DU TOIT, PETRUS CORNELIS VERMEULEN

DEVELOPMENT OF A MODEL TO ESTIMATE GRAZING INDEX VALUES FOR KAROO PLANT SPECIES

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Development of a model to estimate grazing index values for Karoo plant species

by

PETRUS CORNELIS VERMEULEN DU TOIT

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Sing hymns of praise to the Lord;
He spreads clouds over the sky;
he provides rain for the earth
and makes grass grow on the hills.
He gives animals their food.

Psalms 147:7a,8 and 9a,
Good News Bible.

CONTENTS

CHAPTER 1

INTRODUCTION

1.1 National grazing strategy

During the late 1970's and the early 1980's much effort went into the development of techniques whereby veld condition could be recorded (Foran, Tainton & Booysen 1978; Tainton, Foran & Booysen 1978; Mentis, Collinson & Wright 1980; Danckwerts 1982a). The description of this veld condition relied heavily on the classical Clementsian concepts of climax and succession (Clements 1916; Task Group on Unity in Concepts and Terminology 1995). Later on models were developed by means of which the grazing capacities of various areas could be estimated from the described veld condition scores (Tainton, Edwards & Mentis 1980; Danckwerts 1982b). The estimation of fairly accurate grazing capacities was an effort to halt the retrogression of the grazing lands of South Africa (Donaldson undated; Fourie & Roberts 1977; Fourie, Dry & Hamman 1982). These activities culminated in the tabling of the Bill on the Conservation of Agricultural Resources in Parliament in 1983 (Wentzel 1983) and the White Paper on Agricultural Policy the following year (Hayward 1984). This was promoted by the erstwhile minister of agriculture, Minister Hayward, as the National Grazing Strategy (Anonymous 1985).

All of the techniques described during the late 1970's and the early 1980's recorded the veld condition, in terms of the plant species composition. The current grazing capacities of the different veld types were then estimated from these plant species scores (Edwards & Coetsee 1971; Edwards 1974; Tainton et al. 1980; Vorster 1982; Danckwerts 1982b). By and large the estimated long-term grazing capacities for the different areas, proposed by officials attached to the South African Department of Agriculture, were based on experience and considered opinion. Although the proposed long-term grazing capacities tried to incorporate varying climatic conditions over years, in many instances the real long-term grazing capacities of the different areas were not accurately represented.

Without exception all of these methods were based on the botanical species composition relative to the climax of the area in question (Task Group on Unity in Concepts and Terminology 1995) and did not take into account the influence exerted on the grazing capacity by the grazing animal (Bothma 1988). The treatment of this recorded data base differed in the different regions. However, the main aim of all these methods was to define the current grazing capacity, in terms of the relation between the ecological status and/or palatability of the vegetation and the number of animals which could safely be grazed on this vegetation without deterioration in the species composition and erosion setting in (Walker 1980; Wentzel 1983; Van Rooyen, Grunow & Theron 1988).

Since the publication of the White Paper on Agricultural Policy, much effort went into the planning of grazing management and related studies, mainly in an effort to tie in the botanical species composition of an area to the real, observed current grazing capacity. This seems to be the crux of the matter.

1.2 The Ecological Index Method

One of the methods which impacted directly on the estimation of grazing capacity in the Karoo Region, was the publication of the Ecological Index Method by Vorster (1982). This method has been widely used throughout the Karoo Region and largely acceptable results were obtained. However, the method suffered from two deficiencies. In short, these are firstly, that the late succession grasses received too high an index value to be used in the computations when the current grazing capacity is estimated (Tainton et al. 1980; Edwards 1981; Vorster 1982). From research undertaken by Botha (1991), it is clear that not all the late succession grasses should have an index value of 10 (Du Toit & Botha 1993). The second deficiency is the marriage of the two different value systems whereby index values are accorded to the plants. The grasses were scored as to their successional position in the ecology of the grazing system, whereas the karoo bushes were scored on their relative palatabilities to the grazing animals. Palatability is an agronomic attribute of the plant species. Since palatability of the karoo bush species and the successional importance of the grass species in the ecology of the grazing system are not homologous, this has major implications when estimating current grazing capacity. The estimated value describing the current grazing capacity of an area is an agronomic value, referring to the number of animals that can be kept on a certain area of land at a specific moment.

It is now considered inappropriate to combine both agronomical and ecological attributes of plant species in a single formula, when the grazing capacity of veld, which is an agronomic value, is to be estimated.

1.3 Subjectively estimated grazing index values

The abovementioned deficiencies led to the formation of a committee whose task it was to compare all the plant species usually encountered when carrying out botanical surveys in the Karoo and to subjectively estimate agronomic grazing index values for them (refer to Appendix 1). These index values can rightly be referred to as agronomic index values, since mainly agronomic attributes i.e. the ability to produce forage and the forage value during different seasons of the plant species featured in the estimates of the grazing index values recorded for the plant species. The use of these grazing index values in the estimation of current grazing capacities yielded acceptable results (Botha, Du Toit, Blom, Becker, Olivier, Meyer & Barnard 1993; Du Toit, Botha, Blom, Becker, Olivier, Meyer & Barnard 1995), when compared to the long-term grazing capacity norms as prescribed by the South African Department of Agriculture.

However, these grazing index values are still subjective value judgements as to the actual agronomic value of the Karoo plant species.

1.4 Objectively estimating grazing index values

The author felt that a method should be developed whereby these grazing index values could be objectively estimated from certain of the plant characteristics themselves, such as available forage production and chemical properties.

The present study aims to address this very issue. The proposed model for estimating the grazing index values will attempt to objectively allocate a grazing index value to a species, based on the agronomic properties, size, available forage production and chemical properties of the plant species. These properties have been studied and analyzed over a period of three years, in order to largely exclude the extreme variations in productivity which is characteristic of the vegetation occurring in the semi-arid veld types (Sneva & Hyder 1962). Various species from four distinct agro-ecological regions (Botha pers. comm.[1]) were studied. An attempt has been made to study related species within the same genus and related genera in the different regions, in order to ascertain the differences in grazing value between species in an area and between related species of different areas, so as to be in a position to extrapolate findings over a larger area.

The objectively estimated grazing index values should reflect more objectively the agronomic value of the plant species and, with the application of the Grazing Index Method, should estimate more acceptable current grazing capacities for the areas where it will be applied.

1.5 The Grazing Index Method

The Ecological Index Method has been well tested in the Karoo areas and it is well known and provides reasonably accurate results. The Grazing Index Values (GIV's) will be used within the framework of the Ecological Index Method (EIM) of grazing capacity calculation, but in place of the Ecological Index Values (EIV's)(10, 7, 4 and 1). However, in order to distinguish between the instances where the EIV's were used in the estimate of the current grazing capacity and those instances where the GIV's were used, the method employing the subjectively estimated Grazing Index Values or the objectively estimated Grazing Index Values, will now be referred to as the Grazing Index Method (refer to chapter 8).

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1. Botha, W. Van D., Grootfontein Agricultural Development Institute, Private Bag X 529, Middelburg. 5900. Eastern Cape Province.

The objectively estimated Grazing Index Values arrived at by means of the model, should enable verification of the general ranges and relative positioning of the grazing index values of the different species included in the list of Grazing Index Values arrived at by means of the subjective scoring method. The objectively estimated grazing index values should estimate agronomically more acceptable current grazing capacities. These estimated current grazing capacities should be more in line with the long-term grazing capacity norms propounded by the South African Department of Agriculture.

Short descriptions and summaries of the experimental work on which the thesis is based can be gleaned from chapters 5 and 6. Chapter 5 deals with the harvesting of the plant material in the four different agro-ecological areas where the species have been studied. Decriptions of the four agro-ecological areas can be found in chapter 4. In chapter 6 a fairly detailed account of the stocking rate trial is given where the stem diameters of the species were measured, in order to validate the separation between the grazable and ungrazable material on the basis of the 2 mm hypothesis. Chapter 7 outlines the development of the model by which the grazing index values are to be estimated, while the method through which these grazing index values are to be applied is discussed in full in chapter 8. These objective grazing index values are applied to botanical surveys and compared to the results obtained when the method is applied using both the ecological index values and the subjective grazing index values, in chapter 9.

CHAPTER 2

ACTIONS TAKEN SINCE THE PUBLICATION OF THE ECOLOGICAL INDEX METHOD

In the Karoo, any review of the literature dealing with the estimation of the current grazing capacity of a piece of veld, will start off with the Ecological Index Method described by Vorster (1982). Since this publication, great strides have been made in objectively quantifying and confirming the current grazing capacities of the various areas in the Karoo Region. It further serves as the starting point for any discussion on the index values applied to the species groups or plant species which are used to estimate current grazing capacities in the Karoo. Various researchers have speculated on the inappropriateness of the ecological index values to estimate the current grazing capacities. In order to correct apparent shortcomings, a number of researchers met and over a period, the committee made species by species comparisons of the index values of all the species commonly encountered during botanical surveys and subjectively adjusted their index values. With the aid of these adjusted index values, current grazing capacities were estimated, which closely approximated the long-term grazing capacity norms prescribed by the South African Department of Agriculture. Since this publication is not yet freely to hand, a fairly detailed account is rendered here. It must be remembered that these adjusted index values still represent subjective value judgements as to the actual grazing index value of the Karoo plant species. I have therefore decided that an objective method should be found to estimate the grazing index values of the Karoo plants.

2.1 The Ecological Index Method

The Ecological Index Method (EIM), (Vorster 1982) is the standard procedure used in the karoo and desert grassveld areas to compute veld condition scores from which current grazing capacities are estimated and grazing capacities throughout the region are compared. This method employs subjectively allocated index values. The group classification of the karoo plant species (Blom 1981), served as the basis for the allocation of these subjective index values to the different plant species. Two widely differing features, viz.: (i) the ecological significance of the grass species and (ii) the relative palatability ratings of the karoo bush species, formed the basis of the group classification. This classification system gave rise to the 10, 7, 4, and 1 ecological index value series (EIV). The range of these index values, 1 to 10 are strongly reminiscent of the climax adaptation values published by Curtis & McIntosh (1951) and Brown & Curtis (1952). Vorster (1982) linked the groups described by Blom (1981) to the decreaser, increaser and invader concepts described by Dijksterhuis (1949), in the Quantitative Climax Method. Foran et al. (1978) and Tainton et al. (1980) used these concepts in the high rainfall sour grassland areas of Natal and recognised decreasers, increasers I and increasers II. Vorster (1982) subsequently allocated ecological index values to these groups on the following basis:

1) perennial climax grasses (decreasers), an index value of 10;

2) perennial sub-climax grasses and palatable karoo bushes (increasers IIa), an index value of 7;

3) perennial pioneer grasses and the less palatable karoo bushes (increasers IIb) an index value of 4; and

4) annual pioneer grasses, unpalatable karoo bushes (increasers IIc) and invader plants, an index value of 1.

Owing to the generally low rainfall received by the Karoo, no Increaser I species category was identified for the Karoo vegetation.

2.1.1 Ecological Index Values

The ecological index values are used in the computation of the veld condition scores (Tainton 1981), following veld condition surveys of sample sites. Grazing capacities are then estimated from these veld condition scores. The veld condition score computed for the sample site represents the ecological state of health of the grass sward on the one hand, but it represents the agronomic state of health (Tainton 1981) of the karoo bushes on the other, since ecological attributes were used to score the grasses, and palatability, which is an agronomic attribute, was used to score the karoo bushes. Because the score is based partly on ecological principles and partly on the palatability of a part of the forage, it is inappropriate to estimate grazing capacities, which are agronomic values, from these veld condition scores, where the veld condition score is assumed to indicate the agronomic potential of the site to support livestock. Several other factors need to be considered when a realistic grazing capacity is to be estimated, such as for instance dry matter production (Bayer 1989; Botha et al. 1993). The EIM is therefore largely dependent upon classical succession theory, as are many of the other methods currently employed elsewhere in South Africa (Foran et al. 1978; Tainton et al. 1980; Bayer 1989; Hardy & Hurt 1989; Hurt & Bosch 1991).

