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A PRELIMINARY REPORT ON THE DYNAMICS OF THE VEGETATION OF THE KALAHARI GEMSBOK NATIONAL PARK

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Abstract – Different methods were used intermittently to monitor the changes in the floristic composition, basal cover and density of the herbaceous and woody vegetation over a seven year period in the Kalahari Gemsbok National Park. Periods of drought and the variability of rainfall appear to have a significant influence in the short term on herbaceous species, while there was not much variation in the woody species composition or density.

Introduction

The vegetation structure of the Kalahari is described by Leistner (1979) as "savanna or 'bushveld', grassland with interspersed tall shrubs and/or trees". Dunes and sandy flats are largely covered by an open shrub or tree savanna, sparse

dwarf shrub formations occur on calcrete outcrops, while riverbeds and pans support open grass communities.

Descriptions of the vegetation of the Kalahari can also be found in Acocks (1975), Leistner (1959, 1967), Leistner & Werger (1973), Bothma & De Graaff (1973) and Werger & Leistner (1975). The different plant communities of the southern Kalahari are grouped by Leistner & Werger (1973) according to the four main habitats namely communities of the sand, the calcrete, the pans and the riverbeds.

According to Werger & Leistner (1975) two types of vegetational changes occur in the southern Kalahari: those due to changes in climate, and those due to succession towards an environmentally controlled equilibrium.

Climatically influenced changes in the vegetation are those that occur as a result of seasonal variation (short-term and mostly phenological), those affected by periodic variation in climate over a few years (medium-term) and those that result from long-term changes in climate.

Autogenic succession rarely occurs in the southern Kalahari (Werger & Leistner 1975). In allogenic succession, overgrazing and trampling in particular play an important role. However, few vegetation types in South Africa are as well preserved as that of the southern Kalahari (Edwards & Werger 1972).

Although fairly detailed descriptions are available of the vegetation of the Kalahari Gemsbok National Park, little is known of the vegetation dynamics. The aim of this report is to give some insight into the medium-term changes in the vegetation.

Methods

The changes in the vegetation as described here, were monitored over a seven year period, since 1978 to 1984, and the project is still ongoing. Different methods were employed namely:

a. the wheel point method (Tidmarsh & Havenga 1955), to determine the floristic composition, percentage basal cover and percentage presence of the herbaceous layer species;
b. a transect survey consisting of contiguous 2,5 m x 5 m quadrats determining the percentage frequency and density of woody species;
c. permanently marked plots (50 m x 100 m or 100 m x 100 m) to monitor the density, stem circumference and height of the woody species and
d. the nearest individual method (Mueller-Dombois & Ellenberg 1974) for determination of the floristic composition and density of the woody species.

The different formulae used, are:

percentage basal cover of a species

$$= \frac{\text{number of strikes for a species}}{\text{total number of wheel points}} \times 100$$

percentage presence

$$= \frac{\text{number of times a plant species is the nearest to the wheel point}}{\text{total number of wheel points}} \times 100$$

Fig. 1. Map of the Kalahari Gemsbok National Park to show the different localities of the surveys.

percentage frequency

$$= \frac{\text{number of times a species is present in a quadrat}}{\text{total number of quadrats}} \times 100$$

density = number of individuals per hectare

The interval between successive surveys at a specific locality differs from one to six years. The vegetation of six different localities were monitored namely Cubitje Quap, Dankbaar, Gharagab, Kij Garries, Kousaunt and Stoffelsdraai (Fig. 1).

According to the habitat map of Bothma & De Graaff (1973), the different localities are representative of the following habitats:

Tree savanna — Dankbaar, Gharagab
Dunes with trees and shrubs — Stoffelsdraai
Dunes without trees and shrubs — Kij Garries
Flat open plains along rivers — Cubitje Quap, Kousaunt

The studies are conducted during the period April to June every year.

Results

a. The wheel point method

The total percentage basal cover varied over the study period from 1,87% to 4,47% (Tables 1, 2 and 3). The highest percentage was recorded at Kij Garries in the south in 1978 and the lowest at Stoffelsdraai in 1981. The decline in the percentage basal cover at Kij Garries and Stoffelsdraai from 1978 to 1981 can possibly be attributed to the variability of the rainfall (Fig. 2). The year 1978 was preceded by above average rainfall from approximately 1973 to 1977, while 1981 was preceded by three years of normal to below average rainfall.

