resources during the growing season in well managed areas such as in clay soil type might have affected *C. pospischilii* in the development of tillers. Tuft diameter assists the plant in facilitating growth after grazing. Tuft diameter also assists in improving soil conditions through addition of organic matter and other nutrients from decomposed leaves and also increases soil mulching.

Conclusion

Uncontrolled utilization of vegetation which leads to overgrazing is common in most of

CPAs. This overutilization of grazing lands results in the shortage of most highly desirable species. In heavily grazed areas, forbs and pioneer grasses increase, and are less valuable to livestock. Soil type affected the mineral status of the sites, with heavily grazed clay-loam (Mashung Matlala) and sandy-loam (Mawela) CPAs having low levels of minerals. These results suggest that utilization of rangelands in CPAs needs to be improved through grazing management procedures that consider vulnerable soil types such as the clay and sandy-loam types. Stocking rates in these sites need to be monitored so that they do not exceed the carrying capacity. Furthermore, is it important to assess the nutritional status of forages and woody vegetation composition in different soil types of the CPAs. This would help in developing a comprehensive veld management plan for these areas.

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References

Agri Laboratory Association of Southern Africa. 1998. *Feed and Plant Analysis Methods.*

Aguado-Santacruz, G.A, and E. Garcia-Moya. 1998. "Environmental Factors and Community Dynamics at the Southernmost Part of the North American Graminetum–I. On the Contribution of Climatic Factors to Temporal Variation in Species Composition." *Plant Ecology* **135** (1): 13-29.

Amiri, F., A. Ariapour, and S. Fadai. 2008. "Effects of Livestock Grazing on Vegetation Composition and Soil Moisture Properties in Grazed and Non-Grazed Range Site." *The Journal of Biological Sciences* **8**:1289-1297.

Araujo, L.C.D., P.M. Santos, D. Rodriguez, and J.R.M. Pezzopane. 2018. "Key Factors that Influence for Seasonal Production of Guinea Grass." *Scientia Agricola* **75**:191-196.

Bareja, B.G. 2011. "The Abiotic Factors Affecting Plant Growth and Development Include Topography and Soil." Crop Farming Review. Accessed September 25, 2018. (http://www.cropsreview.com/abiotic-factors.html.

Biondini, M.E., B.D. Patton, and P.E. Nyren. 1998. "Grazing Intensity and Ecosystem Processes in a Northern Mixed-Grass Prairie, USA." *Ecological Applications* **8:**469-479.

Bezuidenhout, R. 2015. "Veld Management Systems that are Sustainable." Farmers Weekly Magazine, February 13.

Blank, R.R., J. Chambers, B. Roundy, and A. Whittaker. 2007. "Nutrient Availability in Rangeland Soils: Influence of Prescribed Burning, Herbaceous Vegetation Removal, Overseeding with *Bromus tectorum*, Season, and Elevation." *Rangeland Ecology & Management* **60**: 644-655.

Cingolani, A.M., M.R. Cabido, D. Renison, and V. Solís Neffa. 2003. "Combined effects of environment and grazing on vegetation structure in Argentine granite grasslands." *Journal of Vegetation Science* **14**: 223-232.

Dadkhah, M., and G.F. Gifford. 1980. "Influence of Vegetation, Rock Cover, and Trampling on Infiltration Rates and Sediment Production 1." *Journal of the American Water Resources Association* **16**: 979-986.

Dahl, B.E. 1995. "Development Morphology of Plants." In *Wildlife Plants: Physiological Ecology and Developmental Morphology*, edited by Bedunah, and R.E. Sosebee, 22-58. Society for Rang Management.

Delgado-Balbuena, J., J.T. Arredondo, H.W. Loescher, E. Huber-Sannwald, G. Chavez-Aguilar, M. Luna-Luna, and R. Barretero-Hernandez. 2013. "Differences in Plant Cover and Species Composition of Semiarid Grassland Communities of

Central Mexico and its Effects on Net Ecosystem Exchange." *Biogeosciences* **10**:4673-4690.

Deng, L., Z. Zhang, and Z. Shangguan. 2014. "Long-Term Fencing Effects on Plant Diversity and Soil Properties in China." *Soil and Tillage Research* **137**:7-15.

Department of Agriculture (Department of Agriculture retrieved 2018). Waterberg District Environmental Management Framework Report. National Department of Environmental Affairs (DEA) in partnership with the Limpopo Department of Economic Development, Environment and Tourism (LEDET), and the Waterberg District Municipality (WDM).