A number of unanswered questions exist around the testing of succession theory in the Karoo (Hoffman 1988), while many of the generally accepted early succession species do not react according to classical succession theory in the arid regions of southern Africa (Van Rooyen, Bredenkamp, Theron, Bothma & Le Riche 1994). State and transition models (Westoby, Walker & Noy-Meir 1989) has entered the ecological arena as well as the concept of thresholds (Laycock 1991), these theories will eventually displace much of the older successional theory as well as its concomitant terminology. However, while strongly supporting these concepts, Friedel (1994) argues that their spatial hierarchy still needs defining. Consider for the moment two species encountered during this study. Aristida congesta and Themeda triandra, in the older literature they were described as pioneer and climax grasses respectively (Blom 1981), their function and position in the older ecology were well understood. It is not obvious in what way they will be accommodated in the state and transitional models, so that their obviously different roles in the ecology will be understood? Therefore it is felt that to make use of the terms early-, mid-, and late successional stage plants in the interim, will neither be too offensive to adherents of the state and transitional model theory, nor to the adherents of the threshold theory.

Research by Botha (1991), revealed that the ecological index values currently used for the grasses, may lead to either over- or under-estimation of the current grazing capacity. Bayer (1989) also referred to the necessity of relating species groupings and species weightings to their grazing use. With the foregoing in mind, it became necessary to review the grazing index values of the species. In a system where every species has its own grazing index value, veld condition survey activities will be concentrated on the veld, irrespective of successional or state and transition model theory, where descriptive terminology in any case still has not been sorted out.

2.2 The subjective species evaluation method

In order to correct these apparent shortcomings and in an effort to move away from the classical succession theory, the index values of all the species commonly encountered during botanical surveys, were subjectively adjusted by means of a species by species comparison. A number of researchers and extension officers involved in the calculation of grazing capacities and attached to the Grootfontein Agricultural Development Institute, estimated the grazing value of those plant species most commonly recurring in species lists compiled from botanical surveys. Each species was assessed on the basis of the following six parameters:

1). The ability of the species to produce forage, i.e. the amount of grazable dry matter produced per year: Low producers score 1, while high producers score 10.

2). The feed value during the growing season, December, January and February in the summer rainfall area and June, July and August in the winter rainfall area: Species with a low feed value score 1, while species with a high feed value score 10.

3). The feed value during the dormant season, June, July and August in the summer rainfall area and December, January and February in the winter rainfall area, as in no. 2.

4). Relative ease with which the species can be grazed i.e. the presence or absence of spines: Very spiny plants score 1, while plants without spines score 10. The presence of resins and aromatic oils in a species downgraded the score due to anti-herbivory.

5). Perenniality: Annual plants score 1, while strong perennial sod-forming grasses score 10.

6). Ability of the plant to protect the soil against surface soil erosion: Upright karoo bushes have a low score while decumbent bushes score fairly high, annual tufted grasses score 1, tufted perennial grasses, depending on productivity and habit, have an intermediate score due to the erosive channeling effect they may have on runoff water, while sodforming grasses, where infiltration of rainwater is heightened, score 10.

These six parameters were chosen to ensure the comparability of the individual species score estimates and to ensure an estimate relatively free from subjectivity. It will be appreciated that these six parameters represent agronomic properties of the species.

In the case of undesirable plants i.e. poisonous and/or invader plants, a factor commensurate with the degree of poisonousness of the plants, was introduced in order to down-weight the grazing value of the particular species. High producing ephemeral plants were likewise downweighted, but specifically by the ratio of the number of months in which they did not produce dry matter to grazing livestock.

Each participant scored the species according to his knowledge of, and experience with a particular species. Each parameter was scored out of ten. The individual parameter scores were summed and the final species score calculated to lie between zero and ten. The use of a scale with values ranging from 1 to 10 has become customary and is often proposed in biological and ecological work (Curtis & McIntosh 1951; Brown & Curtis 1952; Vorster 1982; Hurt & Bosch 1991).

The average was calculated for the individual species scores, submitted by each participant and one standard deviation from the mean calculated for each species score. Values falling outside of the range created by the mean, plus and minus one standard deviation, were discarded. A new mean was calculated for the remaining values. The resultant score, now called the grazing index value (GIV), was vetted by the participants and either accepted or rejected. In the case of a rejected score, the individual species scores were scrutinized and adjusted on a consensus basis. When adjusting individual species scores, the scores of related species, as well as unrelated species but with known similar grazing values, were considered. It will be clear that the different phases of the operational research study (Wilkes 1989), were followed in arriving at an acceptable solution, the grazing index value.

2.3 Results of the scoring method

2.3.1 Species comparisons

Just over 60 % of the 240 scores originally submitted were accepted, illustrating a high degree of concurrence between participants. During the second round, less than 15 % of the scores were unacceptable. In this case species were relatively unknown or presented problems when the different parameters had to be scored.

The EIM series of index values (1, 4, 7, and 10) were changed to a continuous series of grazing index values between 0 and 10 (Curtis & McIntosh 1951; Brown & Curtis 1952; Vorster 1982; Hurt & Bosch 1991), 0.8 to

10 for the grasses and 0.7 to 7.7 for the karoo bushes (Du Toit et al. 1995). With the implementation of this system, it was argued that the karoo bushes could not attain a top score of 10, since they are neither as productive nor as adaptable to high rainfall as are the grasses. The late successional stage grasses now range in score from 6 to 10, instead of the index value of 10 applicable to all climax grasses previously, irrespective of their dry matter productivity. Closely related species which have different grazing values can now be accommodated in the series of index values. From the exposition above, it is apparent that this new series is comprised mainly of the agronomic features of the different species. Comparisons of veld condition scores and calculated grazing capacities using the EIM index values, with veld condition scores and calculated grazing capacities, using the grazing index values, emphasise the value of making these adjustments (Table 2.1).

The value of these adjustments can be seen when comparing closely related species, for instance Pentzia species. In terms of P. incana, the closely related P. punctata is not as poor as the value of 1 used previously suggested, but it could obviously not be classified in the same category. Likewise, the inclusion of P. sphaerocephala in a higher category than P. incana is justified, but the difference in grazing value is not as large as the index value of 7 used previously, suggested. Refer to Table 2.1 for the series of values in the case of the Pentzia species.

2.3.2 Grazing capacity calculations

In areas where the botanical composition is dominated by grasses, the EIM apparently over-estimates the current veld condition score. It is known that not all the climax grasses are of equal grazing value. Due to the high index value of the climax grasses, areas dominated by these grasses have a high veld condition score and therefore a high calculated grazing capacity. It was found that the veld condition scores for these areas lie relatively far above the regression line describing the rain

Table 2.1. The series of grazing index values enables the distinction between closely related *Pentzia* species

Species	EIV[1]	GIV[2]
P. cooperi	1	2.9
P. tortuosa	4	2.9
P. punctata	1	3.4
P. calcarea	1	3.5
P. elegans	4	3.8
P. dentata	4	4.2
P. pinnatisecta	4	4.5
P. globosa	4	4.8
P. spinescens	4	4.8
P. incana	4	5.7
P. lanata	4	5.7
P. sphaerocephala	7	6.9

[1] EIV = ecological index value

[2] GIV = grazing index value

fall - veld condition relation as illustrated in Figure 2.1. In areas dominated by karoo bushes on the other hand, the estimated veld condition scores lie close to the regression line describing the rainfall - veld condition relation (Figure 2.1).

The "better fit" obtained when regressing veld condition score on rain fall, using the grazing index values of the species in the calculation of the current veld condition, is illustrated in Figure 2.2. The estimated veld condition scores and calculated grazing capacities for seven sample sites from four different homogeneous areas, are presented in Table 2.2. For the purposes of these comparisons, both the grazing index values and the EIM values were used in the calculations. They clearly show the marked influence that the high index value of the late succession grasses has on the estimated veld condition score and hence on the calculated current grazing capacity. In the late successional stage grassveld areas, the veld condition score is high when the EIM scores are used in the calculation. This leads to the assumption that a heavy stocking rate can be applied. When the grazing values are used in the calculation, the veld condition score is lower, indicating the necessity of applying a lighter, more conservative stocking rate. In areas dominated by karoo bushes, use of the grazing values in the calculation of the current veld condition score yields a higher grazing capacity figure, i.e. a heavier stocking rate can be applied, than when the ecological index values are used. The better fit obtained when regressing grazing capacity on rainfall, using the grazing index values of the species instead of the ecological index values, agrees closely with regressions of the applied stocking rates on rainfall.

2.4 Grazing index values of Karoo plant species

A species list with the proposed subjectively estimated grazing index values can be found in the publication "Estimating grazing-index values for Karoo plants" (Du Toit et al. 1995) (the species list only, is included as Appendix 1).

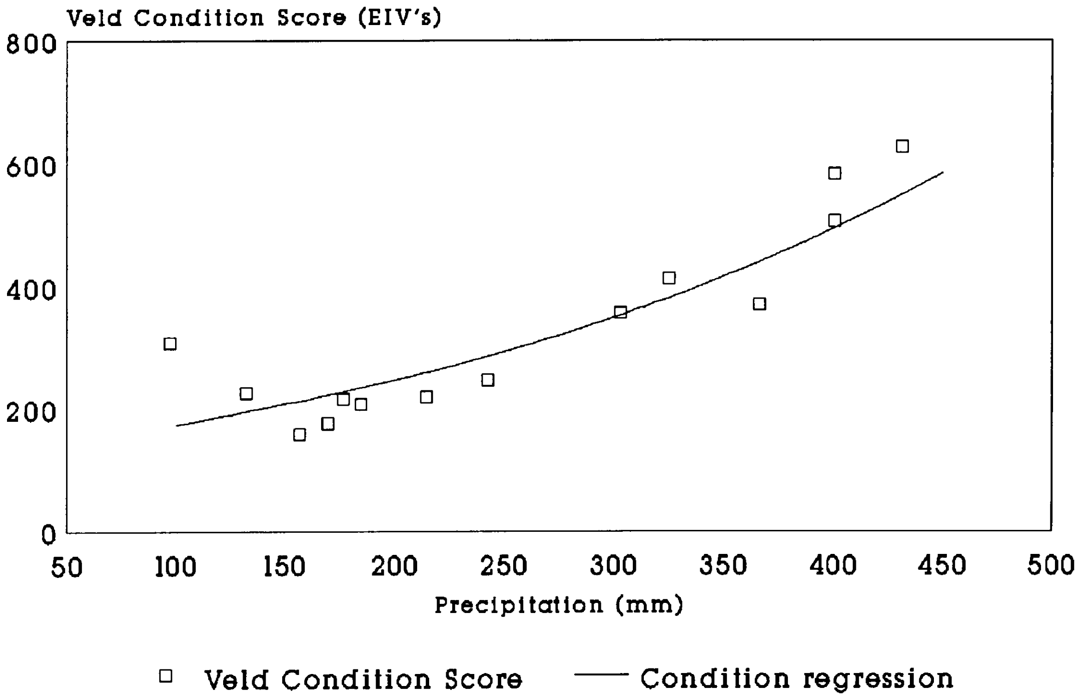

Figure 2.1 A regression of the veld condition score, as determined by using the ecological index values of the species, on precipitation.

