CHAPTER 4

Influence of livestock grazing on the distribution and production of woody plants within a piosphere

4.1 Introduction

Woody plants are an important component of semi - arid rangelands throughout the world. These plants are generally well adapted to persist and spread in these regions under natural and man- induced perturbations including overgrazing and drought. The ecological status of woody plants in semi – arid grass / shrub rangeland has been outlined by Pratchatt 1978, Teague *et al.* 1981, Walker *et al.* 1981; Stuart – Hill *et al.* 1983*;* Stuart Hill 1985; Smit 1989 and Smit & Rethman 2000. Seeds of many shrub species are capable of being passed through the digestive tract of animals intact, with improved chances of germination and survival when deposited in faeces. In many cases the shrub component provides palatable and nutritious forage to animals, but more often the woody species become undesirable from a livestock management point of view because of excessive densities.

The measurement of browse species production presents additional problems, not encountered with the herbaceous species. Some of the basic problems which make practical sampling difficult, as indicated by Rutherford (1979), are that browse: a) is often not easily distinguishable in a uniform way in the field b) it consist of a very large number of small discrete parts c) its three dimensional distribution on a plant is often highly varied and d) spatial distribution of woody plants can be highly heterogeneous. Browse species are often large, have indeterminate growth, and are difficult to harvest (Cook & Stubbendieck, 1986). Rutherford (1979) mentioned that techniques specifically aimed at the determination of browse production rates were not as standardized as those for herbaceous vegetation production. Several scientists have developed regression equations expressing the relationship between twig length and diameter with twig weight (Lyon 1970; Halls & Harlow 1971; Dean *et al.* 1981). While these methods provide a means of estimating twig weight, they do not provide an estimate of the browse available per unit area (Cook & Stubbendieck

1986). It would be necessary to extrapolate these data to an individual plant and to an area basis. Canopy volumes of individual plant species on an area basis have been used to predict browse availability (Teague *et al*. 1981; Smit 1989; Smit 1996) as have indices derived from canopy and trunk diameters (Hobson & de Ridder 1991). The indirect measure of canopy volumes appears more practical than the twig lengths and diameter measurements, or hand harvest of leaves to determine the production of browse, as applied by Aucamp *et al*. (1984)

Monitoring of woody plants aims at measuring the number of plants by species, plant size and vertical distribution of live canopy. These parameters are used to determine the potential productivity of available browsable material and competitive influence of the woody plants on grass productivity (Teague *et al*. 1981; Aucamp *et al*. 1983; Stuart - Hill *et al*. 1987; Smit 1989). High bush densities cause a significant reduction in the grazing capacity of the range. Aucamp *et al*. (1983) found that at densities of Acacia karroo of 1000, 1500 and 2000 tree equivalents per hectare, the grazing capacity of the range can be expected to be 90, 67 and 32% of its potential, respectively. Du Toit (1968; 1972) indicated that the annual production of grass material was reduced by approximately 40 - 50 percent in range encroached with bush.

Because of the complexity of most plant communities, no single criterion will usually serve as the basis for the determination of range rating of any forage type or site (Humphrey 1962). Many factors affect plant production or growth. Species composition and plant density have been used extensively as criterion of forage site condition. Plant composition is a relatively stable and reliable criterion in perennial range, although it is a less sensitive in range condition (Fourie *et al.* 1984). Density data are commonly used to describe tree communities, but are often inadequate to quantify biomass accurately.

Woody plant composition determines, to some extent, those animal species which can best utilize the vegetation since each species shows preference for certain kinds and parts of plants (Kelly (1977). In some cases the shrub component provides palatable and nutritious forage to animals but the woody species often becomes undesirable from a livestock management point of view, because of their excessive density. The conversion of savanna to mature thickets generally reduces herbaceous forage production and livestock accessibility to the forage

(Teague *et al* 1983; Stuart-Hill *et al.* (1983). The objective of this study was directed towards answering questions regarding browse production and density, as influenced by livestock concentrations and grazing around water points.

4.2 Material and Methods

Available browse was determined by measuring the spatial volume of the tree canopies and the relationship to the true leave volume and true tree leaf mass (Smit 1989). This procedure follows three quantitative descriptive units which describe the status of the woody plant community in terms of potential water use, value of tree as a food for browsers and sub-habitat suitable for grass - tree associations. These descriptive units were described as follows:

a) Browse Tree Equivalent (BTE) - defined as the leaf mass equivalent of a 1.5m single stemmed tree.

b) Evapotranspiration Tree Equivalent (ETTE) - defined as a leaf volume equivalent of a 1.5m single stemmed tree.

(c) Canopied sub - habitat Index (CSI) - defined as the canopy spread area of those trees in the transect under which associated grasses, such as Panicum maximum, are likely to occur, expressed as a percentage of total transect area.

A belt transect of 5m x 50m was laid out within the 50m x 50m plot (where herbaceous biomass was studied) at each location along the main transect. On the ranch (fenced / controlled) plots were located at 0, 600, 1200 and 2400m from the water point. On the traditional cattle posts (uncontrolled / free range grazing) plots were located at 0, 500, 1500 and 4000m from the water point. The spatial volume of each separate tree canopy was determined by measurements taken within each belt transect. Measurements included: a) height of a tree, b) height of maximum canopy diameter, c) height of first leaves or potential bearing leaf stems, d) maximum canopy diameter and diameter at 1.5m, and e) base diameter of foliage at height c.

4.3 Statistical Analysis

A biomass estimate from the canopy volume model compiled by Professor Smit (Smit 1996) from University of Orange Free State was used to analyse the woody plant data. The model estimates are based on the relationship between spatial canopy volume of the tree's leaf volume and true leaf mass. The model also calculates single tree density data on a species basis and canopy spread index. The technique follows a regression analysis using standard statistical least squares regression analysis. It incorporates a number of regression equations for specific tree species, as well as a number of general regression equations. General regression equations are used for tree species for which specific regression equations do not presently exist. These values were also calculated per hectare. Only two plant species recorded at Makhi area were incorporated in the general regression model. The estimated leaf volume and leaf mass were calculated for each tree individually by substituting the tree's spatial volumes into a regression equations obtained from harvested leaves. The regression equation simulates the relationship between spatial tree volume and actual leaf mass. Two equations, one for the leaf dry weight and one for the leaf volume were derived for each plant species (Smit 1996). Smit (1996) indicated that by calculating the canopy volume below any specified maximum browse height, an estimate of browse potential within the reach of a browser is possible.