The two most important grass species at Kij Garries and Stoffelsdraai, *Eragrostis lehmanniana* and *Asthenatherum glaucum*, also differed in their percentage basal cover between 1978 and 1981. The percentage basal cover of *E. lehmanniana* at Kij Garries declined from 2,13% to 0,27% while *A. glaucum* at Stoffelsdraai declined from 1,33% to 0,33%. At Kij Garries a number of additional annual herb species were also recorded during 1981.

An increase in the percentage basal cover at Cubitje Quap from 1979 to 1984 was recorded and here also there was an increase in the number of herb species in 1984.

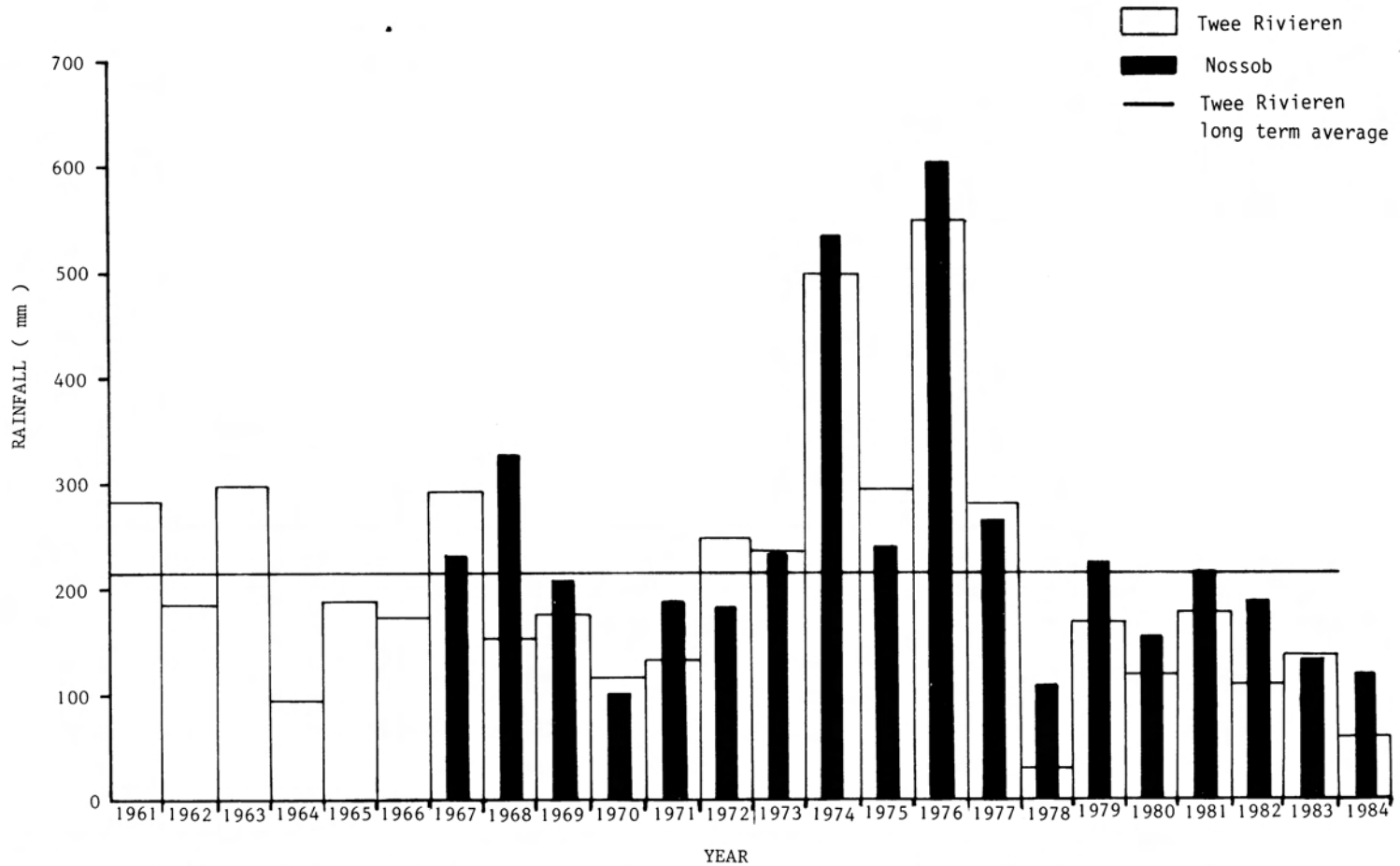

Fig. 2. Rainfall data for Nossob and Twee Rivieren (1961-1984) in the Kalahari Gemsbok National Park. Data for 1984 only collected up to September.