Regression Analysis: **Y = exp(4.83344+0.00341006X)**

R^2 = 0.7664

Correlation Coefficient = 0.875464

Stnd. Error of Est. = 0.225017

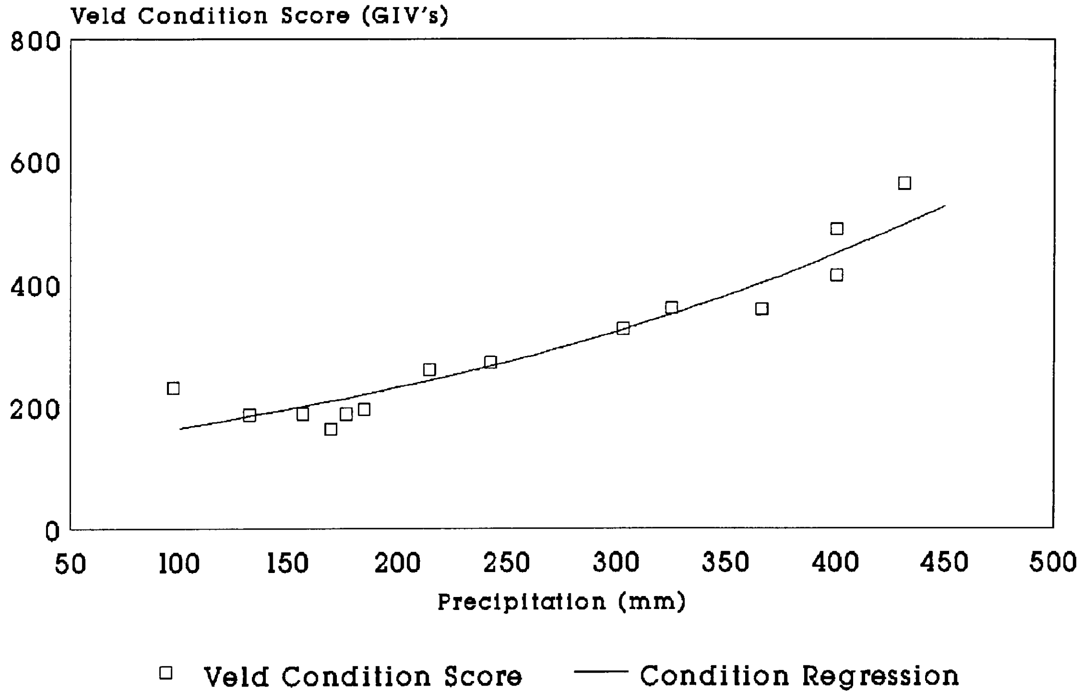

Figure 2.2 A regression of the veld condition score, as determined by using the grazing index values of the species, on precipitation.

Regression Analysis: **Y = exp(4.79914+0.00324814X)**

R^2 = 0.8779

Correlation Coefficient = 0.936968

Stnd. Error of Est. = 0.144791

Table 2.2 Botanical composition, percentage cover (CS), veld condition scores (VCS) and the respective estimated current grazing capacities (CGC) presented for seven sample sites from four reasonably homogeneous areas in the Karoo. Sites follow a gradient from the arid north west through the south and central Karoo to the relatively moist north eastern Karoo. The ecological - and grazing index values of the different species are compared, as well as the results of their respective products with the percentage strikes on the species. CGC is given in $ha.LSU^{-1}$ (large stock unit). A = late successional stage grassland, dry in the west but relatively moist in the east, B = degraded grassland with varying percentages of karoo bush & C = karoo bushveld, as in Chapter 8, Figures 8.1 & 8.3. Data from Botha (1991)

A J Kruger, Grappies Farm (29° 25'S, 19° 57'E), Pofadder district; June 1992, median rainfall 82 $mm.a^{-1}$, grazing capacity norm 39 $ha.LSU^{-1}$.

	%	EIV	Score	GIV	Score
Aristida congesta	1	1	1	1.3	1.3
Eriocephalus spinescens	2	4	8	4.5	9.0
Stipagrostis ciliata	39	10	390	7.2	280.8
Stipagrostis obtusa	25	10	250	6.6	165.0
CS	67	VCS	649	VCS	456
		CGC	26.8	CGC	38.2

S Durandt, Knolepark Farm (30° 38'S, 26° 20'E), Burgersdorp district; February 1992, median rainfall 450 $mm.a^{-1}$, grazing capacity norm 10 $ha.LSU^{-1}$.

	%	EIV	Score	GIV	Score
Cymbopogon plurinodis	78	10	780	7.6	592.8
Digitaria eriantha	2	10	20	8.9	17.8
Pentzia globosa	1	4	4	4.8	4.8
Themeda triandra	9	10	90	9.3	83.7
CS	90	VCS	894	VCS	699
		CGC	9.7	CGC	12.5

Table 2.2 (continued)

B J J Zwiegers, Diephoek Farm (30° 07'S, 24° 15'E), Petrusville district; July 1992, median rainfall 312 $mm.a^{-1}$, grazing capacity norm 20 $ha.LSU^{-1}$.

	%	EIV	Score	GIV	Score
Eragrostis lehmanniana	30	7	210	5.4	162.0
Pentzia globosa	15	4	60	4.8	72.0
Aristida congesta	4	1	4	1.3	5.2
Plinthus karooicus	8	7	56	6.4	51.2
Enneapogon desvauxii	1	1	1	1.0	1.0
Hertia pallens	2	1	2	1.2	2.4
Lycium cinereum	1	1	1	3.0	3.0
Protasparagus suaveolens	4	1	4	1.0	4.0
Eriocephalus aspalathoides	1	4	4	4.0	4.0
Galenia procumbens	5	4	20	4.3	21.5
Eragrostis bergiana	3	4	12	2.8	8.4
CS	74	VCS	374	VCS	335
		CGC	15.5	CGC	20.8

P J J Southey, Hillstone Farm (31° 20'S, 25° 31'E), Middelburg district; July 1992, median rainfall 346 $mm.a^{-1}$, grazing capacity norm 16 $ha.LSU^{-1}$.

	%	EIV	Score	GIV	Score
Sporobolus fimbriatus	14	10	140	9.5	133.0
Eragrostis obtusa	9	7	63	4.0	36.0
Eragrostis lehmanniana	1	7	7	5.4	5.4
Eriocephalus ericoides	15	4	60	5.0	75.0
Pentzia globosa	6	4	24	4.8	28.8
Aristida congesta	20	1	20	1.3	26.0
Cynodon dactylon	4	4	16	4.5	18.0
Lycium cinereum	8	1	8	3.0	24.0
Eragrostis chloromelas	1	7	7	5.5	5.5
Eriocephalus spinescens	1	4	4	4.5	4.5
Chrysocoma ciliata	1	1	1	1.5	1.5
CS	80	VCS	350	VCS	358
		CGC	16.6	CGC	19.5

Table 2.2 (continued)

C F Schoeman, Swartgrond Farm (33° 04'S, 22° 56'E), Beaufort West district; August 1992, median rainfall 199 $mm.a^{-1}$, grazing capacity norm 32 $ha.LSU^{-1}$.

	%	EIV	Score	GIV	Score
Aristida congesta	2	1	2	1.3	2.6
Protasparagus suaveolens	1	1	1	1.0	1.0
Pentzia incana	14	4	56	5.7	79.8
Rhigozum obovatum	2	7	14	6.6	13.2
Eberlanzia ferox	1	1	1	2.7	2.7
Hermannia desertorum	5	7	35	5.9	29.5
Stipagrostis obtusa	2	10	20	6.6	13.2
Eriocephalus ericoides	1	4	4	5.0	5.0
Felicia muricata	3	7	21	6.5	19.5
Lycium cinereum	1	1	1	3.0	3.0
Pteronia sordida	1	4	4	4.5	4.5
Eriocephalus spinescens	1	4	4	4.5	4.5
Enneapogon desvauxii	1	1	1	1.0	1.0
Stipagrostis ciliata	2	10	20	7.2	14.4
Felicia filifolia	1	7	7	5.9	5.9
Zygophyllum microphyllum	1	4	4	4.0	4.0
CS	39	VCS	195	VCS	204
		CGC	29.8	CGC	34.2

Table 2.2 (continued)

C A de Villiers, Abrahamskraal Farm (31° 46'S, 22° 40'E), Victoria West district; February 1992, median rainfall 227 $mm.a^{-1}$, grazing capacity norm 26 $ha.LSU^{-1}$.

Karoo bushveld	%	EIV	Score	GIV	Score
Chrysocoma ciliata	7	1	7	1.5	10.5
Eriocephalus ericoides	9	4	36	5.0	45.0
Eriocephalus spinescens	4	4	16	4.5	18.0
Lycium cinereum	3	1	3	3.0	9.0
Pentzia incana	21	4	84	5.7	119.7
Plinthus karooicus	1	7	7	6.4	6.4
Pteronia sordida	11	4	44	4.5	49.5
Rosenia humilis	7	1	7	3.5	24.5
CS	63	VCS	204	VCS	283
		CGC	42.7	CGC	30.8

Grass/karoo bushveld	%	EIV	Score	GIV	Score
Eberlanzia ferox	1	1	1	2.9	2.9
Eriocephalus spinescens	1	4	4	4.5	4.5
Felicia filifolia	2	7	14	5.9	11.8
Pentzia incana	34	4	136	5.7	193.8
Pteronia glauca	1	4	4	3.2	3.2
Pteronia sordida	4	4	16	4.5	18.0
Rosenia humilis	1	1	1	3.5	3.5
Salsola tuberculata	1	7	7	6.9	6.9
Stipagrostis obtusa	20	10	200	6.6	132.0
Walafrida geniculata	1	7	7	7.0	7.0
Zygophyllum gilfillanii	2	7	14	5.9	11.8
CS	68	VCS	404	VCS	395
		CGC	21.5	CGC	22.0
Mean CGC of Abrahamskraal			32.1		26.4

The Grazing Index Method (GIM; Chapter 8) was developed in an effort to overcome the problems referred to above (succession, state and transition models and threshold models). Its mode of operation is independent of succession theory, since it depends upon the agronomic attributes of the species, with each species playing its own unique role. In broad outline the method is not dissimilar to the EIM, but without its disadvantages and the procedures are well known.

2.5 Conclusions

The GIV's comprise mainly agronomic features of the species and it is reasoned that their use in the computation of the veld condition scores, will yield more acceptable estimated current grazing capacities than was realised with the use of the EIV's.

2.6 Justification for the objective estimation of grazing index values

The grazing index values mentioned above are, however, subjective value judgements as to the actual grazing value of the Karoo plant species. The proposed model for estimating the grazing index values will attempt to objectively allocate a grazing value to a species, based on certain dry matter production properties and chemical properties of the species. These properties have been studied and analysed over a period of three years, in order to largely exclude the extreme variations in productivity that is characteristic of the vegetation of the semi-arid veld types (Sneva & Hyder 1962). Various species from four distinct agro-ecological regions (Botha pers. comm.[2]) were studied. An attempt has been made to study similar species, or related species within the same genus in the different regions, in order to ascertain the differences in grazing value within species, but between different areas so as to be in a position to extrapolate findings over a larger area. The grazing index values will be used in the Ecological Index Method (EIM) of grazing capacity calcula-

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2. Botha, W. Van D., Grootfontein Agricultural Development Institute, Private Bag X 529, Middelburg. 5900. Eastern Cape Province.

tion instead of the ecological index values (10, 7, 4 and 1), because the method has been well tested in the Karoo areas, it is well known and provides reasonably accurate results. However, in order to avoid confusion as to which index values have been used and that an agronomic method of grazing capacity estimation has been used, the use of the Ecological Index Method will fall away and it will be replaced by the Grazing Index Method.

The grazing index values arrived at by means of the model, used in conjunction with the Grazing Index Method, should enable verification of the relative positioning of the species within the series of grazing index values arrived at by means of the subjective scoring method, as well as estimating more reliable current grazing capacities.