4.4 RESULTS

4.4.1 Density of woody plants in controlled grazing conditions – Makhi ranch

Variations in woody plant density (plant / ha), leaf volumes and subdivision of canopy spread index height strata of individual species for each distance along the transect from water point under controlled grazing conditions (Makhi ranch) is illustrated in Table 4.1. The mean densities were 1502, 1673, 1456 and 1575 plants / ha at 0, 600, 1200 and 2400 metres from water, respectively. Plant density was highest at 600m away from the water point and was lower at 1200m and in the immediate vicinity of the water point.

Sixteen plant species were recorded in the immediate vicinity of the water point and these increased to eighteen at the furthest distance from water. Woody vegetation in the Makhi area was dominated by low shrubs, which included D. cinerea, G. flava, B. petersiana and M. sericea, and taller trees including B. albitrunca P. africanum and T. sericea. The density of A. gerradii increased with the decreasing distance from the water point (Table 4.1). Distribution of individual plant species along the transect radiating from the water point showed that D. cinerea, and G. flava were prominent in the vicinity of the water point (first distance from the water point). Although D. cinerea seemed to be well distributed throughout the area, its density was more pronounced at the 600m distance away from the water point. Bauhinia petersiana did not occur in the vicinity immediate to the water point. Grewia flava, B. albitrunca and D. lycioides occurred in high densities at the first distance from water while that of C. gratissimus, B. petersiana and T. sericea followed the opposite trend. High densities of M. sericea occurred at two mid – points of the transect from the water point.

Table 4.1. Individual plant species density (P/ha), leaf volume (LVol cm^3) and subdivision of canopy spread index (CSI %) height strata for each distance from the water point in controlled grazing conditions

Plant spp	Distance from water (m)															
	0				600				1200				2400			
	P / ha	LVol.	CSI2	CSI4	P / ha	LVol.	CSI2	SCI4	P / ha	LVol.	CSI2	SCI4	P / ha	LVol.	CSI2	CSI4
A. flei					40	74	0 .7		73	154	2.3		13	4		
A. ger	267	1792	31.5	19.6	160	442	6.2	1.8	13	104	1.8					
B. alb	147	139	3.2		120	85	1.4		63	24	0.2		73	66	1.2	
B. pet					33	2.0			233	27			440	56		
Com	7	3			33	1.5			13	4			7	4		
C. gra	13	4			133	26			167	48			167	37		
D. cin	207	280	3.4		460	257	0.9		333	229	0.7		280	362	5.1	
D. lyc	120	4			7	2			13	1.0			27	3		
E. rhy	27	12	0.1		40	6			20	3.0			20	18		
G. bic	13	19	0.3		20	3							7			
G. fla	340	177	1.0		207	203			93	76			47	106	1.2	
G. ret	7	3	1.7		40	55	0.4		40	60	0.5		27	17	.2	
M. ser	120	13			173	18			167	27			73	10		
M. sen	7	5							7	3						
O. pul					7	1.1			13	2			53	2		
P. afr	7	6			27	47			67	450	8.9	4.0	47	147	2.7	1.8
T. ser					53	50			47	23	3		67	324	5.5	0.6
R. bav	120	7.4	1.5		67	15			80	37			187	97	0 .6	
R. ten	80	107	1.7		40	11			7	1.0			33	51		
Z. muc	20	20	.6		13	9			7	8.0			7	93	2.7	
Total	**1502**	**2590**	**45**	**19.6**	**1673**	**1319**	**9.6**	**1.8**	**1456**	**1291**	**17.4**	**4.0**	**1575**	**1397**	**19.2**	**2.4**

CSI2 = canopy spread index based on trees with minimum height of 2m. CSI4 = canopy spread index based on trees with minimum height of 4m

Key to species: A. fle = Acacia fleckii, A. ger = A. gerrardii, B. alb = Boscia albitrunca, B. pet = Bauhinia petersiana, B. foe = B. foetida, Com = Commiphora spp, C. gra = Croton gratissimus, D.cin = Dichrostachys cinerea, D. lys = Diospyros lycioides, E. rhy = Erhytia rigidior; G.bic = Grewia bicolar, G. fla = G. flava, G. ret = G. retinervis, M. sen = Maytinus senegalensis, M. ser = Mudulia sericea, O. pul = Ochna pulchra, P. afr = Peltophorum africanum, T. ser = Terminelia sericea, R.bra = Rhigozum revispinosum, R. ten = Rhus tenunervis, X. ame = Ximenia americana, and Z. muc = Ziziphus mucronata

4.4.2 Leaf volume and canopy spread index in controlled grazing conditions

Table 4.1 presents the estimates of leaf volumes and subdivision of canopy spread index distribution for each distance along the transect from water. Despite the low plant density occurring in the immediate vicinity of the water point, leaf volume was higher (2590cm^3) at this point than at other distances, which tended not to be much different. Leaf volume was dominated by A. gerrardii in the first two distances from water while G. flava and D. cinerea were in the second order of dominance. High leaf volumes for P. africanum and T. sericea occurred towards the end of the transect from water.

Canopy spread index provided by trees in both height strata (between ≥2.0 - ≤4.0m and >4.0m) were largest (45% and 19.6%, respectively) at the first distance from water (Table 4.1). In this context, canopy spread index is defined as canopy spread area of those trees in the transect under which associated grasses like P. maximum are most likely to occur, expressed as percentage of the total transect (Smit 1996). Acacia gerrardii and P. africanum were the only species that provided canopy spread index above 4.0m height stratum. Canopy spread index of P. africanum in height stratum above 4.0m, occurred at 1800 to 2400m from water, covering an area of 4% and 1.8%, respectively. Canopy spread index of D. cinerea in height stratum between ≥2.0 - ≤4.0m was found at 2400m point from the water point. Terminalia sericea provided a canopy spread index of 5.5% in the height stratum above 2m at the furthest distance from the water. The impact of livestock grazing probably did not suppress the height of these plants, especially D. cinerea at the furthest distance from the water.

