CHAPTER 5

The influence of livestock grazing around water points on the primary production of herbaceous plants

5.1 Introduction

The measurement of available phytomass is of great value to the range manager and may be one of the most important vegetation and animal determinations. Phytomass is measured to obtain a quantitative measure of production over time. A single field measurement at maturity in grassland would reflect the accumulated seasonal production. To illustrate changes in phytomass over time, measurements should be taken at the beginning and end of the season or treatment period. Another use of phytomass measurements is the determination of forage utilization by animals (clipping plots before and after grazing). The need for a time and cost effective technique to monitor phytomass production, availability and utilization was emphasized in chapter one.

Water is a major determinant of livestock distribution. Animals graze from a water point to a distance they can afford depending on the availability of forage and their dependency on water. In the early days animals in Botswana used to water from surface source such as pans, rivers and hand dug wells through out the year. These limited water sources resulted in the protection of large areas of rangeland from grazing, except by wildlife, especially in the Kalahari sandveld. The introduction of borehole technology and a financial assistance policy opened the Kalahari rangeland to grazing by livestock. This improved livestock distribution, but increased overgrazing because the stocking densities around the water sources were not sufficiently considered. Changes in rangeland condition around water points have been reported by many authors (Lange 1969; Zumer – Linde 1976; Hanan *et al.* 1991; Perkins 1991; Van Rooyen *et al.* 1994 & Thrash 1998). Lange (1969) used the 'piosphere' to describe the pattern of decreasing grazing effects with distance from the water. In the southern Kalahari of Botswana, herbage utilization was affected to a distance of 20km, or more, from the water point (APRU 1985; Skarpe 1983 and Zumer – Linde 1976). It is, therefore, appropriate to estimate the primary production of the vegetation at distances from the water point.

Animals select their diets on the basis of forage availability and quality in addition to their body size, type of digestive system, etc (Owen – Smith 1999). These factors influence the performance of grazing animal in terms of weight gain, reproduction and other parameters. Information on forage availability and quality is, therefore, essential to explain observed livestock diet selection. This study was designed to evaluate the influence of grazing systems and various distances along the transect radiating from water point on the available herbage phytomass at different seasons so as to relate livestock preferences to the relative abundance of plant species. This type of information would be useful in refining adjustment for distances from water in stocking rate determinations, and in decisions regarding location and espacement of water points

5.2 Material and methods

The available herbage phytomass was estimated using a double sample method (Weight estimate method). Samples were taken at five points along the transect radiating from the water point. These points were located at 0, 600, 1200, 1800 and 2400 meters at Makhi ranch (controlled grazing), while in the free range grazing area, these were located at 0, 500, 1500, 2500 and 4000 meters from the water point. The zero (0) point is near the livestock drinking water, where animals concentrate or rest after drinking. A 50m x 50m permanent plot at each point was demarcated in which herbaceous plants was measured. Within each such plot, 20 quadrates of 0.5 x 0.5m were randomly placed to estimate herbage biomass. The first four quadrates were estimated visually and the fifth quadrate was clipped so that the visual estimated weights could be adjusted by a regression technique. Clipping one quadrate in every five provided a ratio of 1:5, which is better than 1:7 ratio recommended for short grass by Ahmed & Bonham (1982). The clipped samples were weighed and bagged by species at clipping time and re - weighed after oven drying. Only the current years growth was collected, by separating the old material from the current growth. Samples were taken at the end of January (summer), the end of April (Autumn), the end of July (winter) and the end of October (spring) over the period of two years.

5.2.1 Statistical Analysis

Descriptive statistics was used to summarize the data according to relevant parameters. The main effects of season, grazing system and distance from water point on available forage phytomass were determined by General Linear Model (SAS 1985). Where differences were significant at the 5% level, Scheffe's test was used to separate the means. All differences discussed in the results or discussion sections are significant at the 5% level unless otherwise noted.