CHAPTER 3

EXPERIMENTAL PROCEDURES, METHODS AND MATERIALS

3.1 Introduction

3.1.1 Present studies

The aim is to objectively quantify the grazing value of various plant species. For this reason those species most commonly found when doing botanical analyses were harvested every three months. These studies have been undertaken over a period of three years in four distinct agro-ecological regions (Botha pers. comm.[3]). An attempt has been made to study the same or related species in the different regions, in order to ascertain the differences in grazing value within a genus and to be in a position to extrapolate findings for the genus/species, over a larger area. The four reasonably homogeneous agro-ecological areas where the species have been studied are:

The Eastern Mixed Karoo (The False Upper Karoo, Veld Type 36)(Acocks 1988);

The Karoo Mountainous Areas (The Karroid Merxmuellera Mountainveld, Veld Type 60);

The Arid Karoo (The Arid Karoo and False Desert Grassveld, Veld Type 29); and

The Great Karoo (The Great Karoo variation of the Karroid Brokenveld, Veld Type 26a).

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3. Botha, W. Van D., Grootfontein Agricultural Development Institute, Private Bag X 529, Middelburg. 5900. Eastern Cape Province.

3.1.2 Season of data collection

Originally the research made provision for the gathering of data during a "wet" and a "dry" season, irrespective of the time of year (Vorster & Blom 1985). Subsequently it was decided to gather data on a more regular basis, irrespective of wet and dry conditions prevailing during different years, in four of the distinct homogeneous areas. An attempt was made to gather data over as wide an area as possible in order to study similar species and to gather differing sets of climatological data which could be used in plant production models. For this reason species were selected in such a manner that related species would be studied in each of the ecological areas (refer to section 3.4 and Tables 1 to 4 in Appendix 9).

Following on the preliminary inspection of data published by Du Preez (1971); Zeeman, Marais & Coetzee (1983); and Zeeman, Marais & Coetzee (1984), it was decided during 1990 that the data collection phase should be expanded to include the four seasons per year (Du Toit 1992a). With data collected during the four plant growth seasons, commencement of growth, active growth, reserve storage and the dormant phases, a more realistic plant growth production curve can be constructed which would provide a better indication of the forage quality and grazing value of the species over the year during the different seasons. Since January 1990, plant production and chemical quality data were gathered during spring (commencement of growth), summer (active growth), autumn (reserve storage) and during winter (the dormant period). Commencement of growth takes place from August/September to October, active growth from November/December to March, reserve storage from about March to May and the dormant period lasts from about June to August.

3.2 Methods

3.2.1 Estimation of canopy spread cover and data collection

The canopy spread cover of a number of grasses and bushes was measured at random at each locality during the three years from 1990 to 1993. A frame with dimensions 1 m x 1 m, subdivided into blocks of 50 mm x 50 mm for the large species and in blocks of 25 mm x 25 mm for the smaller species, was used for this purpose. The frame was randomly placed and the canopy spread cover was estimated by examining the perpendicular projection of the crown onto the frame. The area was estimated by counting the blocks of which half or more of each block was engaged by the perpendicular projection of the crown (Goebel, Debano & Lloyd 1958). The number of blocks counted were then expressed as square centimeters of canopy spread cover. The canopy spread cover of fifty plants per species was obtained in this way. According to Roux (1963), fifty measurements per plant species were found to yield a reliable average value. Care was taken in order to ensure the inclusion of a representative spread of sizes. A range of plants from small to large, were selected per species in order to obtain the natural variation in size. Fifty plants per species were harvested in toto after their sizes have been estimated. The plants were harvested at a height of approximately 20 mm to 50 mm above the soil surface. The plants were selected over an area not larger than one hectare (Vlok 1963), in order to exclude ecotope differences and to minimize slight variations in plant morphology due to ecotope differences. The harvested material was separated into two fractions, these being potentially grazable and ungrazable material on the basis of a rule of thumb that assumes that stems thicker than 2 mm are not grazed (Botha 1981). All the stems with a diameter thicker than 2 mm, were regarded as ungrazable. Those parts with a diameter of 2 mm and thinner were regarded as grazable and therefore contributed to the available harvestable forage (Botha 1981; Vorster & Blom 1982a; Du Toit 1993a). Grass tufts were harvested at a stubble height between 20 to 50 mm. The whole harvested grass fraction was regarded as being grazable. Both the grazable and ungrazable fractions of the karoo bushes were dried in a forced draft oven between 60°C to 80°C, for 24 hours and weighed afterwards.

3.2.2 Chemical analyses

Only the potentially grazable material was chemically analyzed for nitrogen (A.O.A.C. 1960), Ca, P, Na, Mg, K, (Homer & Parker 1961) and acid detergent fibre (Van Soest 1963).

Values of these macronutrients are to be included in the formulae for the objective estimation of the grazing index values. High values and unacceptable ratios will detrimentally affect animal production (Van Hoven & Ebedes 1988). While low values may lead to serious deficiencies in animal feeding (Woods 1959). Unfavourable values will therefore ultimately exert unfavourable influences on the agronomic grazing index value estimated for the plant species.

Owing to the prominence that the parameter total digestible nutrients receives in animal feeding ration formulations (Maynard & Loosli 1962), in the comparison of different feedstuffs (Swift 1957) and, in this case the comparison of different natural forages, it is included in the equations as a primary parameter. It is felt that the two variables incorporated in the determination of TDN (Glover & Duthie 1960; Bartholomew 1985; Bredon & Meaker undated) i.e. the percentages of nitrogen and acid detergent fibre, play a significant role in the estimation of the grazing index value.

In addition to the chemical properties mentioned above, the % ash and ether extract of the species were obtained from the literature in order to be incorporated into the model (Louw, Steenkamp & Steenkamp 1968a, 1968b; Steenkamp & Hayward 1979; Botha, Becker & Van Der Merwe 1990; Botha, Erasmus & Theron 1990; Botha & Nash 1990; Botha, Van Staden & Blom 1990).

3.2.3 Preliminary data handling

The canopy spread cover : total mass relation of the specific species was determined in order to determine the relation between plant cover and the available forage (Payne 1974).

The relation between plant cover, available forage and forage value (chemical content) is used to calculate a grazing index value for each species. The floristic composition, together with the grazing index value of the species at that moment, describes the current grazing capacity. These grazing index values can then be compared to the subjective grazing index values developed earlier at the Grootfontein Agricultural Development Institute (see Chapter 2 and Du Toit *et al*. 1995).

Stepwise regressions (Statistical Graphics Corporation 1991) with the subjective grazing index values, indicated the most important elements to be included in the model by means of which the grazing index value of the species could be objectively determined.

3.2.4 Models used to estimate grazing index values

Two approaches were followed. In the first instance the ether extract (refer to par. 3.2.2) makes a negative contribution to the grazing value of the Karoo bushes. Due to it's contribution to the smell and taste of the karoo bushes, high values act as a deterrent to herbivores, while the higher the ether extract value of certain shrubs, the higher the loss of energy rich esters, ethers and aldehydes through the urine of sheep (Cook, Stoddart & Harris 1952). In the second instance the ether extract makes a positive contribution to the grazing value of the grasses (Van Der Merwe 1985). Grasses with a high ether extract value were found to be late succession species and these grasses are thought to be more productive and nutritious, due to their higher carotene content, than early succession grasses which normally have a low ether extract percentage and therefore a low carotene content.

3.4 Species studied during the investigations

3.4.1 The species studied in the Eastern Mixed Karoo

The species studied in the Eastern Mixed Karoo at Grootfontein during the three years 1990/91, 1991/92 and 1992/93 are enumerated in Table 3.1.

Indicator species

Due to the wide distribution of species belonging to the genus Pentzia, it was decided to use the different species of this genus as indicator species throughout the area where the studies were conducted. Relations as to the relative palatabilities between the different Pentzia species are well known (Blom 1989). However, on the farm Rooikop, in the Great Karoo in particular, it was often difficult to distinguish between P. incana and P. spinescens. Apparently individuals of both species freely hybridized in the dry watercourses. Many individuals could not be placed into one or the other of these species with certainty. Accordingly it was difficult to select only individuals of P. spinescens during the dry periods. However, subjective index values can relatively easily be estimated for the Pentzia species and they can then be placed in a series (refer to Chapter 2, Table 2.1)(Du Toit et al. 1995). The estimated index values of other genera and species can then be compared to the index values allocated to these species, in order to establish or confirm their relative positions and grazing index value ratings.

Table 3.1 Species examined at Grootfontein in the Eastern Mixed Karoo during the three years 1990/91, 1991/92 and 1992/93

1990/91	1991/92	1992/93
Aristida congesta		Aristida congesta
Aristida diffusa		
Digitaria eriantha		
Eragrostis lehmanniana		Eragrostis lehmanniana
	Heteropogon contortus	Heteropogon contortus
	Sporobolus fimbriatus	
	Stipagrostis ciliata	
	Stipagrostis obtusa	
Themeda triandra		Themeda triandra
Chrysocoma ciliata		
Eriocephalus ericoides		Eriocephalus ericoides
	Eriocephalus spinescens	
		Helichrysum lucilioides
Pentzia incana	Pentzia incana	Pentzia incana
	Phymaspermum parvifolium	Phymaspermum parvifolium
		Plinthus karooicus
	Pteronia glauca	
	Pterothrix spinescens	
	Rosenia humilis	Rosenia humilis
Salsola calluna		
	Walafrida geniculata	

3.4.2 The species studied in the Karoo Mountainous Areas

The species studied in the Karoo Mountainous Areas at Vrede during the three years 1990/91, 1991/92 and 1992/93 are enumerated in Table 3.2.

Table 3.2 Species examined at Vrede in the Karoo Mountainous Areas during the three years 1990/91, 1991/92 and 1992/93

1990/91	1991/92	1992/93
Aristida diffusa		
	Digitaria eriantha	*Digitaria eriantha*
	Eragrostis curvula var *conferta*	
		Eragrostis lehmanniana
	Hyparrhenia hirta	
Merxmuellera disticha		
Themeda triandra		*Themeda triandra*
	Eriocephalus ericoides	*Eriocephalus ericoides*
	Felicia fascicularis	
	Felicia filifolia	
		Helichrysum dregeanum
	Nenax microphylla	*Nenax microphylla*
Pentzia globosa	*Pentzia globosa*	*Pentzia globosa*
Phymaspermum parvifolium		*Phymaspermum parvifolium*
		Rosenia oppositifolia
Walafrida saxatilis		

3.4.3 The species studied in the Arid Karoo

The species studied in the Arid Karoo at Klerefontein, Rondefontein and Biesieslaagte during 1990/91, 1991/92 and 1992/93, are enumerated in Table 3.3.

Table 3.3 Species examined at Klerefontein, Rondefontein and Biesieslaagte in the Arid Karoo during the three years 1990/91, 1991/92 and 1992/93.

1990/91	1991/92	1992/93
	Aristida diffusa	
	Eragrostis lehmanniana	Eragrostis lehmanniana
Fingerhuthia africana		
Stipagrostis ciliata		Stipagrostis ciliata
Stipagrostis obtusa B[1]		
Stipagrostis obtusa G[2]		Stipagrostis obtusa
Eberlanzia ferox		Eberlanzia ferox
	Eriocephalus ericoides B	Eriocephalus ericoides
	Eriocephalus ericoides G	
	Eriocephalus spinescens	
	Felicia macrorrhyza	
		Helichrysum lucilioides
Monechma incanum		
	Osteospermum spinescens	
Pentzia spinescens B	Pentzia spinescens	Pentzia spinescens
Pentzia spinescens G		
Plinthus cryptocarpus		Plinthus cryptocarpus
	Plinthus karooicus	
	Pteronia adenocarpa	Pteronia adenocarpa
	Pteronia glomerata	
Pterothrix spinescens		Pterothrix spinescens
	Rosenia humilis	Rosenia humilis
Salsola tuberculata		
		Zygophyllum lichtensteinianum

[1] B = Karoo bush veld on stony shaleveld

[2] G = Bushman grassveld on red sandy soils

3.4.4 The species studied in the Great Karoo

The species studied in the Great Karoo at Rooikop during the three years 1990/91, 1991/92 and 1992/93 are enumerated in Table 3.4.