4.4.3 Leaf dry mass in controlled grazing conditions

Estimates of leaf dry mass per hectare, for each distance along the transect from water, with subdivision into specified strata are presented in Fig. 4.1. Total leaf dry mass was 1226, 567, 572 and 579 kg/ha at distances 0, 600, 1200, and 2400m from water point, respectively. In the immediate vicinity of the water point more than twice the leaf mass was recorded than at other distances. Most of the leaf dry mass at the first point was distributed between the 2 – 4 m height strata. However, with the exception of the first distance from water, the height stratum below 1.5m contributed greater leaf dry mass than the other two strata above 1.5m.

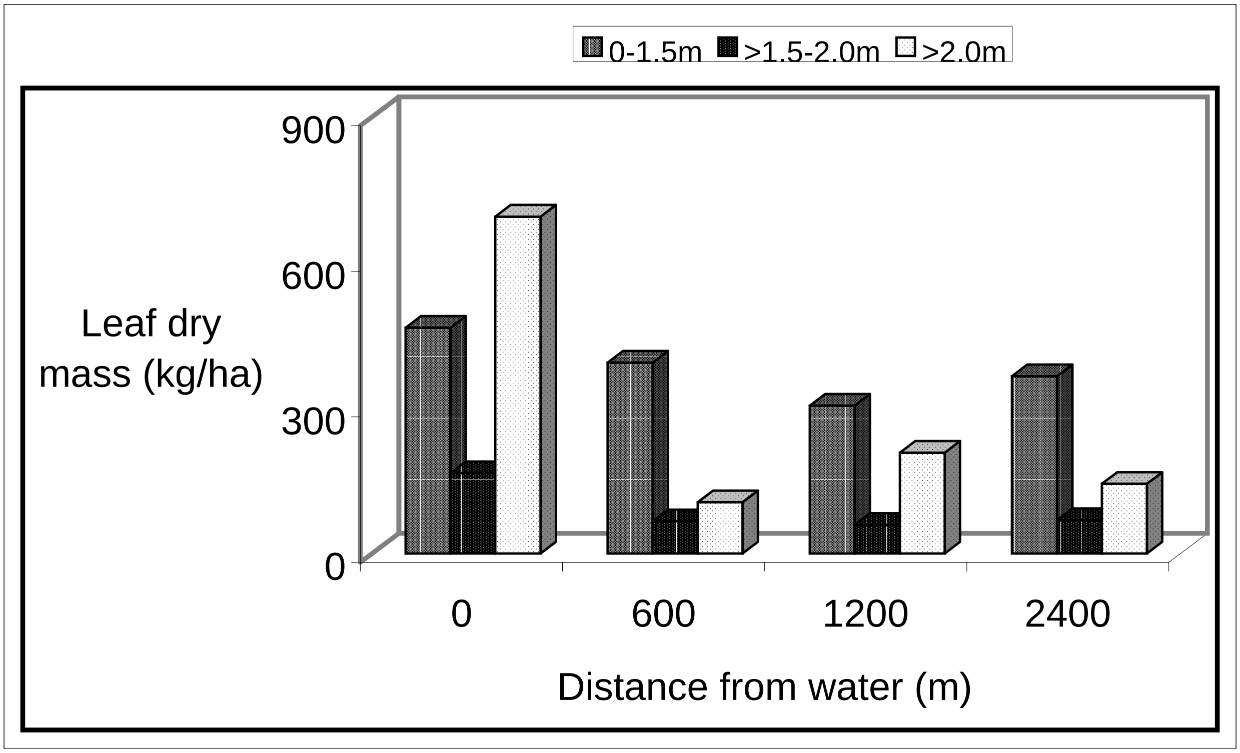

Fig. 4.1. Estimates of total leaf dry mass (kg/ha) at peak biomass of woody plants with subdivision into height strata for each distance from water at Makhi ranch

Total leaf dry mass at Makhi ranch was dominated by A. gerrardii, A. fleckii, D. cinerea and G. flava (Fig. 4.2). Most of the leaf dry mass was distributed below the 2m height strata and was largely contributed by D. cinerea and G. flava, while above the 2m height strata the major contributors were A. gerrardii, A. fleckii, T. sericea and P. africanum. Plant species such as B. petersiana, M. sericea, C. gratissmus and R.. tenuinervis had their leaf mass distributed below 1.5m.