FAO 2017. "Unlocking the Potential of Soil Organic Carbon." *Global Symposium on Soil Organic Carbon,* 21-23 March 2017. FAO - Rome, Italy.

Gwelo, A.F., S. Tefera, and V. Muchenje. 2015. "Temporal and Spatial Dynamics of Mineral Levels of Forage, Soil and Cattle Blood Serum in Two Semi-Arid Savannas of South Africa." *African Journal of Range and Forage Science* **32**: 279-287.

Heitschmidt, R.K., S.L. Dowhower, and J.W. Walker. 1987. "Some Effects of a Rotational Grazing Treatment on Quantity and Quality of Available Forage and Amount of Ground Litter." *Journal of Range Management* **40**:318-321.

Hickman, K.R., D.C. Hartnett, R.C. Cochran, and C.E. Owensby. 2004. "Grazing Management Effects on Plant Species Diversity in Tallgrass Prairie." *Journal of Range Management* **57**:58-65.

Koerner, S.E. and S.L. Collins. 2014. "Interactive Effects of Grazing, Drought, and Fire on Grassland Plant Communities in North America and South Africa." *Ecology* **95**:98-109.

Kwaza, A. 2013. "Species and Spatio-Temporal Variation in the Yield, Nutritive Value and in Vitro Ruminal Fermentation Characteristics of Selected Grass Species from Two Communal Grazing Lands of the Eastern Cape." Doctoral dissertation, University of Fort Hare.

Lake, P.S. 2000. "Disturbance, Patchiness, and Diversity in Streams." *Journal of the North American Benthological Society* **19**:573-592.

Laude, H.M. 1972. "External Factors Affecting Tiller Development." In *The Biology and Utilization of Grasses*, edited by V.B. Younger and C.M. McKell, Chapter **11**:146-154. Academic Press.

Lesoli, M.S. 2008. "Vegetation and Soil Status, and Human Perceptions on the Condition of Communal Rangeland of the Eastern Cape, South Africa." M.Sc. Dissertation, University of Forte Hare, Alice Campus, South Africa.

Liu, J., L. Wang, D. Wang, S.P. Bonser, F. Sun, Y. Zhou, Y. Gao, and X. Teng. 2012. "Plants Can Benefit from Herbivory: Stimulatory Effects of Sheep Saliva on Growth of *Leymus chinensis*." *Plos one* **27**: 1-8.

Londo, A.J., J.D. Kushla, and R.C. Carter. 2006. "Soil pH and Trees Species Suitability in the South." Southern Regional Extension Forestry. A regional peer reviewed Technology bulletin SREF-FM-002.

McNaughton, S.J. 1979. "Grazing as an Optimization Process Grass Ungulate Relationships in the Serengeti." *American Naturalist* **113:** 691-703.

Masiteng, T.J., C. Van der Westhuizen, and M. Matli, M. 2003. "Aspirations and Needs of Farmers on Communal Grazing Areas in the Free State." *South African Journal of Agricultural Extension* **32**: 85-97.

McLean, E.O. 1982. "Soil pH and Lime Requirement. Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties, (methodsofsoilan2)." 199-224.

Medina-Roldán, E., J.T. Arredondo, E. Huber-Sannwald, L. Chapa-Vargas, and V. Olalde-Portugal. 2008. "Grazing Effects on Fungal Root Symbionts and Carbon and Nitrogen Storage in a Shortgrass Steppe in Central Mexico." *Journal of Arid*

Environments **72**:546-556.

Moore, A., and A. Odendaal. 1987. "Die Ekonomiese Implikasies van Bosverdigting en Bosheheer Soos van Toepassing Op 'n Speenkalfproduksiestelsel in die Doringbosveld van die Molopogebied. *J. Grassi. Soc. Sth. Afr.* **4:**139-142.

Mucina, L. and M.C. Rutherford. 2006. "The Vegetation of South Africa, Lesotho and Swaziland." South African National Biodiversity Institute.

Munshower, F.F. 1994. *Practical Handbook of Disturbed Land Revegetation*. Boca Raton, FL. US.: Lewis Publishers.

Munyai, F.R. 2012. "An Evaluation of Socio-Economic and Biophysical Aspects of Small-Scale Livestock Systems Based on a Case Study from Limpopo Province: Muduluni Village." Faculty of Natural and Agricultural Sciences, Department of Animal, Wildlife and Grassland Science, University of the Free State.