Table 1

Percentage basal cover and percentage presence of the herbaceous stratum at Kij Garries in the Kalahari Gemsbok National Park

Plant species	% Basal Cover		% Presence	
	1978	1981	1978	1981
Eragrostis lehmanniana	2,13	0,27	49,56	16,33
Asthenatherum glaucum	1,07	1,13	8,65	12,43
Stipagrostis amabilis	0,47	0,20	7,50	13,25
Hermannia tomentosa	0,33	0,20	13,13	9,15
Eragrostis porosa	0,20	0,13	3,96	6,69
Stipagrostis uniplumis	0,13	0	2,21	2,53
Eragrostis pallens	0,07	0	2,41	1,78
Salsola tuberculata	0,07	0,07	0,74	1,30
Rhigozum trichotomum	0	0	0,40	0,14
Heliotropium ciliatum	0	0	6,51	5,87
Indigofera flavicans	0	0	0,20	0,96
Aptosimum albomarginatum	0	0	0,13	0
Cyperus usitatus	0	0	0,27	0
Chrysocoma obtusata	0	0	0,13	0
Merremia verecunda	0	0	0,80	0,14
Schmidtia kalahariensis	0	0	0,07	3,01
Lebeckia linearifolia	0	0	0,13	0
Aristida meridionalis	0	0,27	1,95	6,76
Indigofera alternans	0	0	1,01	0,41
Sericorema remotiflora	0	0	0,07	0,14
Sporobolus nervosus	0	0	0,13	0
Crotalaria sphaerocarpa	0	0,07	0	0,68
Dicoma capensis	0	0	0	0,07
Chamaesyce inaequilatera	0	0	0	0,41
Sesamum sp.	0	0	0	0,27
Oldenlandia sp.	0	0	0	0,07
Hermbstaedtia sp.	0	0	0	0,55
Hoffmannseggia burchellii	0	0	0	3,83
Oxygonum dregeanum	0	0	0	1,98
Tribulus zeyheri	0	0	0	0,41
Lophiocarpus tenuissimus	0	0	0	0,61
Fimbristylis hispidula	0	0	0	5,33
Citrullus lanatus	0	0	0	0,07
Limeum sulcatum	0	0	0	1,16
Ornithogalum tenuifolium	0	0	0	0,27
Cleome rubella	0	0	0	1,57
Nolletia arenosa	0	0	0	0,34
Pollichia campestris	0	0	0	0,14
Felicia muricata	0	0	0	0,14
Asclepias buchenaviana	0	0	0	0,96
Other species	0	0	0	0,21
TOTAL	4,47	2,34	99,96	99,96

Table 2

Percentage basal cover and percentage presence of the herbaceous stratum at Stoffelsdraai in the Kalahari Gemsbok National Park

Plant species	% Basal Cover		% Presence	
	1978	1981	1978	1981
Asthenatherum glaucum	1,37	0,33	11,13	7,48
Eragrostis lehmanniana	0,90	0,52	18,89	14,51
Pteronia unguiculata	0,34	0,15	4,99	0,95
Aristida meridionalis	0,30	0,21	8,45	8,10
Stipagrostis obtusa	0,27	0,05	2,97	1,34
Rhigozum trichotomum	0,23	0,07	7,70	2,45
Aptosimum albomarginatum	0,12	0	2,66	1,44
Stipagrostis uniplumis	0,07	0,09	6,09	2,58
S. amabilis	0,07	0,07	3,59	2,08
S. ciliata	0,07	0,11	1,96	0,86
Hermannia modesta	0,04	0	8,62	0,64
Aristida sp. (1)	0,04	0	1,24	0
Schmidtia kalahariensis	0	0,12	0,63	15,52
Eragrostis porosa	0	0,07	0	9,88
Heliotropium ciliatum	0	0,04	0,48	4,47
Salsola tuberculata	0	0,04	0,70	0,11
Chrysocoma obtusata	0	0	6,75	0
Hermannia tomentosa	0	0	3,52	1,0
Helichrysum argyrosphaerum	0	0	1,04	0,04
Aristida sp. (2)	0	0	0,72	0
Indigofera flavicans	0	0	0,50	0,35
Sericorema remotiflora	0	0	0,38	0,58
Cucumis africanus	0	0	0,33	0
Salsola rabieana	0	0	0,29	0
Blepharis mitrata	0	0	0,22	0
Hoffmannseggia burchellii	0	0	0,16	0,60
Salsola kali	0	0	0,15	0
Harpagophytum procumbens	0	0	0,12	0,07
Asparagus africanus	0	0	0,08	0
Aizoon schellenbergii	0	0	0,08	0
Indigofera alternans	0	0	0,08	1,03
Acacia haematoxylon	0	0	0,08	0
Aristida sp.	0	0	0,07	0
Elephantorrhiza elephantina	0	0	0,07	0
Rhus tenuinervis	0	0	0,04	0
Boscia albitrunca	0	0	0,04	0
Other species	0	0	5,18	23,92
TOTAL	3,82	1,87	100,00	100,00