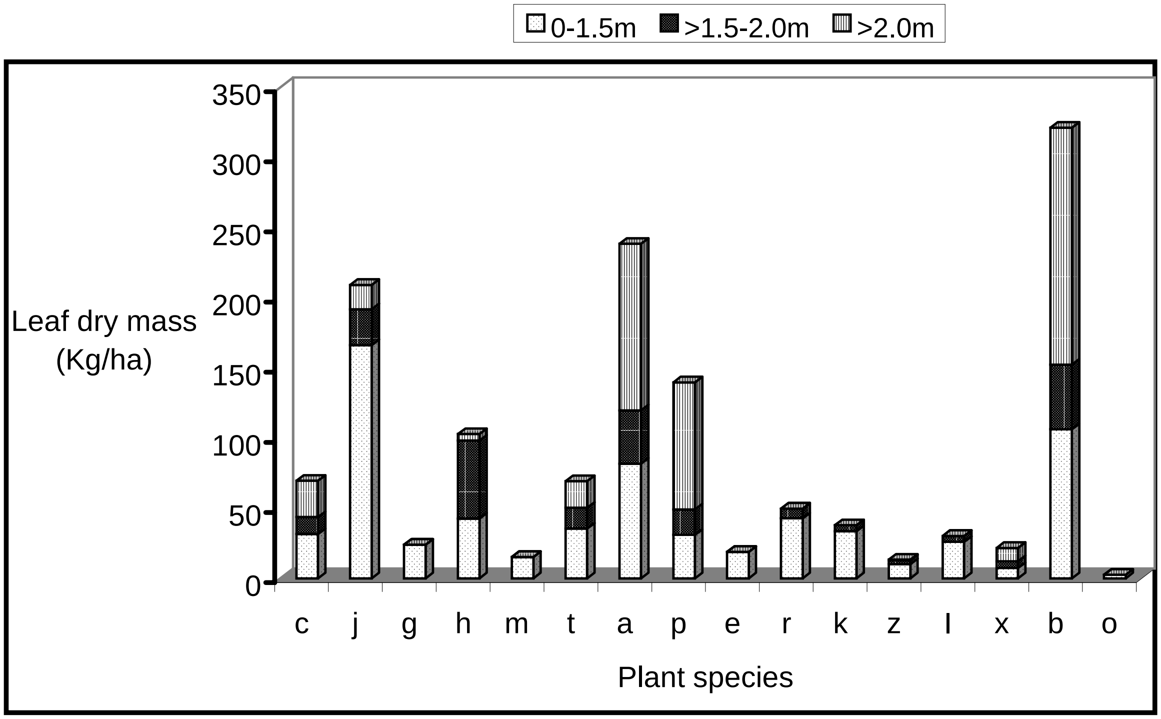

Fig. 4.2. Estimates of leaf dry mass (kg/ha) at peak biomass with subdivision into height strata of individual woody plant species in controlled grazing conditions

Key to species: a = Acacia fleckii, b = Acacia gerrardii, c = Boscia albitrunca, d = Boscia foetida, e = Bauhinia petersiana, f = Commiphora pyracanthoides, g = Croton gratissimus, h = Grewia flava, I = Grewia retinervis, j = Dichrostachys cineria, k = Rhus tenuinervis, m = Mudulea sericea, o = Ochna pulchra, p = Peltophorum africanum, r = Rhigozum brevispinosum, t = Terminalia sericea, x = Ximenia americana and z = Ziziphus mucronata.

4.4.4 Density of woody plants at Masaane cattle post – free range grazing

The density of woody plants at the Masaane cattle post which, is located in the free – range grazing area, was 1920 plants / ha in the vicinity of the water point and this thinned out to 1600 plants / ha at 4000m from the water point (Table 4.2). Six plant species were encountered in the vicinity of the water point while species richness increased to thirteen plant species at 4000m from the water point. The first distance was heavily populated with G. flava (1760 plants/ha) and the density of this species decreased with the increasing distance from water. In contrast, the density of D. cinerea was 380 plants/ha at 4000m point while only 20 plants/ha occurred at first distance from the water point, wile at Makhi ranch, density of this species was highest at the mid – points from water. Croton gratissimus and B. petersiana were not found near the water point but became prominent at the 500m point and beyond, where scattered populations of T. sericea were also found. Unlike at the Makhi ranch, density of B. albitrunca was lower at the first distance and remained constant for the subsequent distances (Table 4.2).

Table 4.2. Individual plant species density (P/ha), leaf volume (LVol cm^3) and subdivision of canopy spread index (CSI %) height strata along the distance from water point at Masaane cattle post.

Plant Species	Distance from water (m) 0				500				1500				4000			
	P / ha	LVol.	CSI2	CSI4	P / ha	LVol.	CSI2	CSI4	P / ha	LVol.	CSI2	CSI4	P / ha	LVol.	CSI2	CSI4
A. flei	20	11			20	57	1.0									
A.ger									20	3.5						
B. alb	20	6			80	145	3.2		80	253	4.2	4.1	80	239	5.5	
B. pet					140	12			20	3			200	10		
Com					40	17	0.8						220	121		
C. gra					220	182	1.5		800	209			260	136		
D. cin	20				100	78			80	43			380	202	1.0	
G. fla	1760	2058	2.7		320	479	0.6		80	182	2.2		220	201		
G. ret					180	45			1120	188			20	42		
M. ser	20	3											20	2		
M. sen													20	1		
O. pul					20	1							80	20		
P. afr					60	450	7.1	3.5								
T. ser					60	45	0.8		80	253	4.9		80	71		
R. bra	40	17											20	1		
X. ame													20	2		
Totals	**1920**	**2195**	**2.7**	**-**	**1840**	**1563**	**15**	**3.5**	**1700**	**1105**	**12.7**	**4.1**	**1600**	**045**	**6.7**	**-**

CSI2 = canopy spread index based on trees with minimum height of 2m. CSI2 = canopy spread index based on trees with minimum height of 4m

Key to species: A. fle = Acacia fleckii, A. ger = A. gerrardii, B. alb = Boscia albitrunca, B. pet = Bauhinia petersiana, B. foe = B. foetida, Com = commiphora spp, C. gra = Croton gratissimus, D.cin = Dichrostachys cinerea, D. lys = Diospyros lycioides, E. rhy = Erhytia rigidior; G.bic = Grewia bicolar, G. fla = G. flava, G. ret = G. retinervis, M. sen = Maytinus senegalensis, M. ser = Mudulia sericea, O. pul = Ochna pulchra, P. afr = Peltophorum africanum, T. ser = Terminelia sericea, R.bra = Rhigozum brevispinosum, R. ten = Rhus tenunervis, X. ame = Ximenia americana, and Z. muc = Ziziphus mucronata

4.4.5 Leaf volume and canopy spread index at Masaane cattle post – free range grazing

Estimates of leaf volume and subdivision of canopy spread index for each distance from the water point of individual plant species at the Masaane cattle post are presented in Table 4.2. Leaf volume was 2195, 1563, 1105 and 1045 cm^3 at distances 0, 500, 1500 and 4000m from the water, respectively. Leaf volume decreased with the increase in distance from water. Most of the leaf volume across the transects was dominated by G. flava, B. albitrunca and to a lesser extent by T. sericea and C. gratissimus. Grewia flava contributed most of the leaf volume at the first distance from the water point while the leaf volume of B. albitrunca tended to increase with the increase in distance from water.