Table 3.4 Species examined at Rooikop in the Great Karoo during the three years 1990/91, 1991/92 and 1992/93.

1990/91	1991/92	1992/93
Fingerhuthia africana		Fingerhuthia africana
Stipagrostis obtusa		Stipagrostis obtusa
Eberlanzia ferox		Eberlanzia ferox
	Eriocephalus ericoides	
Eriocephalus spinescens		Eriocephalus spinescens
	Felicia fascicularis	Felicia fascicularis
	Galenia secunda	
		Helichrysum lucilioides
		Hermannia desertorum
	Nenax microphylla	Nenax microphylla
	Osteospermum microphyllum	
Pentzia spinescens	Pentzia spinescens	Pentzia spinescens
	Pteronia staehelinoides	
Rosenia humilis		Rosenia humilis
	Salsola rabieana	Salsola rabieana
Salsola tuberculata		
	Walafrida geniculata	
Zygophyllum microphyllum		

3.5 The categories of plant species studied

The plant species studied during the three years, 1990/91, 1991/92 and 1992/93, are divided into categories on the basis of firstly, the successional position of the grasses and secondly according to the relative palatability of the karoo bushes. Comprehensive descriptions of these categories can be obtained in the Group Classification (Blom 1981, 1984), in the description of the Ecological Index Method (Vorster 1982) and the Plant Species List for the Karoo Region (Becker, Schoeman & Blom 1992). According to these publications, the studied species are divided into six categories. The subjectively estimated grazing index values for these species can be obtained in Appendix 1.

3.5.1 The early successional grasses

According to Blom (1981, 1984), Vorster (1982) and Becker *et al*. (1992), these are the annual pioneer grasses and they belong to the Increaser IIc category. These authors accorded an index value of 1 to these species. These species are dominant in veld which is in an ecologically poor condition.

Aristida congesta.

These grasses are often common colonizers of bare areas and becomes abundant following periods of high rainfall, preceded by a period of drought. On the whole these grasses are troublesome in that the awns of the inflorescences accumulate around the eyes, mouths and on the bellies of sheep. This condition interferes with the grazing behaviour of the sheep and causes the sheep to lose condition (Du Toit 1994).

3.5.2 The mid-successional grasses

According to Blom (1981, 1984), Vorster (1982) and Becker *et al*. (1992), these are the subclimax grasses and they belong to the Increaser IIa category. These authors accorded these species an index value of 7. These species tend to increase during the veld degradation process when the decreaser species are overgrazed and becomes less vigorous.

Aristida diffusa,
Eragrostis lehmanniana and
Merxmuellera disticha.

3.5.3 The late-successional grasses

According to Blom (1981, 1984), Vorster (1982) and Becker et al. (1992), these are the climax grasses and they belong to the decreaser species category. These authors accorded an index value of 10 to these species. These species are abundant in veld which is in an ecologically sound condition. Whenever these grasses are available in sufficient numbers and growing vigorously, they provide the bulk for grazing and are regarded as nutritive forage.

Digitaria eriantha,
Eragrostis curvula var conferta,
Fingerhuthia africana,
Heteropogon contortus,
Hyparrhenia hirta,
Sporobolus fimbriatus,
Stipagrostis ciliata,
Stipagrostis obtusa and
Themeda triandra.

3.5.4 The palatable karoo bushes

According to Blom (1981, 1984), Vorster (1982) and Becker et al. (1992), these karoo bushes belong to the Increaser IIa species category. These authors accorded an index value of 7 to these species. These species occur co-dominantly with mid-successional grasses and are indicative of veld where degradation of the decreaser species component has started to take place. Where these karoo bushes are abundant they provide nutritive forage and depending on the condition of the veld, they provide the bulk of grazing. They are however, prone to selective overgrazing by sheep.

Felicia fascicularis,
Felicia filifolia,
Felicia macrorrhysa,
Helichrysum dregeanum,
Hermannia desertorum,
Monechma incanum,
Nenax microphylla,
Osteospermum microphyllum,
Osteospermum spinescens,
Phymaspermum parvifolium,
Plinthus cryptocarpus,
Plinthus karooicus,
Salsola calluna,
Salsola rabieana,
Salsola tuberculata,
Walafrida geniculata and
Zygophyllum lichtensteinianum.

3.5.5 The less palatable karoo bushes

According to Blom (1981, 1984), Vorster (1982) and Becker et al. (1992), these karoo bushes belong to the Increaser IIb species category. These authors accorded an index value of 4 to these species. These species usually occur co-dominantly with the early successional grasses (the perennial pioneer grasses of Blom (1981)) and dominates veld where the degradation process has already depleted the mid-successional grasses and the palatable karoo bushes. Both the bulk and nutritive quality of these karoo bushes are lower than that of the palatable karoo bushes.

Eriocephalus ericoides,
Eriocephalus spinescens,
Galenia secunda,
Helichrysum lucilioides,
Pentzia incana,
Pentzia globosa,
Pentzia spinescens,
Pteronia adenocarpa,
Pteronia glauca,
Pteronia staehelinoides and
Zygophyllum microphyllum.

3.5.6 The unpalatable karoo bushes

According to Blom (1981, 1984), Vorster (1982) and Becker *et al*. (1992), these karoo bushes belong to the Increaser IIc species category and together with the annual pioneer grasses (Blom 1981), they dominate veld which is in an ecologically poor condition. These authors accorded an index value of 1 to these species. Veld dominated by these species may cause metabolic disorders in grazing sheep, because of the one-sided diet taken in by sheep and/or the resinous nature of these karoo bushes, this condition is usually aggravated by the presence of the awns of *Aristida congesta* which occurs simultaneously and hampers grazing.

Chrysocoma ciliata,
Eberlanzia ferox,
Pteronia glomerata,
Pterothrix spinescens,
Rosenia humilis,
Rosenia oppositifolia and
Walafrida saxatilis.

3.6 Taxonomic treatment of scientific names in this thesis

Nomenclature of scientific names in this thesis follows Gibbs Russell, Reid, van Rooy & Smook (1985); Gibbs Russell, Welman, Retief, Immelman, Germishuisen, Pienaar, van Wyk, & Nicholas, (1987) and Gibbs Russell, Watson, Koekemoer, Smook, Barker, Anderson, & Dallwitz, (1990). This course of action has been decided upon, since three papers based on this thesis have already been submitted for publication and some major name changes have been reported in Arnold & De Wet (1993) since the preparation and acceptance of these papers for publication.

CHAPTER 4

DESCRIPTIONS OF THE STUDY AREAS

4.1 The Eastern Mixed Karoo

The plant species of the Eastern Mixed Karoo (Anonymous 1981; Botha pers. comm.[4]) were studied on the farm Grootfontein, in the Middelburg District at 31° 28' S and 25° 02' E (on Figure 4.1, the study sites are indicated by numbers 1 to 4, corresponding to the section headings).

The Eastern Mixed Karoo covers the north-eastern portion of the Karoo Region (Figure 4.1, no. 1) and comprises approximately 1,7 ha[6], which constitutes around 5 % of the area of the region. The area lies at an elevation of between 1 100 and 1 500 m (Botha, pers. comm. [4] and present study).

Parent rock of the soils include dolerite, sandstone and mudstone. Duplex soils are common in the eastern areas (Botha & Becker 1995).

Precipitation, falling primarily in the spring and summer months, varies from 275 mm in the west to 500 mm in the east. The spring rainfall decreases from east to west, where the main rains fall during the autumn months (Anonymous 1993).

The dominant Veld Types are the False Upper Karoo and the Dry Cymbopogon-Themeda Veld (Acocks 1988). The vegetation consists primarily of the late successional stage grasses e.g. Cymbopogon plurinodis, Digitaria eriantha, Sporobolus fimbriatus and Themeda triandra (Appendix 9, Table 1). On moving towards the west these grasses are replaced by mid-successional stage grasses, Aristida diffusa, Eragrostis curvula, E. lehmanniana and E. obtusa. Further to the west the grass component changes completely to the desert grass types, Stipagrostis ciliata and S. obtusa in the sandier parts. The karoo bush com-

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4. Botha, W. Van D., Grootfontein Agricultural Development Institute, Private Bag X 529, Middelburg. 5900. Eastern Cape Province.

Figure 4.1 The reasonably homogeneous agro-ecological areas into which the Karoo Region was divided. The borders of the region reflect the position as it was prior to the setting of the new provincial boundaries of 1994 ponent also becomes more important from east to west. The karoo bush component consists primarily of Eriocephalus ericoides, E. spinescens, Pentzia incana, Pteronia glauca, P. tricephala and Rosenia humilis. The more palatable species i.e. Felicia muricata, Plinthus karooicus, Sutera atropurpurea and S. pinnatifida are relatively scarce and make a limited contribution to the karoo bush component. Under mismanagement the vegetation degrades to Chrysocoma ciliata, while the annual, early succession Aristida adscensionis and A. congesta become more abundant (according to Acocks 1988, Botha & Becker 1995 and present observations).

The topography is relatively flat with plains veld and ridge veld dominant. The landscape is crisscrossed by dolerite ridges. Shale, sandstone and mudstone ridges are found less often. Characteristic of the ridges is the general occurrence of Rhus ciliata (Botha & Becker 1995).

The main stock farming enterprises are wooled sheep (Merino sheep and others) and cattle, while Angora goats and Dorper sheep are less important (Botha & Becker 1995).

4.2 The Karoo Mountainous Areas

The species of the Karoo Mountainous Areas, were studied on the farm Vrede, at 31° 17' S and 24° 55' E, on Carlton Heights, in the Middelburg District (Figure 4.1, no. 2).

The Karoo Mountainous Areas form part of the Great Escarp and is an offshoot of the Drakensberg Mountain range. The Eastern Karoo Mountain area comprises about 3 % of the Karoo region. The main mountain ranges making up this area are the Sneeuberg-, the Renoster-, the Kikvors-, the Suurberg- and the Stormberg mountains (Botha, pers. comm.[5] and present study).

The area is mountainous and consists mainly of steep slopes, plateaux and a

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5. Botha, W. Van D., Grootfontein Agricultural Development Institute, Private Bag X 529, Middelburg. 5900. Eastern Cape Province.

few ridges on the foothills. The area occurs at an elevation of approximately 1 500 m (Botha & Becker 1995).

The soils are mainly derived from dolerite, sandstone and mudstones, with Clarens sandstone and basalt occurring more to the east of the area (Botha & Becker 1995).

The dominant veldtype is the Karroid Merxmuellera Mountainveld (Acocks 1988).

The main rainy season is in spring and summer. Snow is common during winter. Precipitation varies from 350 mm in the west to approximately 550 mm in the east (Anonymous 1993).

The vegetation consists mainly of sour grasses with shrubby encroachment of Elytropappus rhinocerotis and Euryops species. Merxmuellera disticha is dominant in the drier areas. The sweeter grass component consists of Cymbopogon plurinodis, Digitaria eriantha, Sporobolus fimbriatus and Themeda triandra (Appendix 9, Table 2). Characteristic is the more palatable vegetation on the doleritic soils. The occurrence of Tetrachne dregei points to veld in a good condition (Roux 1968). Shrubby species are mainly Elytropappus rhicocerotis and Rhus erosa species which indicate veld retrogression. With over-grazing and mismanagement this veld degrades to a mid-successional stage grass and karoo bush veld where Chrysocoma ciliata and Walafrida saxatilis are dominant species (according to Acocks 1988, Botha & Becker 1995 and present observations).