5.3 RESULTS

5.3.1 Seasonal plant species availability in controlled grazing conditions at Makhi Ranch

The variation in the available phytomass of individual herbaceous plant species during each sampling season over two years is illustrated in Table 5.1. There were significant ($P< 0.05$) differences in the amount of herbaceous available phytomass on each plant species between the seasons. The highest phytomass available on all plant species peaked in summer to autumn and was the lowest in spring in both years. Total herbage phytomass on all plant species was higher during the first year (1996/97) than during the second year (1997/98). The lowest phytomass recorded was 257.50 gm^{-2} in the spring of 1997/98 compared to 316.86 gm^{-2} for the same season of the previous year. The amount and distribution of rainfall was the basic cause for these differences. Total rainfall was 553mm and 357.2mm for 1996/97 and 1997/98 growing seasons, respectively (Fig. 2.2). Poor rainfall recorded in February 1997 resulted in lower phytomass availability observed in the autumn of 1996/97. In the 1997/98 growing season, no effective rainfall was measured after February 1998 and this accounted for lower phytomass availability. The phytomass of S. uniplumis and S. pappophoroides, during the summer of 1997/98, was approximately half that of the previous summer. Available phytomass over the experimental period was dominated by S. uniplumis, E. rigidior, D. eriantha, S. pappophoroides and E. lehmanniana.

Table 5.1 Phytomass available (gm^{-2}) on individual plant species, or species groups in each season over two years in controlled grazing - Makhi ranch.

Plant species*	Season of year								
	Summer 1996/97	Autumn 1996/97	Winter 1996/97	Spring 1996/97	Summer 1997/98	Autumn 1997/98	Winter 1997/98	Spring 1997/98	Mean
D. eri	37.42^{ab}	44.16^{a}	38.30^{ab}	31.30^{ab}	33.26^{b}	42.19^{a}	41.56^{a}	32.58^{ab}	36.32
E. leh	68.50^{a}	67.16^{ab}	48.86^{bc}	38.00^{c}	38.82^{c}	40.02^{c}	42.02^{c}	37.88^{c}	49.24
E. rig	85.10^{a}	63.78^{ab}	81.14^{a}	69.92^{ab}	66.30^{ab}	74.76^{ab}	57.24^{ab}	49.92^{b}	68.52
S. uni	90.14^{a}	79.34^{a}	71.80^{ab}	61.70^{ab}	41.46^{c}	73.66^{ab}	50.72^{bc}	50.52^{bc}	65.34
S. pap	53.20^{a}	49.18^{ab}	62.52^{a}	44.60^{ab}	25.06^{b}	39.90^{ab}	45.12^{ab}	36.32^{ab}	44.74
P. max	47.00^{a}	23.98^{b}	30.48^{ab}	0^{c}	29.24^{ab}	14.94^{b}	0^{c}	0^{c}	18.20
Misc grass	41.04^{a}	41.32^{a}	34.66^{a}	33.74^{a}	30.48^{a}	33.68^{a}	35.92^{a}	28.32^{a}	34.92
M.alb/U.tri	24.14^{ab}	21.08^{b}	34.10^{a}	21.80^{ab}	21.74^{ab}	19.12^{b}	14.44^{b}	0^{c}	20.04
C.bie/I.dal	33.20^{a}	30.40^{a}	25.20^{a}	15.80^{a}	21.90^{a}	20.6^{a}	13.60^{a}	0^{b}	19.96
D.aeg/E.afr	58.52^{a}	15.50^{a}	5.04^{b}	0^{d}	5.36^{bc}	1.42^{cd}	0^{d}	0^{d}	10.72
A.thu/T.ter	41.20^{a}	25.98^{ab}	0^{c}	0^{c}	18.24^{b}	13.60^{b}	0^{c}	0^{c}	12.36
Misc Forbs	17.40^{a}	14.10^{a}	15.56^{a}	0^{b}	9.86^{a}	14.10^{a}	17.10^{a}	21.96^{a}	14.04
Total	596.86	475.98	447.66	316.86	341.72	387.88	317.72	257.50	

Values in each column followed by a same superscript are not significantly different (P>0.05) between seasons