Canopy spread index from trees between ≥2.0 - ≤4.0m height stratum was 2.7, 15, 12.7 and 6.7% at distances 0, 500, 1500 and 4000m from water, respectively (Table 4.2). Larger areas were covered at 500 and 1500m points than the first or last distances. Canopy spread index provided by trees higher than 4.0m stratum was 3.5% and 4.1% at 500 and 1500m points from the water, respectively. Unlike at the Makhi ranch, trees of greater than 4m were non – existent at the first and last distances from water point. Trees contributing to the canopy spread index, at stratum above 4m, included T. sericea and B. albitrunca. Like the Makhi ranch, canopy spread index of D. cinerea, at height stratum between ≥2.0 - ≤4.0m, occurred at 4000m from the water point but the area covered was very small (1%). Livestock browsing was the probable cause of the suppression of D. cinerea at distances less than 4000m. Judging from the small percentage of canopy spread index from trees above 2.0m height strata found along the transect from water, this vegetation type might be classified as a shrub savannah.

4.4.6 Leaf dry mass at Masaane cattle post – free range grazing

Estimates of leaf dry mass per hectare for each distance along the transect from water, with subdivision into specified height strata are presented in Fig. 4.3. Total leaf dry mass at Masaane cattle post was 835, 610, 458 and 436 kg/ha at distances 0, 500, 1500 and 4000m from water point, respectively. Total leaf mass thus tended to decrease with the increase in distance from water point. Leaf dry mass was almost equal at the last two distances from water. Most of the leaf dry mass was distributed below 1.5m height strata. As at the Makhi ranch, the greatest leaf mass occurred at the first distance from water. Leaf mass above 1.5m height strata was very low at the first and last distances.

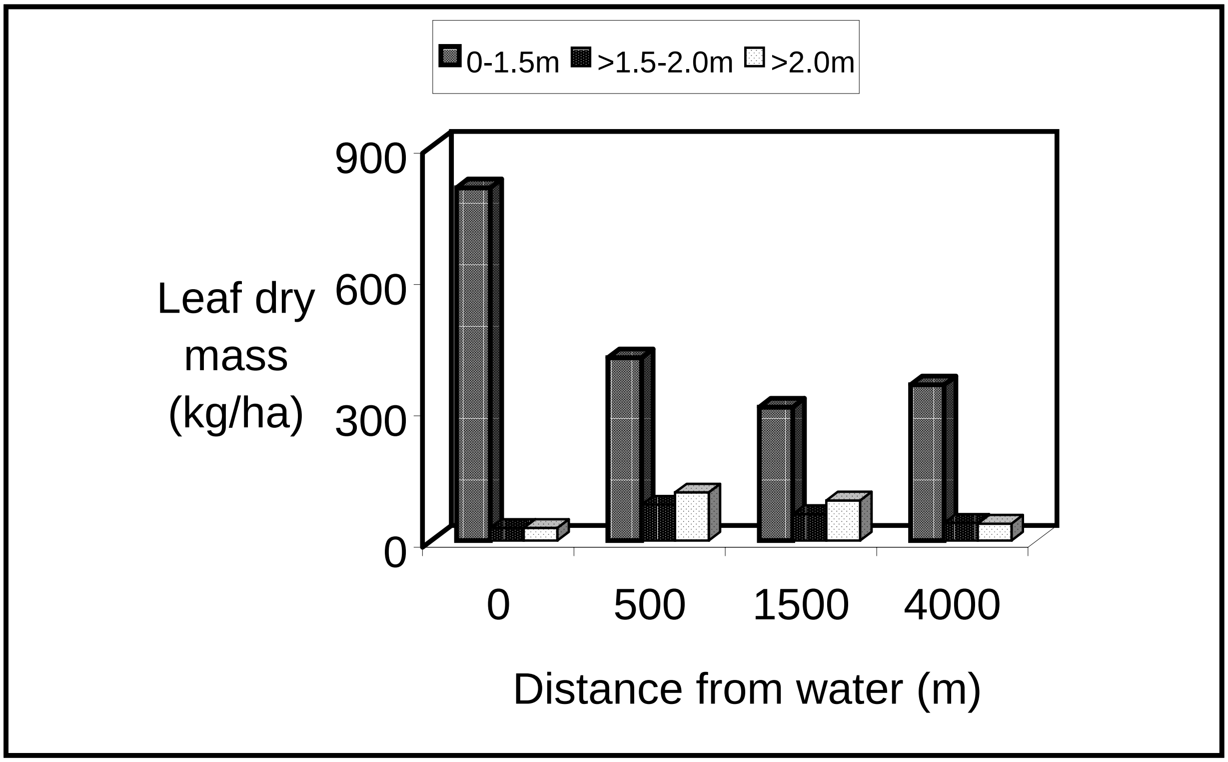

Fig. 4.3. Estimates of total leaf dry mass at peak biomass of woody plants with subdivision into height strata for each distance from water at Masaane cattle post.

Total leaf dry mass at Masaane cattle post was dominated by G. flava, B. albitrunca, C. gratissimus, T. sericea and to a lesser extent, M. sericea and D. cinerea (Fig. 4.4). Most of the leaf dry mass distributed below 1.5m height stratum was made up of G. flava, C. gratissimus, D. cinerea and M. sericea, while the above 2m height strata was dominated by T. sericea and B. albitrunca.