Table 3

Percentage basal cover and percentage presence of the herbaceous stratum at Cubitje Quap in the Kalahari Gemsbok National Park

Plant species	% Basal Cover		% Presence	
	1979	1984	1979	1984
Stipagrostis obtusa	0,9	0,3	22,4	8,1
Rhigozum trichotomum	0,6	0,7	4,7	2,9
Schmidtia kalahariensis	0,3	0,1	29,1	1,2
Gisekia africana	0,2	0	30,4	0,5
Indigofera alternans	0	0	1,8	0
Asclepiadaceae	0	0	0,2	0
Limeum sulcatum	0	0	3,5	0,9
Stipagrostis ciliata	0	0,1	1,6	0,4
Eragrostis porosa	0	0	5,3	0
Tribulus zeyheri	0	0	0,2	0
Enneapogon desvauxii	0	0	0,3	0
Trianthema triquetra	0	0	0,2	0
Stipagrostis uniplumis	0	0	0,1	0
Asparagus africanus	0	0	0,1	0,1
Hermannia tomentosa	0	0	0,1	0
Chamaesyce sp.	0	0,6	0	40,6
Oldenlandia sp.	0	0	0	7,2
Eragrostis sp.	0	0,1	0	11,0
Indigofera sp.	0	0,1	0	8,1
Geigeria ornativa	0	0	0	0,5
Hypertelis sp.	0	0,3	0	11,4
Helichrysum argyrosphaerum	0	0,1	0	3,9
Lotononis sp.	0	0,1	0	1,5
Grielum sp.	0	0,1	0	0,6
Cleome rubella	0	0	0	0,4
Cleome sp.	0	0	0	0,4
Senecio sp.	0	0	0	0,1
TOTAL	2,0	2,6	100,0	99,8

b. Transect surveys

These surveys were conducted at Kousaunt and Cubitje Quap along the Nossob River and at Stoffelsdraai in the interior dune habitat on mainly woody species (Tables 4, 5 and 6).

Table 4

The woody component of a transect survey of contiguous 2,5 m × 5 m quadrats at Kousaunt in the Kalahari Gemsbok National Park

Plant species	% Frequency		Density (Individuals/ha)	
	1979	1983	1979	1983
Zygophyllum tenue	41,6	72,0	2 982	9 250
Rhigozum trichotomum	22,1	12,5	474	450
Salsola tuberculata	20,8	15,0	367	490
Plinthus karooicus	9,6	3,0	158	80
Asparagus africanus	8,8	14,0	105	350
Acacia erioloba	0,5	0	90	0
Plinthus cryptocarpus	2,7	0	30	0
Pteronia unguiculata	1,1	0	13	0
Lycium oxycarpum	0,8	0,5	64	100
Dicoma capensis	0,3	0	4	0
Eriocephalus pubescens	0,3	4,0	2	90
Other species	0,5	3,0	4	70

Table 5

The woody component of a transect survey of contiguous 2,5 m × 5 m quadrats at Cubitje Quap in the Kalahari Gemsbok National Park

Plant species	% Frequency		Density (Individuals/ha)	
	1979	1984	1979	1984
Rhigozum trichotomum	71,88	75,90	1 205	2 160
Acacia mellifera	1,97	4,90	29	26
Acacia erioloba	0,49	1,32	5	9
Asparagus africanus	0,49	1,97	4	11
Hermannia tomentosa	0,33	0	4	0
Blepharis mitrata	0,16	0	4	0
Boscia albitrunca	0,16	1,0	1	4
Grewia retinervis	0,16	0	1	0
Lycium oxycarpum	0	0,66	0	4
Grewia flava	0	0,99	0	8
Aptosimum sp.	0	0,33	0	1
Monechma sp.	0	0,33	0	1