The main stock farming ventures are woolled sheep (Merino) and cattle with Angora goats and Dorper sheep occupying a relatively minor position (Botha & Becker 1995).

4.3 The Arid Karoo

The species of the Arid Karoo, were studied on the farms Klerefontein at 30° 58' S and 21° 58' E, Biesieslaagte at 31° 01' S and 21° 54'E and Rondefontein at 31° 01' S and 22° 02' E of the Carnarvon Research Station, in the Carnarvon District (Figure 4.1, no. 3).

The Arid Karoo occurs inland of the Great Escarp, at an elevation of between 1 000 and 1 300 m. The area comprises approximately 10 % of the Karoo region (Botha, pers. comm.[6] and present study).

Precipitation occurs mainly in the form of autumn rains and varies from 125 mm to 250 mm (Anonymous 1993).

The dominant veld types are the Arid Karoo and False Desert Grassveld and the False Arid Karoo (Acocks 1988).

Soils are derived from shales and dolerites. Vegetation on the doleritic soils consists mainly of grass species. Characteristic of the northern part of the area is the high pH of the soils (adapted from Botha & Becker 1995).

The vegetation consists mainly of karoo bushes, shrubs, grasses and succulents. The dominant karoo bushes are Eriocephalus ericoides, E. spinescens, Pentzia spinescens, Pteronia adenocarpa, P. glauca, P. glomerata, Rosenia glandulosa, R. humilis, Zygophyllum microphyllum and other less palatable species (Appendix 9, Table 3). The palatable component consisting of Felicia muricata, Monechma incanum, Plinthus karooicus and Salsola tuberculata make up a minor part of the karoo bush component. Shrubs, mainly Lycium cinerium and Osteospermum spinescens are restricted to deeper soils, while Rhigozum obovatum occurs on the stony ground. Rhigozum trichotomum occurs in dense stands on northfacing slopes. The grasses are mainly Stipagrostis species and many annual, early succession species. There are sharp divisions between the doleritic, shale and red sandy soils (kalahari sands). The grasses on the doleritic soils include Aristida diffusa and Heteropogon contortus, while Fingerhuthia africana, Eragrostis nindensis and Stipagrostis obtusa are found on the shale derived soils. The kalahari sands support relatively dense stands

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6. Botha, W. Van D., Grootfontein Agricultural Development Institute, Private Bag X 529, Middelburg. 5900. Eastern Cape Province.

of grass, mainly *Eragrostis lehmanniana*, *Stipagrostis ciliata* and *S. obtusa*. *S namaquensis* occurs frequently along the watercourses (according to Acocks 1988, Botha & Becker 1995 and present observations).

The area is relatively flat, with plainsveld and ridges dominating the topography. Dolerite hills and some mountains break the flat topography (Botha & Becker 1995).

In this area stock farming concentrates on small stock breeds, of which the Afrino-, Merino- and Dorper sheep are the most important. Angora goat farming is practiced on a limited scale (Botha & Becker 1995).

4.4 The Great Karoo

The species of the Great Karoo, were studied on the farm Rooikop, at 32° 41' S and 22° 50' E, in the Beaufort West District (Figure 4.1, no. 4).

The Great Karoo is situated between the Great Escarp to the north and the Swartberg mountain range to the south. The western boundary is the winter rainfall area, while to the east it is bounded by the shrubveld of the Noorsveld (*Euphorbia coerulescens*) and the Succulent Mountain Scrub (*Portulacaria afra*, Spekboomveld) (Acocks 1988). The area comprises some 1,7 ha^{6} (Botha, pers. comm.[7] and present study).

The topography is generally relatively flat to undulating with some mountains and high hills. Most of the soils are derived from shale and sandstone. The area occurs at an altitude of from 700 to 900 m (Botha & Becker 1995).

Precipitation comes mainly during the autumn, with winter rain occurring only exceptionally. Precipitation varies from 125 mm to 200 mm (Anonymous 1993).

The dominant veld type is the Karroid Brokenveld (Acocks 1988). The vegeta-

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7. Botha, W. Van D., Grootfontein Agricultural Development Institute, Private Bag X 529, Middelburg. 5900. Eastern Cape Province.

tion is rather sparse and consists of karoo bushes, shrubs, succulents and desert grasses in the sandy areas. The grass component is rather limited and most of the vegetation consists of karoo bushes and shrubs. Acacia karroo is a characteristic tree along the watercourses (adapted from Acocks 1988).

The dominant shrubby plants are Lycium cinerium in the watercourse areas and Rhigozum obovatum on the sandstone ridges. Karoo bushes are Eriocephalus ericoides, E. spinescens, Felicia fascicularis, Nenax microphylla, Pentzia spinescens, Pteronia glomerata, P. staehelinoides, Salsola rabieana and S. tuberculata (Appendix 9, Table 4). The more palatable species comprise only a minor part of the vegetation. Succulent bushes comprise Aridaria noctiflora, Delosperma multiflora, Drosanthemum hispidum, D. lique and Eberlanzia ferox. The grasses mainly consist of Stipagrostis species, mainly S. obtusa and other annual early succession grass species in the sandy areas. Along watercourses S. namaquensis and in suitable doleritic habitats Cenchrus ciliaris and other late succession grasses are found. Aristida diffusa and Fingerhuthia africana are fairly common on the sandstone ridges where they are well protected from grazing (according to Acocks 1988, Botha & Becker 1995 and present observations).

The stockfarming is practiced with Merino sheep, Dorper sheep and Angora goats as the main breeds (Botha & Becker 1995).

CHAPTER 5

RESULTS : RELATIONS BETWEEN VARIOUS PLANT VARIABLES

Various plant variables were studied in an effort to gain an insight into the production of available forage during the different seasons of the year and to explain the differences in plant quality, as expressed by the chemical content during the different seasons. It is known that this plays a role in the forage value of the plants and the acceptability of the plants to the grazing animals, during the different seasons. It was the intention to include these variations in plant quality into the objectively estimated grazing index value.

5.1 The Eastern Mixed Karoo

5.1.1 Available forage

Refer to Appendix 3 for Tables 1 - 15, detailing the canopy spread cover, mean available forage, chemical analyses and climatic variables.

5.1.2 Available forage and canopy spread cover

The relation between available forage and canopy spread cover, for all values from 1990 to 1993, can be seen in Figure 5.1. The coefficient of determination, $r^2 = 0.6247$ with $Y = 3.2917 + 0.0623X$ and the standard error of the Y estimate = 12.2611. The slope of the regression relation is not in a 1 : 1 ratio, it is much flatter. This means that as the plants increase in size, there is not the expected corresponding increase in available forage. If it is then borne in mind that the available forage was over-estimated by about 25 % (section 6.3.2), the regression relation should have a much flatter slope still. The individual values for the three years are as follows: 1990/91, $r^2 = 0.5514$, $Y = 6.4982 + 0.0580X$ with the standard error of the Y estimate = 15.9017; 1991/92, $r^2 = 0.6157$, $Y = 0.4971 + 0.0702X$ with the standard

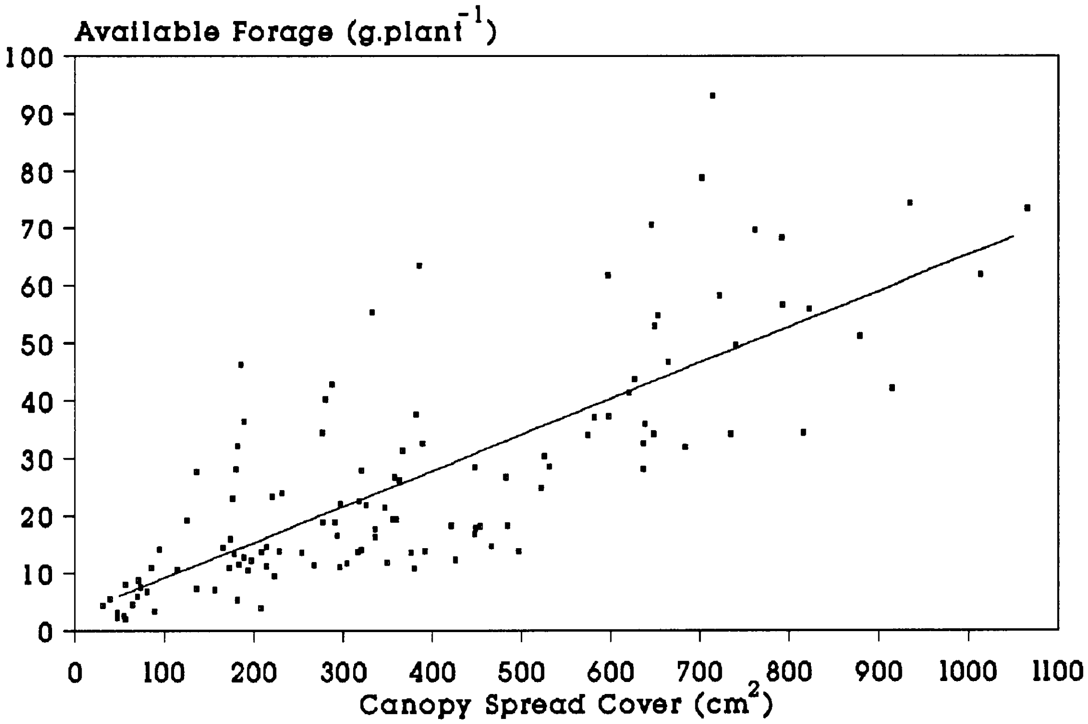

Figure 5.1 The relation between available forage and canopy spread cover

error of the Y estimate = 12.0890; 1992/93, r^2 = 0.6526, Y = 4.8802 + 0.0563X with the standard error of the Y estimate = 9.5903. The coefficient estimates are highly variable, varying from -7 to 16. The lowest F-ratio is associated with the regression with the largest variability i.e. F = 41.8 and the variability ranges from -3 to 16 during 1990/91. The second lowest F-ratio is associated with the regression with the second largest variability i.e. F = 57.7 and the variability ranges from -7 to 8 during 1991/92. The largest F-ratio is associated with the regression with the lowest variability i.e. F = 71.4 and the variability ranges from 0 to 10 during 1992/93. All the F-ratios are highly significant (Statistical Graphics Corporation 1991). The F-values indicate that the slopes of the linear regressions for the different periods are significantly different (Van Ark 1995). From this it would seem that there is considerable variation in the available mass recovered from a plant with a certain canopy spread cover. It can be stated unequivocally that cover on its own does not provide a reliable estimate of available forage, in contrast to the finding of Mueller-Dombois & Ellenberg (1974). Uresk (1990) proposed that frequency and canopy spread cover be multiplied to provide an index value of available forage. This index value will probably represent a reliable indication of available forage.

The relation between canopy spread cover and frequency (the number of hits) recorded during botanical surveys, however, resulted in low r^2-values (Appendix 8). Regressions of the number of hits recorded during linepoint surveys (frequency) versus cover (area in cm^2 covered per plant) and available forage (g per plant) rendered r^2-values of 0.0709 and 0.0115. Indeed, Mueller-Dombois & Ellenberg (1974) referred to the poor correlation between cover and frequency.

5.1.3 Timing of botanical surveys in order to estimate grazing capacity

When the different regressions of available forage on canopy spread cover are studied for the different survey times (all available data points), the results are slightly different to that reported above.