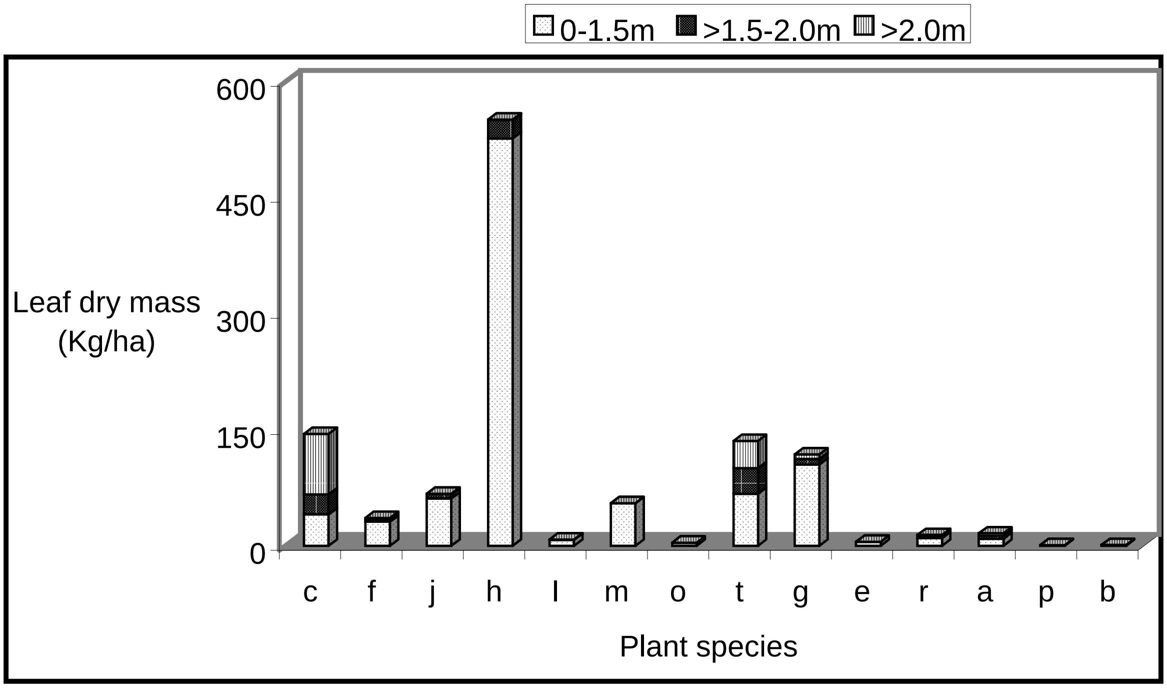

Fig. 4.4. Estimates of leaf dry mass at peak biomass with subdivision into height strata of individual woody plant species at Masaane cattle post.

Key to species: a = A. fleckii, b = A. gerrardii, c = B. albitrunca, d = B. foetida, e = B. petersiana, f = C. pyracanthoides g = C. gratissimus, h = G. flava, I = G. retinervis, j = D. cinerea, k = R. tenuinervis, m = M. sericea, o = O. pulchra, p = P. africanum, r = R. bravispinosum, t = T. sericea, x = X. americana and z = Z. mucronata

4.4 7 Density of woody plants at Motshwagole cattle post – free range grazing

The density of woody plants at the Motshwagole cattle post was lowest at the first two distances compared to the furthest two distances from water (Table 4.3). The furthest (1500m and 4000m) distances had almost the same plant densities. Acacia gerrardii, B. albitrunca and G. flava were the most prominent species in the vicinity of the water point. Five plant species were recorded around the water point and this increased to thirteen species at 1500m from the water point. Grewia flava was more abundant at the first two distances and started to decline at the third distance, where B. petersiana started to occur, again indicating that B. petersiana is a decreaser and G. flava is an inceaser II. Like the Masaane cattle post, a high density of D. cinerea was found at the 4000m and was non – existent at the first point. (Table 4.3).

Table 4.3. Individual plant species density (P/ha), leaf volume (LVol cm^3) and subdivision of canopy spread index (CSI %) height strata along the distance from water point at Motshwagole cattle post

PlantSpecies	**Distance from water (m)**															
	0				500				1500				4000			
	P / ha	LVol.	CSI2		P / ha	LVol.	CSI2		P / ha	LVol.	CSI2	CSI	P / ha	LVol.		CSI2
A. fle	CSI4				CSI4				80	73			CSI			
A. ger													40	49	1.0	
A. mel	200	515	7.9		160	1071	20.5						80	612	13.0	4.7
B. alb	40	28			15.2				80	48						
B. foe	360	92														
B. pet	140	11			80	170	3.0		840	90						
B. afr					40	413	1.5	1.5	20	3			560	56		
Com									180	108						
C. gra									60	15						
D. cin					40	24			80	77			220	75		
G. fla									80	394	5		400	239		
G. ret	320	144			80	27			80	161	1.5		20	63		
M. ser					360	624	2.0		80	22						
P. afr					20	25			20	72	1.1					
T. ser									360	785	5.1					
R. bra					20	1			120	75	0.4					
Total									**1680**	**1880**	**13.4**		300	105		
	1060	**788**	**7.9**		40	21							**1620**	**1199**	**14.0**	**4.7**
					980	**2402**	**26**									
					16.7											

CSI2 = canopy spread index based on trees with minimum height of 2m. CSI4 = canopy spread index based on trees with minimum height of 4m

Key to species: A. fle = Acacia fleckii, A. ger = A. gerrardii, B. alb = Boscia albitrunca, B. pet = Bauhinia petersiana, B. foe = B. foetida, Com = Commiphora spp, C. gra = Croton gratissimus, D.cin = Dichrostachys cinerea, D. lys = Diospyros lycioides, E. rhy = Erhytia rigidior; G.bic = Grewia bicolar, G. fla = G. flava, G. ret = G. retinervis, M. sen = Maytinus senegalensis, M. ser = Mudulia sericea, O. pul = Ochna pulchra, P. afr = Peltophorum africanum, T. ser = Terminelia sericea, R.bra = Rhigozum revispinosum, R. ten = Rhus tenunervis, X. ame = Ximenia americana, and Z. muc = Ziziphus mucronata

4.4.8 Leaf volume and canopy spread index at Motshwagole borehole - free range grazing

Estimates of leaf volume and subdivision for canopy spread index for each distance along the transect from water is presented in Table 4.3. Leaf volume for each distance was 788, 2402, 1880 and 1199 cm^3 at distances 0, 500, 1500 and 4000m from water, respectively. Greatest leaf volume occurred at 500m and lowest at adjacent to the water point. Most of the leaf volumes, regardless the distance, were dominated by A. gerrardii and G. flava.