Table 6

The woody component of a transect survey of contiguous 2,5 m × 5 m quadrats at Stoffelsdraai in the Kalahari Gemsbok National Park

Plant species	% Frequency		Density (Individuals/ha)	
	1978	1981	1978	1981
Hermannia modesta	58,35	0,45	1 845	6
Pteronia unguiculata	39,90	0	436	0
Rhigozum trichotomum	27,90	23,70	879	901
Chrysocoma obtusata	26,55	10,15	631	198
Aptosimum albomarginatum	21,55	16,90	889	1 686
Helichrysum argyrosphaerum	9,55	0	131	0
Indigofera alternans	7,80	23,70	181	763
Hermannia tomentosa	6,70	25,70	79	611
Acacia haematoxylon	5,75	9,40	52	89
Aptosimum pubescens	4,70	6,50	140	106
Salsola rabieana	3,10	6,35	30	64
Indigofera flavicans	2,85	21,60	49	422
Lebeckia linearifolia	2,80	1,45	29	11
Pentzia sp.	2,15	0	57	0
Pteronia sp.	2,00	0,75	37	10
Asparagus africanus	1,65	2,05	10	16
Acacia mellifera	1,30	1,10	12	9
Grewia flava	1,15	1,90	10	28
Indigofera daleoides	0,95	0	19	0
Boscia albitrunca	0,85	0,65	7	5
Hermbstaedtia linearis	0,35	0	3	0
Hoffmannseggia burchellii	0,35	0	4	0
Lycium oxycarpum	0,20	1,05	1	9
Requienia sphaerosperma	0,15	33,05	1	623
Cleome rubella	0,15	0	1	0
Rhus tenuinervis	0,15	1,25	1	23
Ehretia rigida	0,15	0,50	1	14
Monechma incanum	0	24,50	0	1 398
Oxalis lawsonii	0	10,60	0	68
Pollichia campestris	0	8,15	0	201
Plinthus sericeus	0	3,20	0	31
Geigeria ornativa	0	2,95	0	25
Nolletia arenosa	0	1,30	0	14
Acacia erioloba	0	1,15	0	9
Elephantorrhiza elephantina	0	0,30	0	15
Other species	0	0,15	1	23

Table 7

Dynamics of the woody component in a 100 m × 100 m permanent plot in an Acacia erioloba *dune street east of Dankbaar in the Kalahari Gemsbok National Park*

Plant species	Number of individuals/ha														
	Trees >2 m			Trees 2 m and <			Shrubs			Seedlings			Total		
	1978	1980	1983	1978	1980	1983	1978	1980	1983	1978	1980	1983	1978	1980	1983
Acacia erioloba	20	17	18	70	86	51	0	0	0	6	2	13	96	105	82
Acacia erioloba (dead)	4	2	1	0	1	0	0	0	0	0	0	0	4	3	1
Acacia haematoxylon	0	0	0	6	5	5	0	0	0	0	0	0	6	5	5
Grewia flava	0	0	0	0	0	0	14	11	16	0	0	0	14	11	16
Boscia albitrunca	1	1	1	0	1	0	0	0	0	0	0	0	1	2	1
Rhus tenuinervis	0	0	0	0	0	0	10	11	14	0	0	0	10	11	14

Tree = single stemmed individual Shrub = multi stemmed individual

Table 8

Dynamics of the woody component in a 100 m × 100 m permanent plot in an Acacia luederitzii *dune street east of Dankbaar in the Kalahari Gemsbok National Park*

Plant species	Number of individuals/ha														
	Trees >2 m			Trees 2 m and <			Shrubs			Seedlings			Total		
	1978	1980	1983	1978	1980	1983	1978	1980	1983	1978	1980	1983	1978	1980	1983
Acacia erioloba	6	6	6	9	58	9	0	0	29	7	18	0	22	82	44
Acacia luederitzii	3	8	8	22	8	4	0	0	6	378	40	1	403	56	19
Boscia albitrunca	3	1	1	0	37	0	11	0	32	9	6	0	23	44	33
Acacia mellifera	1	1	1	1	1	2	0	0	1	1	0	0	3	2	4
Rhus tenuinervis	0	0	0	0	0	0	0	1	3	2	0	0	2	1	3
Grewia flava	0	0	0	0	0	0	13	15	18	0	0	0	13	15	18
Grewia sp.	0	0	0	0	0	0	35	53	31	0	2	0	35	55	31
Monechma incanum	—	0	0	—	0	0	—	849	892	—	0	0	—	849	892
Rhigozum trichotomum	—	0	0	—	0	0	—	350	403	—	0	0	—	350	403
Ehretia rigida	0	0	0	0	0	0	37	91	59	0	0	0	37	91	59