Annual plant species (grasses and forbs), had in general, a high phytomass during summer periods but this declined drastically in winter and spring, resulting in bare ground (Table 5.1). During summer of 1997/98, however, the phytomass of D. aegyptium and E. africana (annual grasses), A. thunbergii and T. terrestris (annual forbs) was significantly ($P<0.05$) lower due to poor rainfall in December 1997. The phytomass of P.maximum was low, or non – existent, during the dry seasons

5.3.2 Plant species available at points along the transect from the water point in controlled grazing conditions

Table 5.2 illustrates the variation in the phytomass availability of individual plant species along the transect from the water point. There were significant ($P<0.05$) differences in the availability of phytomass of each plant species between points. Total herbage phytomass for all plant species at each point was 142.58, 325.0, 360.46, 385.74 and 366.02 gm^{-2} at 0, 600, 1200,1800 and 2400m from the water point, respectively. The point in the immediate vicinity of the water point produced less than half of all other points. Beyond the 600m point the effects of livestock grazing tended to taper off. The increased grazing pressure near the water point was probably the reason for these differences. The furthest point (2400m) had slightly less material than at 1800m. The most probably reason might be that the 2400m location was only 100m from the perimeter fence, where animals tended to rest and to concentrate their grazing immediately after the rest.

Table 5.2. Phytomass availability (gm^{-2}) of individual plant species and species group at each distance from the water point in controlled grazing - Makhi ranch.

Plant species	Distance from water(m)				
	0	600	1200	1800	2400
D. eri	0^{c}	27.90^{b}	38.90^{a}	38.84^{a}	37.96^{a}
E. leh	23.52^{b}	43.32^{a}	46.08^{a}	56.72^{a}	53.12^{a}
E. rig	19.58^{b}	63.02^{a}	77.08^{a}	77.22^{a}	74.84^{a}
S. pap	0^{b}	38.76^{a}	45.10^{a}	49.66^{a}	45.18^{a}
S. uni	0^{b}	69.56^{a}	62.20^{a}	64.12^{a}	60.28^{a}
P. max	29.04^{a}	0^{b}	0^{b}	0^{b}	0^{b}
Misc grasses	3.94^{b}	26.02^{a}	37.40^{a}	37.08^{a}	33.54^{a}
M. alb/U. tri	16.06^{a}	18.16^{a}	19.24^{a}	23.26^{a}	22.82^{a}
C. bie/ I. dal	0^{b}	23.06^{a}	21.24^{a}	24.22^{a}	21.74^{a}
D. aeg/E. afr	5.08^{a}	0.20^{a}	0^{b}	0^{b}	0^{b}
A. thu/T. ter	19.16^{a}	0^{b}	0^{b}	0^{b}	0^{b}
Misc forbs	26.20^{a}	15.22^{a}	13.22^{a}	14.62^{a}	16.54^{a}
Total	142.58	325.0	360.46	385.74	366.02

Values in each column followed by the same superscript are not significantly ($P>0.05$) different between distances

Due to the daily concentration of animals around the water point, certain plant species were limited to such areas. Table 5.2 illustrates that D. aegyptium and E. africana (grasses), T terrestris, and A. thumbergii (forbs) were only found at the 0m (zero) zone but were rare at 600m point or beyond. Such plants tend to be associated with soil disturbance. The occurrence of P. maximum at this location was influenced by the huge tree canopies of A. gerradii, and higher soil nutrients (Chapter 3), occurring in the vicinity of the water point. The occurrence of S. uniplumis, S. pappophoroides, D. eriantha (grasses), C. biensis and I. daleoides (forbs) were observed starting at the 600m point from the water point. Due to its morphological growth form, S. uniplumis, with its growing points raised above ground surface, is sensitive to trampling, while D. eriantha and S. pappophoroides although having their growing points below ground surface were sensitive to grazing pressure (decreaser plants)

Cassia biensis and I. daleoides (perennial forbs) tended to be uniformly distributed at all points along the transect, except the one next to the water point, where phytomass was probably reduced by trampling. Urochloa trichopus and M. albescens (annual grasses) were more or less evenly distributed along the transect from the water point. Phytomass available in the vicinity of the water point was mostly accounted for by annual grasses and forbs and their contribution was largely restricted to the growing seasons.