Canopy spread index provided by trees between ≥2.0 - ≤4.0m height stratum was 26% at 500m point and larger than at any other point along the transect (Table 4.3). Acacia gerrardii provided 20% of the canopy spread index from trees between ≥ 2.0 - ≤4.0m height stratum and the remaining 4% was provided by Boscia species and G. flava. Canopy spread index from trees above 4.0m stratum was 16.7% and 4.7% at 500 and 4000m from water, respectively and was almost all contributed by A. gerrardii.

4.4.9 Leaf dry mass at Motshwagole cattle post - Free – range grazing

Unlike Makhi Ranch or the Masaane cattle post, the Motshwagole cattle post had the greatest leaf dry mass at the second and third (500 and 1500m point) distances from water (Fig. 4.5). The point in the immediate vicinity of the water point had almost all the leaf dry mass distributed below 2m height strata. Excepting the first distance from the water point, there was a tendency of a decrease of leaf dry mass with the increase of distance from water. Leaf mass above 2.0m was largest at the 500m point from water. Most of the leaf mass across the distances was distributed below 1.5m height stratum.

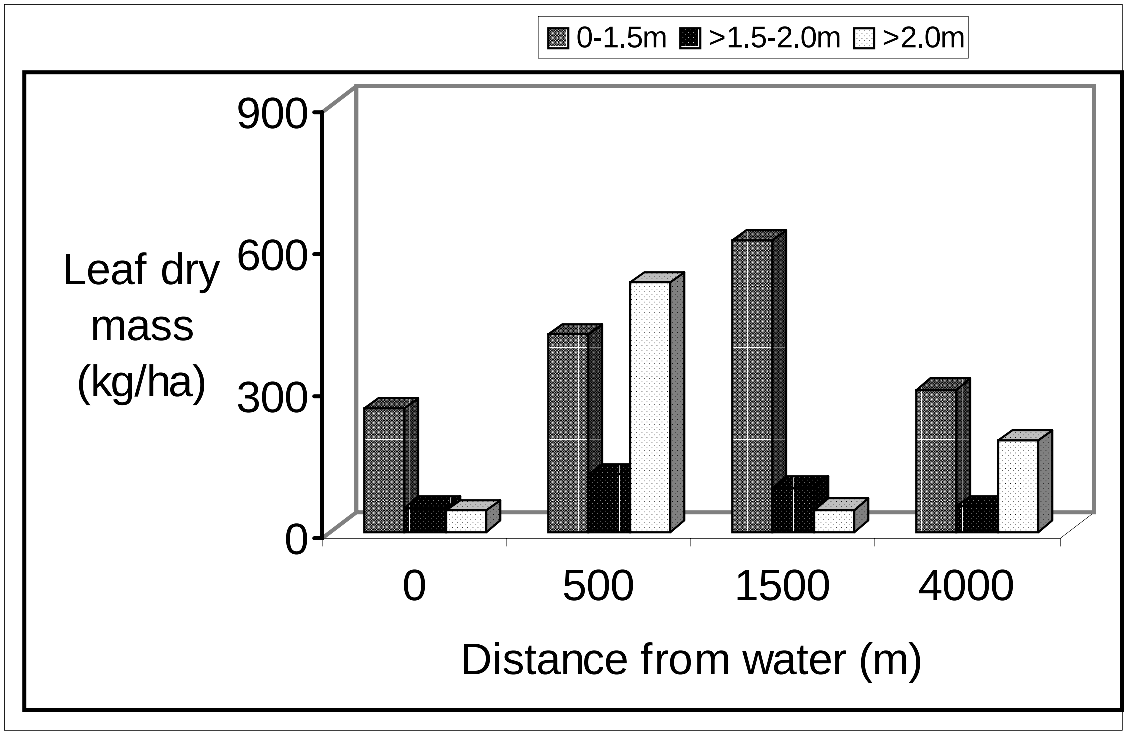

Fig. 4.5. Estimates of total leaf dry mass (kg/ha) at peak biomass of woody plants with subdivision into strata for each distance from water at Motshwagole cattle post.

Total leaf dry mass at the Motshwagole cattle post was dominated by A. gerrardii, A. fleckii, D. cinerea and T. sericea (Fig. 4.6). Grewia flava, D. cinerea and A. fleckii contributed the most leaf dry mass below 1.5 m height stratum, while A. gerrardii, A. fleckii and T. sericea dominated the above 2m height strata.

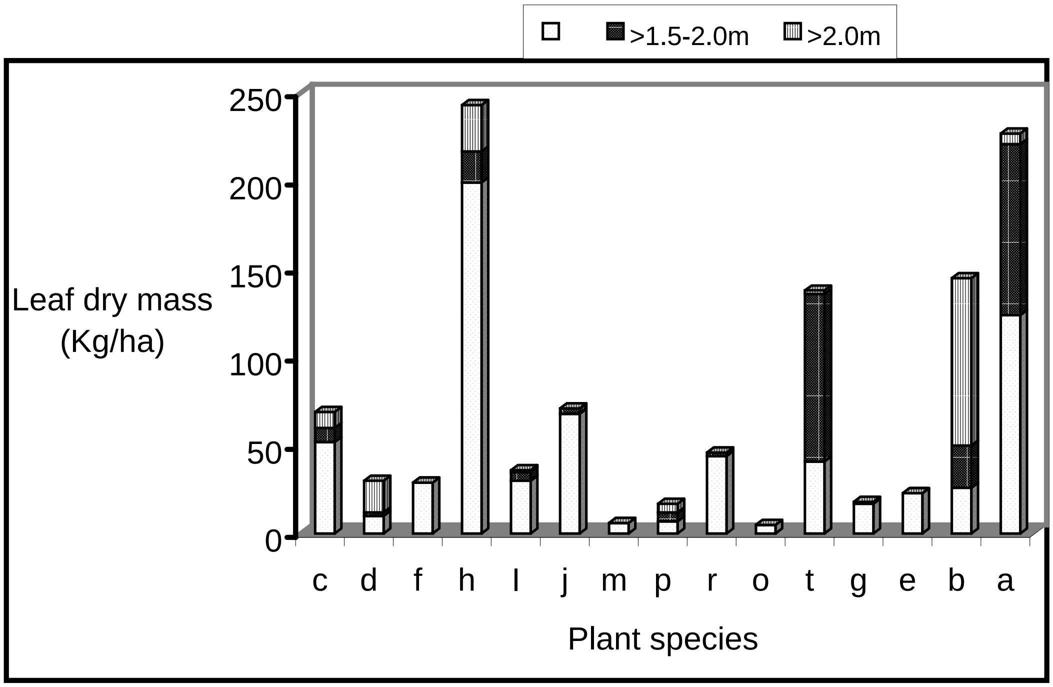

Fig. 4.6. Estimates of leaf dry mass (kg/ha) at peak biomass with subdivision into height strata of individual woody plant species at Motshwagole cattlle post.