— = not counted
Tree = single stemmed individual
Shrub = multi stemmed individual

At Kousaunt the highest percentage frequency and density were shown by *Zygophyllum tenue, Rhigozum trichotomum* and *Salsola tuberculata*. In terms of density *Zygophyllum tenue* showed a marked increase from 1979 to 1983.

Rhigozum trichotomum had the highest density at Cubitje Quap during 1979 and 1984 and there tends to be an increase in the percentage frequency and density of species such as *R. trichotomum, Acacia erioloba, Asparagus africanus, Boscia albitrunca* and *Grewia flava*.

Between 1978 and 1981 the first six species at Stoffelsdraai (Table 6) showed a decline in percentage frequency and/or density. In fact, *Pteronia unguiculata* and *Helichrysum argyrosphaerum* were absent in 1981. However, a number of species increased in frequency and density since 1978, for example *Indigofera alternans, Hermannia tomentosa, Acacia haematoxylon, Requienia sphaerosperma* and *Monechma incanum*.

Table 9

Dynamics of the woody component in a 100 m × 50 m permanent plot at Dankbaar in the Kalahari Gemsbok National Park

Plant species	Number of individuals/ha				
	1980	1981	1982	1983	1984
Acacia erioloba	748	550	448	612	412
	(208)	(42)	(0)	(214)	(8)
Chrysocoma obtusata	106	46	0	2	0
Rhigozum trichotomum	76	76	70	78	90
					(2)
Monechma incanum	72	68	90	54	64
Pollichia campestris	68	136	0	22	0
Boscia albitrunca	36	36	62	62	44
			(40)		
Ehretia rigida	28	28	0	24	30
Lycium oxycarpum	28	16	30	32	24
Sericorema remotiflora	26	30	18	0	14
Grewia flava	24	18	2	4	2
Acacia luederitzii	20	12	10	18	8
Plinthus sericeus	12	12	10	0	0
Acacia haematoxylon	2	2	0	0	2
Grewia retinervis	2	0	0	6	10
Rhus tenuinervis	2	4	0	0	2
TOTAL	1 250	1 034	740	914	702

() = number of seedlings/ha

c. Permanent plots

In an *Acacia erioloba* plot east of Dankbaar the density of the woody species showed no specific tendencies from 1978 to 1983 except a slight increase in the number of *Rhus tenuinervis* individuals (Table 7).

In an *Acacia luederitzii* plot east of Dankbaar the density of *A. luederitzii* changed from 1978 to 1983 (Table 8). There was a sharp decline in seedlings as well as trees smaller than 2 m, although the trees higher than 2 m increased from three to eight. An increase in density was recorded for *Grewia flava* and the dwarf shrubs *Monechma incanum* and *Rhigozum trichotomum*.

Table 10

Dynamics of the woody component in a 100 m × 50 m permanent plot 5,1 km from Dankbaar on a track to Gharagab in the Kalahari Gemsbok National Park

Plant species	Number of individuals/ha 1982	1983	1984
Pollichia campestris	232	184	166
Acacia erioloba	140	126	122
	(4)	(2)	(4)
Asparagus sp.	26	40	42
Rhigozum trichotomum	12	12	16
Lycium oxycarpum	4	4	4
Acacia haematoxylon	2	2	0
Boscia albitrunca	2	2	2
Plinthus sericeus	0	22	14
Monechma incanum	0	0	10
Cassia italica	0	104	0
TOTAL	418	496	376

() = number of seedlings per ha

In a experimental plot at Dankbaar ±50 m east of the water point the density of *Acacia erioloba* differed from year to year due to differences in the number of seedlings (Table 9). There was, however, a gradual decline from 1980 to 1983 in the total number of *A. erioloba* individuals. Other species that have showed a decline are *Grewia flava* and *Plinthus sericeus*. *Boscia albitrunca* increased up to 1982 but decreased subsequently. *Chrysocoma obtusata* and *Pollichia campestris* appeared to suddenly disappear in certain years probably due to drought or intensive grazing conditions.