5.3.3 Plant species availability on different grazing systems at Makhi Ranch

The variation in phytomass of individual plant species as influenced by the system of grazing, is illustrated in Table 5.3. Total phytomass available on all plant species was 399.26, 381.34, 420.63 and 184.27 gm^{-2} for the continuous grazing system, 3 – paddock grazing system, 9 – paddock grazing system and the non – grazing exclosures, respectively. The 3 – paddock system was significantly inferior ($P<0.05$) to the 9 – paddock system and the control which did not differ significantly, from the 1 – paddock system.

There was a significantly ($P< 0.05$) less phytomass of D. eriantha in the continuous and 3 – paddock grazing systems than the non-grazing exclosure or the 9 – paddock grazing treatments. P. maximum was low in the continuous system compared to other two systems. Phytomass availability was dominated by S. uniplumis and E. rigidior in all the treatments. Available phytomass of miscellaneous grasses was almost the same across the treatments.

The non – grazing exclosure had higher phytomass although plant species diversity was surprisingly low compared to other treatments. With the exception of C. biensis and I. daleoides, there were no annual plants found in the non – grazing exclosure.

Table 5.3 Phytomass availability (gm^{-2}) of individual plant species, or species group, at each grazing system in controlled grazing

Plant species	Grazing Systems			
	1 P system	3 – P system	9 – P system	Control
D. eri.	33.50^{bc}	31.76^{c}	41.92^{ab}	47.14^{a}
E. leh	52.74^{a}	42.38^{a}	46.86^{a}	54.06^{a}
E. rig	72.84^{a}	61.92^{ab}	65.06^{a}	37.46^{b}
S. uni	66.68^{a}	63.46^{a}	58.84^{a}	45.60^{a}
S. pap	43.76^{a}	43.92^{a}	47.23^{a}	-
P. max	17.68^{a}	25.28^{a}	33.46^{a}	-
Misc grasses	35.16^{a}	32.10^{a}	36.54^{a}	-
M. alb / U. tri	18.26^{b}	20.34^{ab}	23.96^{a}	-
C. bie / I.dal	20.62^{a}	$24.7o^{a}$	19.38^{a}	11.70^{a}
D. aeg / E. afr	3.44^{a}	3.66^{a}	5.88^{a}	-
A. thu / T. ter	19.06^{a}	18.56^{a}	20.82^{a}	-
Misc Forbs	15.52^{a}	13.26^{a}	20.68^{a}	-
Total	399.26^{ab}	381.34^{b}	420.63^{a}	184.27^{c}

Values in each column followed by the same superscript are not significantly different between the grazing systems

Forage plants regarded as 'key grazing species' in terms of quality or amount in this particular sandveld area are D.eriantha, S. pappophoroides and E.lehmanniana. Although the phytomass on the continuous system and the 9 – paddock systems was not significantly different, the available phytomass of quality species was higher in 9 – paddock system than the continuous or the 3 – paddock systems (Table 5.3), thus, placing the 9 – paddock system in superior position.

5.3.4 Availability of phytomass on different plant species in free range grazing areas

Table 5.4 illustrates the variation in available phytomass of individual herbaceous plant species at the two cattle posts in the free range grazing area. A comparison between the available phytomass of total plant species revealed no significant (P>0.05) difference between the two cattle posts, hence the data for the two were pooled together for the seasons and along the transect from the water point. However, there were differences in phytomass of few individual species between the two cattle posts. The available phytomass of D. eriantha, S. pappophoroides, and M. albescens / U. trichopus was higher (P<0.05) and E. rigidior was lower at Motshwagole cattle post while the phytomass available on D. aegytinum and E. africana was higher at Masaane cattle post.