Key to species: a = A. fleckii, b = A. gerrardii, c = B. albitrunca, d = B. foetida, e = B. petersiana, f = C. pyracanthoides g = C. gratissimus, h = G. flava, I = G. retinervis, j = D. cinerea, k = R. tenuinervis, m = M. sericea, o = O. pulchra, p = P. africanum, r = R. bravispinosum, t = T. sericea, x = X. americana and z = Z. mucronata

4.5 DISCUSSION

Bush encroachment is a characteristic feature of the sacrificial areas (piospheres) found around the water points in Eastern Kalahari (Perkins 1991). Piospheres in semi – arid environments are the results of livestock dependency on discrete and spatially located water points.

The leaf volumes and leaf dry mass values appear to reflect quantitative variations in the contribution of a relatively small number of woody species. Low growing plant species including B. petersiana, M. sericea etc made less of a contribution to the leaf volume and leaf mass, compared to higher growing plants such as A. gerrardii, D. cinerea, T. sericea, G. flava etc. Both leaf volume and leaf dry mass, with the exception of Motshwagole cattle post, tended to decrease with the increase in distance from water point due to the reduced density and canopy spread index of the plants. Both Motshwagole and Makhi cattle posts were dominated by A. gerrardii with canopy spread index above 2.0m height and large amounts of leaf dry mass at the first or second distances. However, at the Masaane cattle post, the high density of G. flava, associated with large leaf volumes at the first distance from water, provided high leaf dry mass. Grewia flava and D. cinerea, as heavily browsed plant species by both livestock and game (Palgrave 1977), contributed substantially to the total leaf dry mass within the height below 2.0m and their dominance as shrubs was evident from the small amount of leaf mass that was carried above 2.0m height strata. Thus, a large quantity of leaf dry mass is within the browse line of goats as defined by Aucamp (1981) and Sweet & Mphinyane (1986). Leaf dry mass above 2.0m was largely contributed by A. gerrardii, T. sericea and B. albitrunca at all cattle posts.

High plant density occurring immediately after the first distance from water point was reported by Perkins (1991), who indicated a sacrificial zone around the drinking trough up to 200m followed by a high bush density zone. In this study, one borehole (Makhi ranch) had high bush density at the second distance while the Masaane cattle post in the free range grazing was densely populated at the first distance from the water point. Plant densities at Makhi and Masaane cattle posts generally decreased with the increase in distance while that at Motshwagole cattle post tended to increase with increased distance from water. Plant density at the first two distances was lower compared to further distances at Motshwagole cattle post probably due to the age and stocking rate applied (chapter 2). Abandoned old cattle kraals around the borehole provide evidence of pressure exerted on plant density by livestock.

Common to all these data is the lack of any obvious quantitative shift in species composition within piospheres, particularly with respect G. flava and D. cinerea. Differences in species composition between piospheres appear to exist, particularly the contrast between D. cinerea at Makhi ranch and the dense stands of G. flava at Masaane cattle post or the abundance of B.

albitrunca at both Makhi ranch and Motshwagole cattle post occurring around the vicinity of the water point. Both Makhi ranch and Masaane cattle post had high densities of G. flava at the first distance from water. However, differences were that density of D. cinerea were 20 plants / ha and over 200 plants / ha, at Masaane cattle post and Makhi ranch, respectively. Unlike G. flava and D. cinerea, B. petersiana and C. gratissimus were not found at the vicinity of the water point suggesting that the latter are decreaser species and the former are increasers. This may reflect broader scale variations in woody layer that may further accentuate piosphere effect with centripedal movement of seeds through livestock dung deposition likely to occur over time (Kelly 1977). In general, there seemed to be no clear pattern in the density distribution along the transect from the water point particularly for D. cinerea. Boscia albitrunca is not a recognised encroacher on Botswana's rangelands. Its appearance has been explained by the deep regard with which this species is held in Southern African folklore (Palgrave 1977). It might be considered as a remnant of the flora that was in place before the imposition of piospheres. Similarly the occurrence of A. gerradii may be explained by the fact that this species is often used to locate potential borehole sites in sandveld, as its presence may indicate tapable water. This was certainly the case in vicinity of the two boreholes (Makhi ranch and Masaane borehole) and other surrounding boreholes in the area.

4.6 CONCLUSION

The incidence of daily livestock concentrations in the vicinity of water points result in woody vegetation dominated by shrubby plants of less than 2m height due to livestock browsing. Total leaf volume and leaf dry mass values appear to reflect quantitative variation in contribution by a relatively small number of woody species. Within the height stratum below 2.0m G. flava and D. cinerea contributed substantially to the total leaf dry mass. Leaf volume and leaf mass above 2.0m were largely provided by A. gerrardii, T. sericea, and B. albitrunca

High densities of G. flava tended to be confined to the immediate vicinity of water points rather than further distances, while species such as B. petersiana and C. gratissimus occur only at further distances from water. There was no clear pattern in the density distribution of D. cinerea along the transect from the water point.

Plant species diversities increased with the increase in distance from the water point. Makhi ranch and Motshwagole cattle post had higher species diversity than Masaane cattle post.

The dominance of G. flava and D. cinerea as shrubs in this study was evident from the small amount of leaf dry mass that was carried above 2.0m height strata.