During commencement of growth (September to November) the r^2 = 0.5919, Y = 7.3515 + 0.0497X and the standard error of the Y estimate = 11.1623. The F-ratio is 36.26 (Statistical Graphics Corporation 1991). During active growth (December to March) the r^2 = 0.4613, Y = 7.0655 + 0.0431X and the standard error of the Y estimate = 10.3724. The F-ratio is 22.12. During reserve storage (March to May) the r^2 = 0.7886, Y = 0.3880 + 0.0751X and the standard error of the Y estimate = 11.2893. The F-ratio is 100.75. During dormancy (July to August) the r^2 = 0.4777, Y = 4.7859 + 0.0627X and the standard error of the Y estimate = 15.5842. The F-ratio is 24.69. The F-values indicate that the slopes of the linear regressions for the different periods are significantly different (Van Ark 1995).

For the grasses and karoo bushes individually, the same condition is found, except that for the karoo bushes there are two periods when available forage is well-correlated with canopy spread cover. The relation between canopy spread cover and available forage in the case of the grasses in May has a r^2 = 0.9061, while in the case of the karoo bushes in May the r^2 = 0.8590 and in November the r^2 = 0.7941 (refer to Appendix 3). During the other periods, in the case of both the grasses and the karoo bushes, a r^2-value of between 0.50 en 0.65 is calculated.

These data, the high r^2 = 0.7886 and the high F-ratio = 100.75 during May, indicates that the best correlation between canopy spread cover and available forage exists during the early reserve storage period i.e. in autumn (March, April and May).

From the data presented above it is concluded that, if it is the intention to establish the relations between canopy spread cover, available forage and frequency, the best time to carry out botanical surveys in the Eastern Mixed Karoo, is during the reserve storage period (March to May). In the event that the relations between canopy spread cover, available forage production and frequency can be established, it may just be possible to refute the claims made by Mueller-Dombois & Ellenberg (1974) i.e., that cover is poorly correlated to frequency.

5.1.4 Canopy spread cover and available forage

During the 1992/93 season the mean size and available forage per plant in May was 307.5 cm^2 and 22.7 g respectively, in August 356.4 cm^2 and 25.3 g, in November 302.7 cm^2 and 21.8 g and in January 270.2 cm^2 and 18.3 g (Appendix 3, Tables 1 & 2), while the sum of the preceding twelve month's rainfall was respectively 428.1 mm, 407.2 mm, 302.5 mm and 215.8 mm.

The mean available forage of karoo bushes is on average a few grammes higher than that of the grass tufts for the same canopy spread cover (Appendix 3), this possibly indicates that the interpretation of the canopy spread cover in the case of the grass tuft _per se_ is interpreted too loosely. The canopy spread cover should include only the perpendicular projection of the culms above the base of the grass tuft, where living rooted material is anchored. If however, it is borne in mind that the separation procedure over-estimates the available forage production of the karoo bushes by about 25 % (Du Toit 1993a), it becomes clear that the karoo bushes produce less available, grazable forage than the grasses, per unit area. The mean area covered by the grasses was on average less than half that covered by the karoo bushes. This then means that the production potential of grazable grass forage per unit area, is approximately twice as high as the potential grazable forage produced by the karoo bushes.

5.1.5 Chemical composition and quality of the dry matter

Total digestible nutrients, nitrogen and fibre

The total digestible nutrients (TDN)(Appendix 3, Table 4) of the forage was calculated using the results of nitrogen and acid detergent fibre determinations. In the formula used to calculate TDN, the crude fibre determinations are replaced by acid detergent fibre determinations (Du Toit 1991; Appendix 2). Nitrogen and acid detergent fibre values are supplied in Appendix 3, Tables 5 & 6. The total digestible nutrients are therefore calculated according to the formula:

TDN = 75.1 + ((6.25 x log % N) - (0.75 x (- 4.32 + (0.92 x % acid detergent fibre)))).

This formula is composed of the formulae developed by:

i Glover and Duthie (1960) and Bredon & Meaker (undated, cited by Bartholomew 1985) where : **TDN = 75.1 + ((6.25 x log % crude protein) - (0.75 x % crude fibre))** and

ii Du Toit (1991) where : **Crude fibre = - 4.32 + 0.92 x % acid detergent fibre** (refer to Appendix 2).

From the TDN calculations it is clear that with high rainfall the mean TDN content of the forage is relatively low, due to the low crude fibre and crude protein contents of the plants at these times. During May of the three seasons, the TDN percentage of the forage is respectively 48.43, 48.06 and 43.94. During the 1990/91 season the TDN percentage in May was 48.43 %, in August it was 48.25 %, in November it was 50.94 % and in January it was 51.87 %. The corresponding rainfall for the twelve preceding months was 341.2 mm, 344 mm, 314.3 mm and 234.7 mm. This decline in the TDN percentage agrees closely with the findings of Angell, Miller & Haferkamp (1990). They found a close relation between the values of crude protein and TDN and that crude protein values consistently declined as the season advanced from summer to winter, this therefore implies that the same conditions also apply to TDN.

At rainfall recorded around the long term mean (for Grootfontein = 350 mm), the TDN percentage of karoo bushes vary from 42 % to 57 %, while that of the grasses vary from 46 % to 50 %. It is clear that the TDN percentage of grasses varies in a much narrower band than does that of the karoo bushes. The lower the recorded rainfall, the higher the variation in the TDN percentage of the forage. In this case the TDN percentage varies from 48 % to 56 % in the case of the grasses, while in the case of the karoo bushes it varies from 45 % to 66 %. This has a direct bearing on the animal type farmed with in a specific area i.e. bulk grazers or rough grass grazers such as cattle in the tall grassveld areas and a concentrate or fine grass and selective grazer such as sheep in the karoo bush and short grass areas (cf. Van Rooyen, Grunow & Theron 1988). Cattle with their larger rumen and larger intake of dry matter, with a lower TDN content, can utilize the roughages of lower quality better than can sheep with their relatively small rumen and low dry matter intake. Sheep need roughages of higher quality i.e. higher TDN content to satisfy their requirements for growth and production.

Macronutrients (K, Ca, Mg, Na and P)

The results of the chemical analyses are presented in Appendix 3, Tables 7 - 11. The various elements are discussed in respect of two common ratios and the role they play in ruminant feeding.

The potassium ÷ (calcium + magnesium) ratio (Kemp & T'Hart 1957) is presented in Appendix 3, Table 12. According to Kemp & T'Hart (1957) and Kidambi, Matches & Griggs (1989), the ratio must be of the order of 1.8 to 2.2 to ensure the adequate feeding of dairy cows, otherwise there is a real threat of tetany. From Appendix 3, Table 12 it is clear that the ratio of especially Eriocephalus ericoides, a less palatable karoo bush, is unacceptably high, while Stipagrostis ciliata and S. obtusa, two late successional grasses and previously having high index values, have unacceptably low ratios. Some species which exhibit unfavourably high ratios at times are for example Themeda triandra, Phymaspermum parvifolium and Walafrida geniculata. Chrysocoma ciliata and Pterothrix spinescens, regarded as unpalatable and poor forage, at times exhibit unfavourably low or high ratios.

According to Du Toit, Louw & Malan (1940) growing sheep needs approximately 0.16 % calcium and 0.14 % phosphorus in their diet, while Louw (1969) recommends that the diet must contain between 0.2 % to 0.5 % calcium and 0.2 % to 0.46 % phosphorus, which is in close agreement with figures quoted by Woods (1959). The calcium : phosphorus ratio must therefore be in the region of 1.0 for normal growth and development. The calcium : phosphorus ratio is presented in Appendix 3, Table 13. The deductions that can be made from this table are that the calcium level is too low in some respects while the phosphorus level is always too low, for normal growth and development.

Values of these macronutrients are included in the formulae for the objective estimation of the grazing index values. It is surmised that low or high values and unacceptable ratios will have detrimental effects on animal production (Van Hoven & Ebedes 1988). Low values may lead to serious deficiencies in animal feeding (Woods 1959). These unfavourable values will eventually exert unfavourable influences on the agronomic grazing index value estimated for the plant species.

5.2 The Karoo Mountainous Areas

5.2.1 Available forage

Refer to Appendix 4 for a detailed exposition of the canopy spread cover, mean available forage and chemical analyses of the species. The relation between available forage and canopy spread cover can be referred to in Appendix 4. Generally very low r^2 values are calculated for the relation between canopy spread cover and available forage in the case of the grasses. The r^2 values range from 0.000009 in July to 0.0849 in November.

In the case of the karoo bushes, much higher r^2 values are calculated. These r^2 values range from 0.5402 in April to 0.8573 in July. The highest value was calculated during the dormant season. Whereas in the Eastern Mixed Karoo the best relation between canopy spread cover and available forage production exists in autumn, while in the Karoo Mountain Areas it seems as though the best relation is in winter (July).

5.2.2 Timing of botanical surveys

The exposition above poses a problem, in that it is difficult to recommend a time in which to do botanical surveys where the objective is the estimation of grazing capacities. The Karoo Mountain Areas are Merxmuellera disticha dominated veld. From the r^2 values it seems that the best time to carry out botanical surveys, in this predominantly grassveld area, will be during the initial growth stage (September to November). However, if the fact is taken into consideration that the relation between canopy spread cover and available forage is so low in the case of the grasses, the recommendation can be made that to suit the karoo bushes, the botanical surveys can be carried out during the end of autumn (March to May).

5.2.3 Chemical composition and quality of the dry matter

The chemical analyses are presented in Appendix 4, Tables 3 - 13. The nitrogen content increases according to the classical growth curve pattern of the karoo bushes. The nitrogen content is low during the dormant period and relatively high during the active growth stages (Angell *et al*. 1990). The converse is true for the acid detergent fibre.

Total digestible nutrients, nitrogen and fibre

The total digestible nutrients were calculated according to the formula presented in Section 5.1.5. Unfortunately there is no weather station in the vicinity of the site where the plant species were studied, so that it is impossible to relate the TDN percentages at various times to the climatic variables. There is, however, no reason to believe that it will react differently to that described for the Eastern Mixed Karoo. The two study sites are approximately 30 km apart and it is believed that although the total rainfall may vary quite considerably, the trend in chemical composition in relation to rainfall will be similar.

The mean TDN content of the plants are fairly high (49.31 %), in November during the initial growth stage and then levels off to 47.87 % and 47.98 % during the active growth stage and onset of reserve storage in January and April/May respectively. In July during the dormant period the TDN % is lower, at 46.60 %. Generally the TDN percentage in the Karoo Mountain Areas follows the trend as seen in the Eastern Mixed Karoo, except that the mean TDN values may be slightly lower.

5.3 The Arid Karoo

5.3.1 Available forage

Refer to Appendix 5 for a detailed exposition of the canopy spread cover, mean available forage, chemical analyses and botanical surveys of the species of the Arid Karoo. The relation between available forage and canopy spread cover is indicated in Appendix 5. The r^2 values range from 0.4288 to 0.5322 for the karoo bushes and from 0.5110 to 0.8950 for the grasses. In both instances the highest r^2 values are calculated during the active growth stage, i.e. in October. This is not contrary to the expected high r^2 values during the reserve storage period as experienced in the Eastern Mixed Karoo. The reason for this phenomenon is that the main rainy season expected for the Arid Karoo is during autumn. Therefore the vegetation reacts to the growing season almost in reverse of the normal expectations. The high r^2 values calculated for the grasses is due to the more defined nature of the canopy of the grass tuft, and the species studied. The leafblades of the grass species of the Arid Karoo are not as spreading, as was found with the leafblades of the species studied in the Karoo Mountain Areas.

The high r^2 values calculated for October indicate that the relation between canopy spread cover and available forage production is relatively stable, despite this being the active growth stage during normal seasons. This points to the desirability of carrying out botanical surveys for the purpose of estimating grazing capacity in the Arid Karoo during October.

5.3.2 Chemical composition and quality of dry matter

Total digestible nutrients, nitrogen and fibre

The chemical analyses are presented in Appendix 5, Tables 3 - 13. The nitrogen content follows the classical growth curve pattern of the karoo bushes. The nitrogen content is low during the dormant period and high during the active growth stage (Angell et al. 1990). The acid detergent fibre is just the converse.