Table 5.4. Phytomass availability (gm^{-2}) of individual plant species, and species group at two cattle posts in free range grazing.

Plant species	Cattle Post	
	Motshwagole	Masaane
D. eri	47.62^{a}	34.72^{b}
E. leh	41.52^{a}	36.62^{a}
E. rig	46.80^{b}	50.54^{a}
S. uni	67.96^{a}	71.32^{a}
S. pap	45.74^{a}	42.10^{a}
Misc grasses	48.62^{a}	28.34^{b}
M. alb / U. tri	26.86^{a}	18.26^{b}
C. bie / I.dal	32.18^{a}	29.08^{a}
D.aeg / E. afri	9.98^{b}	30.24^{a}
A.thu / T. ter	39.16^{a}	25.52^{a}
Misc forbs	23.78^{a}	21.06^{a}
Total	430.22	387.8

Values in each column followed by the same superscript are not significantly different (P>0.05) between the boreholes

5.3.5 Seasonal availability of phytomass of different plant species in free range grazing area.

The herbage available on individual plant species observed, during sampling seasons over two years, is illustrated in Table 5.5. Comparison of different season revealed differences in the total available phytomass of all species for each season. Significantly ($P<0.05$) low phytomass was evident during Spring 1997/98 and highest ($P<0.05$) phytomass peaked in autumn 1996/97.

The available phytomass of annual grasses and those species growing near the water point, were very low ($P<0.05$) during the summer of 1997/98 because of the dry December experienced in 1997,which resulted in their disappearance during the dry season (winter and spring). Their phytomass diminished starting from autumn due to the physiological nature where leaf senescence occurs followed by death of the plant. Grasses and forbs of the miscellaneous groups were uniformly distributed between the seasons except for the spring 1997/98. Most of the available phytomass was contributed by S. uniplumis, E. rigidior, E. lehmanniana, D. eriantha and S. pappophoroides.

Table 5.5. Phytomass availability (gm^{-2}) of individual plant species, and species group in each season over two years in the free range grazing area.

Plant species	Season of year								
	Summer 1996/97	Autumn 1996/97	Winter 1996/97	Spring 1996/97	Summer 1997/98	Autumn 1997/98	Winter 1997/98	Spring 1997/98	Mean
D.eri	28.06^{bc}	51.86^{ab}	49.90^{ab}	41.46^{abc}	30.88^{bc}	63.34^{a}	24.34^{bc}	19.68^{c}	38.74
E. leh	54.44^{ab}	52.84^{ab}	47.12^{abc}	36.10^{abc}	38.34^{abc}	63.70^{a}	52.14^{ab}	28.08^{b}	42.34
E. rig	39.26^{a}	55.28^{a}	59.94^{a}	44.74^{a}	33.38^{a}	61.32^{a}	55.62^{a}	^{c}	47.74
S.uni	56.86^{a}	106.88^{a}	83.90^{a}	55.48^{a}	79.96^{a}	68.66^{a}	50.66^{a}	45.36^{a}	68.34
S.pap	63.28^{ab}	74.78^{a}	69.00^{a}	30.94^{abc}	34.64^{abc}	60.02^{a}	34.66^{bc}	44.20^{a}	48.10
Misc grass	40.90^{a}	54.98^{a}	42.66^{a}	43.18^{a}	38.14^{a}	47.06^{a}	47.06^{a}	23.42^{c}	41.54
M.alb/U.tri	32.36^{ab}	43.54^{a}	19.02^{bc}	0^{d}	24.94^{b}	34.90^{a}	28.16^{ab}	43.60^{a}	20.24
C.bie/I.dal	60.64^{a}	33.08^{ab}	0^{d}	0^{d}	24.80^{bc}	30.58^{a}	18.58^{b}	0^{d}	21.02
D.aeg/E.afr	32.36^{a}	32.32^{a}	7.56^{b}	0^{c}	17.78^{a}	^{b}	0^{c}	0^{d}	12.20
A.thu/T.ter	46.44^{a}	26.08^{b}	6.20^{b}	0^{c}	15.46^{b}	7.34^{b}	0^{c}	0^{c}	9.36
Misc.forbs	27.14^{a}	25.70^{a}	17.70^{a}	14.82^{a}	16.44^{a}	6.90^{b}	12.06^{a}	0^{c}	15.84
Total	481.71	557.27	403.0	266.72	354.76	24.60^{a} 468.42	325.28	8.47^{b} 212.81	

Values in each column followed by the same superscript are not significantly different (>0.05) between seasons

5.3.6 Phytomass availability on different plant species along the transects from the water point in free range grazing areas.