Ohmunn, L.F., D.F. Grigal, and L.L. Rogers. 1981. "Estimating Plant Biomass for Undergrowth Species of Northeastern Minnesota." NTIS, Springfield, VA. 1981.

Papadopoulos, Y.A. H.T. Kunelius, and A.H. Fredeen. 1993. "Factors Influencing Pasture Productivity in Atlantic Canada." *Canadian Journal of Animal Science* **73**:699-713.

Rahim, I.U. and D. Maselli. 2004. "Improving Sustainable Grazing Management in Mountain Rangelands of the Hindu Kush–Himalaya." *Mountain Research and Development* **24**:124-133.

Ravhuhali, K.E. 2018. "Spatial Variation in Density, Species Composition and Nutritive Value of Vegetation in Selected Communal Areas of the North West province." PhD thesis. North West University, South Africa.

Ravhuhali, K.E., V. Mlambo, T.S. Beyene, and L.G. Palamuleni. 2019. "A Comparative Analysis of the Morphology and Nutritive Value of Five South African Native Grass Species Grown under Controlled Conditions." *African Journal of Range and Forage Science* **36**(1): 67-70.

Roodt, V. 2011. *Grasses of the Kruger National Park and surrounding Bushveld*. Veronica Roodt Publications.

SAS. 2010 Statistical Analysis System User Guide: Statistics, Version 9.3 SAS Institute, Cary, NC, USA.

Shackleton, S.E. 1990. "Autecology of *Cymbopogon validus* in Mbambati Game Reserve, Transkei." MSc thesis, University of the Witwatersrand, South Africa

Snyman, H.A. 1998. "Dynamics and Sustainable Utilization of Rangeland Ecosystems in Arid and Semi-Arid Climates of Southern Africa." *Journal of Arid Environments* **39**:645-666.

Stern, M., M. Quesada, and K.E. Stoner. 2002. "Changes in Composition and Structure of a Tropical Dry Forest Following Intermittent Cattle Grazing." *Revista de biología tropical* **50**:1021-1034.

Tefera, S., H.A. Snyman, and G.N. Smit. 2007. "Rangeland Dynamics of Southern Ethiopia: (2). Assessment of Woody Vegetation Structure in Relation to Land Use and Distance from Water in Semi-Arid Borana Rangelands." *Journal of Environmental Management*. **85**:443-452.

Tefera, B. and G. Sterk. 2010. "Land Management, Erosion Problems and Soil and Water Conservation in Fincha'a Watershed, Western Ethiopia." *Land Use Policy* **27**:1027-1037.

Tessema, Z.K., W.F. de Boer, R.M.T. Baars, and H.H.T. Prins. 2011. "Changes in Soil Nutrients, Vegetation Structure and Herbaceous Biomass in Response to Grazing in a Semi-Arid Savanna of Ethiopia." *Journal of Arid Environments* **75**:662-670.

van Oudtshoorn, F. 2007. "Veld Management the Basic." Department of Agriculture Information pamphlet. Limpopo Province.

van Oudtshoorn, F. 2014. *Guide to Grasses of South Africa*. Briza Publication.

van Oudtshoorn, F. 2015. *Veld Management*

Principles and Practices. Briza Publications

Viljoen C.J. 2012. "Soil Analysis of Bathlako Mine. Volclay Bathlako Mining Soil, Land use Land Capacity Assessment, Report: P274." Golder Associates. Viljoen and Associates.

Walkley, A. and I.A. Black. 1934. "An Examination of the Degtjareff Method for Determining Soil Organic Matter, and a Proposed Modification of the Chromic Acid Titration Method." *Soil Science* **37** (1): 29-38.

Warren, A. and M. Khogali. 1992. "Assessment of Desertification and Drought in the Sudano-Sahelian Region, 1985-1991." United Nations Sudano-Sahelian Office.

WOCAT. 2018. "Aloe Vera Living Barriers." Accessed 20 September 2018. https://qt.wocat.net/qt_summary.php?lang=english&qt_id=550.

Xie, Y., and R. Witting. 2004. "The Impact of Grazing Intensity on Soil Charactereristics of Stipa grandis and Stipa bungeana steppe in Northern China." *Acta Oecologica* **25:**197-204.

Zatout, M.M. 2014. "Effect of Negative Human Activities on Plant Diversity in the Jabal Akhdar Pastures." *International Journal of Bioassays* **3**:3324-3328.