In a plot 5,1 km north of Dankbaar on the track to Gharagab, fewer individuals of *Acacia erioloba* and *Pollichia campestris* were recorded in 1984 than in 1982 (Table 10). An *Asparagus* sp. and *Monechma incanum* increased since 1982 while *Acacia haematoxylon* and *Cassia italica* disappeared from the plot thereafter.

Table 11

Presence of tree species (nearest individual — 30 m intervals) in a dune street and on a dune crest east of Dankbaar in the Kalahari Gemsbok National Park

Plant species	Dune street 75 points				Dune crest 88 points			
	Number of individuals		% Presence		Number of individuals		% Presence	
	1978	1984	1978	1984	1978	1984	1978	1984
Acacia erioloba	51	56	68,00	63,60	51	34	57,95	38,64
Acacia luederitzii	14	9	18,70	10,20	15	18	17,04	20,45
Boscia albitrunca	6	2	8,00	2,30	12	35	13,64	39,77
Acacia haematoxylon	3	0	4,00	0	2	0	2,27	0
Acacia mellifera	1	1	1,30	1,14	8	1	9,09	1,14
Grewia flava	0	15	0	17,05	0	0	0	0
Lycium sp.	0	4	0	4,55	0	0	0	0
Rhigozum trichotomum	0	1	0	1,14	0	0	0	0

d. Nearest individual method

The floristic composition of trees in the dune street and on the dune crest do not differ markedly, but there is some difference in the density of the respective species (Table 11). *Acacia erioloba* and *Grewia flava* appear to be more frequent in the dune street, while *Boscia albitrunca* occurs more frequently on the dune crest.

Since 1978, *Acacia luederitzii* individuals have decreased in the dune street and increased on the dune crest.

Discussion

A feature that is of great significance to the vegetation of the Kalahari is the variability and unreliability of the rainfall (Leistner 1967). During drought periods annuals are virtually absent while during particularly wet seasons numerous species, which are normally rare, will occur in great profusion.

The Kalahari year lacks a clear demarcation into four calendar seasons and has instead essentially two seasons (summer and winter), linked by transitional periods (Leistner 1967). Most precipitation occurs from October to April with a peak in March at Twee Rivieren. At least 85% of the plants in the southern Kalahari germinate in the precipitation period, which suggests that the flora is largely of tropical origin. Winter rains are scarce but are of great significance to the winter annuals and therefore play an important role in the seasonal dynamics of the vegetation.

Depending on the time of the year and the amount of rainfall, different plant species germinate and grow in the Kalahari. Early summer rains promote growth of perennial grass species while late summer rains are beneficial to the woody component. Summer annuals are also different from the winter annuals (Leistner 1967).

It is thus clear that great differences in the floristic composition, basal cover or density can be expected in the short and medium term in the Kalahari. According to

the wheel point surveys, which were always undertaken between April and June, the biggest change in the herbaceous stratum was with regard to basal cover and less so in the floristic composition. There was, however, an increase in annual forb species in 1981 and 1984, probably due to good late summer rains, for example *Tribulus zeyheri, Oldenlandia* sp., *Chamaesyce inaequilatera, Lophiocarpus tenuissimus* and *Cleome rubella*.

The dominant herbaceous species away from rivers and pans are *Eragrostis lehmanniana, Asthenatherum glaucum, Aristida meridionalis, Stipagrostis uniplumis* and *S. amabilis*. Along the Nossob River, *Stipagrostis obtusa* and *Schmidtia kalahariensis* are conspicuous grass species, while *Rhigozum trichotomum* is an important woody species.

The relatively dry years between 1978 and 1981 led to a decrease in the basal cover of herbaceous species such as *Eragrostis lehmanniana, Stipagrostis obtusa* and *Hermannia modesta*. Simultaneously an increase in the basal cover of species such as *Aristida meridionalis, Schmidtia kalahariensis, Eragrostis porosa, Heliotropium ciliatum* and *Fimbristylis hispidula* occurred.

During the same period the density of the seedlings of *A. erioloba* and *A. luederitzii* decreased, although the density of the trees remained more or less constant. *Rhus tenuinervis* and *Boscia albitrunca* showed a slight increase in density.

It is clear that in the short to medium term the woody species composition or density remained more or less constant. On the other hand the herbaceous species are much more dynamic and are greatly influenced by seasonal climatic factors.