The available phytomass on each plant species or group of species, along the transect from the water point is illustrated in Table 5.6. Comparison of the phytomass between the points revealed differences between the distances. Total available phytomass at each point increased with the increase in distance from the water point. The point in the vicinity of the water point was totally dominated by annual plants (grasses and forbs). Available phytomass of perennial plant species only occurred from the 500m zone from water point, and beyond.

Table 5.6 Phytomass availability (gm^{-2}) of plant species and species groups at each point along the transects from water point in the free range grazing area.

Plant species	Distance from water (m)				
	0	500	1000	2500	4000
D. eri	0^{c}	17.14^{b}	15.70^{b}	33.34^{ab}	53.22^{a}
E. leh	0^{c}	16.94^{b}	41.06^{a}	44.12^{a}	50.42^{a}
E. rig	0^{d}	24.12^{c}	50.10^{b}	74.00^{a}	67.42^{ab}
S. uni	0^{b}	0^{b}	68.80^{a}	56.06^{a}	79.86^{a}
S. pap	0^{c}	2.18^{b}	13.46^{a}	43.76^{a}	53.64^{a}
Misc grasses	0^{c}	11.50^{b}	47.86^{a}	36.14^{ab}	37.46^{ab}
M. alb / U. tri	21.08^{abc}	12.30^{c}	15.30^{bc}	25.38^{ab}	33.30^{a}
C. bie / I. dal	0^{b}	29.86^{a}	27.18^{a}	21.90^{a}	30.26^{a}
D. aeg / E.afr	18.86^{a}	16.86^{a}	0^{b}	0^{b}	0^{b}
A. thu / T. ter	26.78^{b}	67.00^{a}	1.530^{c}	0^{d}	0^{d}
Misc forbs	13.42^{a}	19.12^{a}	25.04^{a}	22.72^{a}	41.42^{a}
Total	80.14^{c}	197.90^{b}	280.9^{ab}	357.42^{a}	447.0^{a}

Values in each column followed by the same superscript are not significantly different (P>0.05) between the distances

Herbage available in the 0m zone was about one third of that in the 500m zone, which in turn was only about half that in the 4000m zone. Annual forbs (eg. T. terrestris), associated with soil disturbance, were found as far as the 1000m zone or 500m for D. aegytinum / E. africana, a situation which was not observed in the controlled grazing conditions. The occurrence of these species at such distances from the water point suggests that the size of the "sacrifice area" is larger in the cattle posts of the free range grazing area than in the controlled conditions. Stipagrostis uniplumis (perennial grass) occurred starting from the 600m zone and beyond. Comparison of distances between 2500 and 4000m from water point generally showed no significant ($P>0.05$) difference in the availability of the major grass species although the trend tended not to taper off, suggesting that grazing influence was still present at 4000m (Table 5.6).

5.4 DISCUSSION

The zonation of vegetation along the transect from the water point reflected the type of management, indicating different classes of range condition, which can be used in range evaluation and planning. Heavy grazing pressure and trampling in the vicinity of the water point killed sensitive perennial grass species resulting in a zone dominated by annual plants. A rapid transitional zone occurs beyond this, which is a zone of more or less uniform grazing influence by livestock, where perennial plants dominate.

Differences between the wet and dry season forage availability of the annual grasses and forbs were primarily due to early cessation of growth and ultimately death of plants, which coupled with grazing pressure and physical losses, led to the drastic decline in their availability during spring. In practice, such incidents of forage scarcity need to be remediated by stock reduction or feeding of hay.

Digitaria eriantha is widely recognised as a palatable and desirable grazing species (Drewes 1984). Its abundance indicates that the veld is in good condition (Field 1977) and it has been classified within the decreaser catagory (Field 1977; Thrash 1998). Results from this study confirm that this species is a decreaser and sensitive to trampling in sandveld areas (Table 5.6). Perkins (1991), however, indicated that this species was associated with high grazing pressure and soil disturbance. Certain plant species were found to occur at various distances

along the transects, or associated with many other plants (wide range). Such species included E. lehmanniana, U. trichopus and to a lesser extent E. rigidior. Plant species such as A. thunbergii, T. terrestris, (forbs), D. aegyptium and E. africana are associated with soil disturbance and higher soil fertility, hence their occurrence where animal concentrate their dung or urine and soil trampling. The occurrence of P. maximum in the sandveld is of a rare species, and it was totally grazed out in the communal cattle post area. In this study, the amount of phytomass recorded occurred under the tree canopies of A. gerradii, which were found in the vicinity of the water points, where higher soil nutrients were accumulated through dung and urine from animals. Due to the sub – habitat nature of this species, Stuart – Hill (1985); Teague & Smit (1992) and Smit & Rethman (2000) emphasized the fact that herbaceous plants should not be viewed in isolation from the woody vegetation.

Other miscellaneous grasses, which included A. congesta, A. graciliflora, E. pallens, P. squarrosa, M. repens and P. patens, exhibited no definite trend with regard to grazing systems, or different seasons, except that their phytomass declined during spring at the water point due to limited availability of forage. Lack of response to grazing systems, or to season of the year, of these plant species is the result of their poor preference by livestock.

Problems of the impact on rangeland condition near water points are likely to cause soil erosion because of the reduced protection of soil surface during the dry seasons and enhanced bush encroachment because these areas will not burn (Grossman *et al.* 1999). If water points are used by livestock to any extent, an impact on the vegetation is expected, or cannot be avoided. Fusco *et al.* (1995) illustrated in their data that even long term conservative cattle grazing causes a reduction in perennial grass phytomass the closer to the water. What is perhaps more important is the ecological extent of the “sacrifice area” around the water points over time. The main focus should, therefore, concentrate not on preventing the changes around water points, but on controlling the changes such that livestock production can be made sustainable.

Two practical approaches had been mentioned by certain workers that can minimize degradation and enhance the productivity of perennial grasses around the water points. Fusco *et al.* (1995) indicated the adjustment of stocking rate with distance from water. However, in Botswana, data on the influence of travel distance between forage and water on cattle

performance are not available. Research is needed to evaluate how travel distance between water and forage affects animal performance, particularly during forage scarce periods. Martin & Ward (1970) found that the yield of perennial grasses, over a period of eight years, doubled when rotational access to water points was practiced compared to continuous grazing.

5.5 CONCLUSION

High grazing pressure and trampling near water points cause sacrifice areas in which perennial herbaceous plants cannot survive. Annual plants grow on bare areas near the water point during growing seasons and their presence is inversely proportional to distance from the water point. Beyond these sacrifice area, the effects taper off rapidly until an upper level is approached (grazing effect diminish).

The sacrifice zone was larger in the free range grazing areas than in the controlled grazing management systems. Over the study period, significantly higher amounts of available phytomass were recorded in summer and autumn with low phytomass available occurring in spring.

Phytomass production of annual plants was more variable than that of the perennials under the variable rainfall conditions.

The 3 – paddock system produced less phytomass compared to the other systems, while phytomass of quality plant species was favoured by the 9 – paddock grazing system. Less utilized plant species were not responsive to either grazing system or season of the year.

In the free range grazing management system, the influence of grazing did not taper off at 4000m from the water point suggesting that animals travel beyond this point, while in the controlled conditions, grazing influence tapered off at 1200m from the water point suggesting that forage availability was more limiting in the free range grazing system.