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Appendix 1

List of plant names referred to in the text (Families arranged in alphabetical order)

Acanthaceae

Blepharis mitrata C.B.Cl.
Monechma incanum (Nees) C.B.Cl.
Monechma sp.

Aizoaceae

Aizoon schellenbergii Adamson
Gisekia africana (Lour.) Kuntze
Hypertelis sp.
Limeum sulcatum (Klotzsch) Hutch.
Plinthus cryptocarpus Fenzl
Plinthus karooicus Verdoorn
Plinthus sericeus Pax

Amaranthaceae

Hermbstaedtia linearis Schinz
Hermbstaedtia sp.
Sericorema remotiflora (Hook. f.) Lopr.

Anacardiaceae

Rhus tenuinervis Engl.

(*Continued overleaf*)

Asclepiadaceae

Asclepias buchenaviana Schinz

Asteraceae

Chrysocoma obtusata (Thunb.) Bayer
Dicoma capensis Less.
Eriocephalus pubescens DC.
Felicia muricata (Thunb.) Nees
Geigeria ornativa O. Hoffm.
Helichrysum argyrosphaerum DC.
Nolletia arenosa O. Hoffm.
Pentzia sp.
Pteronia unguiculata S. Moore
Senecio sp.

Bignoniaceae

Rhigozum trichotomum Burch.

Boraginaceae

Ehretia rigida (Thunb.) Druce
Heliotropium ciliatum Kaplan

Capparaceae

Boscia albitrunca (Burch.) Gilg & Ben.
Cleome rubella Burch.
Cleome sp.

Chenopodiaceae

Lophiocarpus tenuissimus Hook. f.
Salsola kali L.
Salsola rabieana Verdoorn
Salsola tuberculata (Moq.) Fen

Convolvulaceae

Merremia verecunda Rendle

Cucurbitaceae

Citrullus lanatus (Thunb.) Matsumura & Nakai
Cucumis africanus L.f.

Cyperaceae

Cyperus usitatus Burch.
Fimbristylis hispidula (Vahl) Kunth

Euphorbiaceae

Chamaesyce inaequilatera Sond. Soják
Chamaesyce sp.

Fabaceae

Acacia erioloba E. Mey.
Acacia haematoxylon Willd.
Acacia mellifera (Vahl) Benth.
Acacia luederitzii Engl.
Cassia italica (Mill.) Lam. ex F. W. Andr.
Crotalaria sphaerocarpa Perr. ex DC.
Elephantorrhiza elephantina (Burch.) Skeels
Hoffmannseggia burchellii (DC.) Benth. ex Oliv.
Indigofera alternans DC.
Indigofera daleoides Benth. ex Harv.
Indigofera flavicans Bak.
Indigofera sp.
Lebeckia linearifolia E. Mey.
Lotononis sp.
Requienia sphaerosperma DC.

Illecebraceae

Pollichia campestris Ait.

Liliaceae

Asparagus africanus Lam.
Asparagus sp.
Ornithogalum tenuifolium Delaroche

Oxalidaceae

Oxalis lawsonii F. Bol.

Pedaliaceae

Harpagophytum procumbens (Burch.) DC. ex Meissn.
Sesamum sp.

Poaceae

Aristida meridionalis Henr.
Aristida sp.
Asthenatherum glaucum (Nees) Nevski
Enneapogon desvauxii Beauc.
Eragrostis lehmanniana Nees
Eragrostis pallens Hack.

Eragrostis porosa Nees
Eragrostis sp.
Schmidtia kalahariensis Stent
Sporobolus nervosus Hochst.
Stipagrostis amabilis (Schweick.) de Winter
Stipagrostis ciliata (Desf.) de Winter
Stipagrostis obtusa (Del.) Nees
Stipagrostis uniplumis (Licht.) de Winter

Polygonaceae

Oxygonum dregeanum Meisn.

Rosaceae

Grielum sp.

Rubiaceae

Oldenlandia sp.

Scrophulariaceae

Aptosimum albomarginatum Marloth & Engl.
Aptosimum pubescens Weber
Aptosimum sp.

Solanaceae

Lycium oxycarpum Dun.

Sterculiaceae

Hermannia modesta (Ehrenb.) Mast.
Hermannia tomentosa (Turcz.) Schinz ex Engl.

Tiliaceae

Grewia flava Burret
Grewia retinervis Burret
Grewia sp.

Zygophyllaceae

Tribulus zeyheri Sond.
Zygophyllum tenue P. E. Glover