The total digestible nutrients were calculated according to the formula presented in Section 5.1.5.

The mean TDN content of the plants are fairly high in January, April and July, 49.63 %, 50.80 % and 49.87 % respectively. In October the mean TDN content is 47.80. This is still fairly high, but points to the fact that October is closer to a dormant period physiologically than to a commencement of the growth period. January can be regarded as a late commencement of the growth period.

Taking the above data into account, there seems to be a close relation between canopy spread cover, available forage and forage quality.

5.4 The Great Karoo

5.4.1 Available forage

Refer to Appendix 6 for an exposition of the canopy spread cover, mean available forage, chemical analyses and botanical survey of the species of the Great Karoo.

The relation between available forage and canopy spread cover can be referred to in Appendix 6. The r^2 values range from 0.4665 to 0.7819 for the karoo bushes and from 0.4201 to 0.8161 for the grasses. In both instances the highest r^2 values are calculated in early autumn during the reserve storage period. From these data it is clear that the best correlation between canopy spread cover and available forage exists during autumn. The conclusion is reached that the best time to carry out botanical surveys for the purposes of estimating grazing capacity is during the autumn months.

5.4.2 Chemical composition and quality of dry matter

The chemical analyses are presented in Appendix 6, Tables 3 - 12. The nitrogen content and percentage acid detergent fibre follow the classical growth curve pattern of the karoo bushes. The nitrogen content is low during the dormant periods and high during the active growth stages (Angell et al. 1990), the acid detergent fibre is just the converse.

The total digestible nutrients were calculated according to the formula presented in Section 5.1.5.

The mean TDN content of the plants are fairly variable. It is high during commencement of growth and again during the reserve storage period, 47.70 % and 47.26 % respectively. During winter the TDN content drops to 46.45 %, but is unexpectedly low during the active growth stage, 45.71 %. The low recorded values are most probably attributable to the prevailing drought conditions.

5.4.3 Botanical surveys conducted in the Great Karoo and use of the grazing index values

In Appendix 6, Tables 13 & 14 the results of the botanical surveys conducted with a 10 m^2 quadrat are presented. The number of plants per quadrat were counted and means determined per species for the results of three to five surveys per site. The species index values are inserted according to two scales. The subjective value was estimated according to the following parameters; production, ease with which the species can be grazed, perenniality, forage value during the summer, forage value during the winter and protection against soil erosion. The 10, 7, 4 and 1 scale is used as it was originally used in the Ecological Index Method. It is obvious that there are fairly large differences in the calculated current grazing capacities between the different types of veld with the use of the two different index value scales.

CHAPTER 6

THE DIFFERENCE BETWEEN GRAZABLE AND UNGRAZABLE FORAGE

When separating the harvested material, it was separated into two fractions, on the basis of a rule of thumb that assumes that stems thicker than 2 mm are not grazed (Botha 1981). All the stems with a diameter thicker than 2 mm, were then supposedly regarded as ungrazable. Those parts with a diameter of 2 mm and thinner were regarded as grazable and were therefore regarded as contributing to the available grazable forage (Botha 1981; Vorster & Blom 1982a; Du Toit 1993a). In order to test this hypothesis, a trial was undertaken in an established stocking rate trial, at Carnarvon, where differentially grazed stems were available for measurement in the different stocking rate treatments.

6.1 The 2 mm hypothesis

As mentioned earlier, by definition all the material thicker than 2 mm is regarded as non-grazable (Botha 1981). In order to test this definition, a field trial was undertaken on the farm Biesieslaagte (31° 01'S, 21° 54'E), at the Carnarvon Research Station, situated in the Arid Karoo (Acocks 1988). Two less palatable karoo bush species (Blom 1981) were selected for monitoring, they were Pentzia spinescens and Rosenia humilis. The less palatable species, Eriocephalus ericoides was also considered for measurement, but for the most part was excluded, due to it's uneven distribution over the study area.

6.1.1 Stocking rate trial

The species were selected in an established stocking rate trial, where Afrino sheep (a hardy sheep cross consisting of 50 % Mutton Merino, 25 % Merino and 25 % Roundribbed Afrikaner, an indigenous sheep breed) graze the veld at four stocking rates. The trial was initially laid out to determine the optimum stocking rate for this area. The applied stocking rates were 26.4 ha.Large Stock Unit^{-1} , 36.3 ha.LSU^{-1}, 46.2 ha.LSU^{-1} and

52.8 ha.LSU^{-1}. One LSU was taken to represent 6.6 sheep and the small stock unit (SSU) in this case would be a six tooth Afrino wether with a mass of 50 kg (LSU[8]). Areas allocated to the different stocking rate treatments were 54 ha, 72 ha, 90 ha and 108 ha. Each of these areas were subdivided into 3 equal sized paddocks. In each year two paddocks per treatment were rotationally grazed by 10 sheep, with a period of stay of three months. The third paddock was rested from grazing for a full year. Due to the large area involved in the trial (324 ha), the trial was not replicated, however, the applied stocking rates remained the same from one year to the next. Of necessity therefore, statistical treatment of the data had to be in the form of regression analyses, following Jones & Sandland (1974) and Edwards (1980, 1981) for the gain.ha^{-1} calculations.

Three considerations support the decision to work only with the less palatable species group.

1. The less palatable species group accounts for more than 70 % of the floristic composition of the veld and contributes the major portion of the available forage. This group was therefore considered the most suitable to monitor.

2. Preliminary investigations indicated that unpalatable species are seldom grazed and it is therefore unlikely that they will respond to stocking rate manipulations.

3. It was observed that the diameter of grazed stems of the palatable species, Limeum aethiopicum and Salsola calluna regularly exceeded 5 mm, regardless of stocking rate. This can partly be ascribed to the relative palatability of these species on the one hand and

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8. A LSU is the equivalent of a steer with a mass of 450 kg and mass gain of 500 g.day^{-1} on grass pasture with a mean digestible energy concentration of 55 %. To maintain this, 75 MJ metabolizable energy.day^{-1} is required (Meissner 1982).

partly to their low abundance on the other. The low abundances recorded for these species probably indicate overgrazing at some stage in the past, probably during the trekboer system of grazing management (Acocks 1988). They are therefore considered not to be suitable for monitoring.

6.1.2 Data collection

Twenty five plants per species were randomly selected in an arc, between 100 m and 200 m away from the watering point, in the most recently grazed paddock of each stocking rate. Closer to the watering point, all karoo bushes are fairly severely grazed, after the animals have just drunk water. Further away, it is more time consuming to find recently grazed stems to measure, due to the habit of the animals to nibble here and there, while walking. Karoo bushes that were obviously grazed quite recently, were selected for measurement.

The discolouration of the wounds, left at the apex of the stems after grazing, enabled the distinction to be made between "old" grazed-off stems and recently grazed stems. Old stem wounds were greyish, while recent wounds had a strawcoloured to light-greenish tint. Stems that had a strawcoloured apical stem wound, were selected for measurement and the measurement was taken at the point where the stem was browsed off. Owing to the variable palatability of different plants of the same species, a maximum of four readings were taken per plant in order not to introduce bias. Recently browsed stems were selected at random on a specific plant. The readings were taken with sliding Vernier callipers. In laterally compressed stems, the mean of the widest and narrowest measurements was used, in order to provide a single measurement for that stem.

The trial period ran from the 1990/91 season to the 1992/93 season, with measurements being taken during February of each year. This date corresponds to the peak growth activity calculated for this area using climatic variables (Du Toit 1990). At low stocking rates fairly thin stems are grazed off. With an increase in stocking rate, thicker stems are grazed. At high stocking rates during favourable rainfall seasons, the abundance of available forage influences the thickness of the stems being grazed. The diameter of the grazed-off stems at the higher stocking rates reaches a maximum and remains constant.

With these data it should be possible to calculate an optimum stocking rate from the stocking rate : grazed stem relation. It was reasoned that, with growth at its optimum and with young, succulent stems, the defoliation : stocking rate relation of the karoo bushes would be described by a quadratic curve. The measured diameter of grazed stems at the different stocking rates was therefore regressed on stocking rate in a quadratic regression. This relation, in the form of the quadratic curve, can then be used to calculate the optimum stocking rate, at which the veld should be grazed in this area. The asymptote of the curve represents the stocking rate at which the diameter of the grazed-off stems reaches a maximum, this stocking rate represents the optimum stocking rate (Jones & Sandland 1974; Edwards 1980, 1981).

6.2 Results

Mean diameters of grazed stems for Pentzia spp. over all seasons were 1.14 mm for the lightest and 1.68 mm for the heaviest stocking rate (Table 6.1). The seasonal means over all stocking rates were 1.30 mm, 1.27 mm and 1.54 mm for P. spinescens. Mean diameters of grazed stems measured for Rosenia spp. over all seasons were 1.34 mm for the lightest and 1.89 mm for the heaviest stocking rate. The seasonal means over all stocking rates were 1.65 mm, 1.44 mm and 1.72 mm for R. humilis (Table 6.1).

The fairly low mean diameter measured for P. spinescens and R. humilis in the high stocking rate treatment (5.5 ha.SSU^{-1}) during the 1992/93 season was influenced by the high proportion of Eriocephalus ericoides found in that specific camp. When present, E. ericoides seems to be grazed in preference to

Table 6.1 Mean diameters (mm) of grazed stems at the point of removal in the different stocking rates, over three seasons, the ha/SSU quoted are simply conversions of the ha/LSU quoted in par. 6.3.1

	Season						
	1990/91 (21 Feb '91)		1991/92 (6 Feb '92)		1992/93 (2 Feb '93)		Overall mean
	Pentzia spinescens						
Stocking Rate ($ha.SSU^{-1}$)	mean	SE	mean	SE	mean	SE	
8	1.016	0.2842	0.979	0.4382	1.411	0.2856	1.135
7	1.315	0.3772	0.915	0.2816	1.511	0.3515	1.247
5.5	1.373	0.3196	1.471	0.3272	1.395	0.3348	1.413
4	1.500	0.3674	1.714	0.3776	1.835	0.4555	1.683
Mean	1.301		1.270		1.538		1.370
	Rosenia humilis						
Stocking Rate ($ha.SSU^{-1}$)	mean	SE	mean	SE	mean	SE	
8	1.392	0.3630	1.199	0.3678	1.421	0.3793	1.337
7	1.677	0.4835	1.194	0.6788	1.710	0.4119	1.527
5.5	1.771	0.4607	1.557	0.4119	1.657	0.3991	1.662
4	1.775	0.4765	1.822	0.3979	2.073	0.4556	1.890
Mean	1.654		1.443		1.715		1.604
			Eriocephalus ericoides				
Stocking Rate ($ha.SSU^{-1}$)			mean	SE	mean	SE	
8			1.333	0.3962	1.486	0.3066	1.4095
7			1.482	0.4442	1.705	0.4678	1.5935
5.5			1.872	0.5696	1.725	0.3645	1.7985
4			1.989	0.4895	2.242	0.4827	2.1155
Mean			1.669		1.7895		1.7293

P. spinescens, probably owing to the somewhat more succulent nature of it's stems and leaves.

These results coincide with the observations made by Vorster & Blom (1982b), at the Grootfontein Research Station situated in the False Upper Karoo (Acocks 1988). They found that on veld dominated by Ankerkaroo (Smith 1966), Pentzia incana a less palatable species, Merino sheep grazed stems to a mean diameter of 1.35 mm, while Dorper sheep grazed stems to a mean diameter of 1.55 mm.

On this veld, at the recommended stocking rates, the hypothesis that sheep voluntarily graze stems which have a diameter of up to 2 mm, must be rejected. The stems of the less palatable species component, the most abundant species group in the Arid Karoo (Acocks, 1988), are seldom grazed below the 2 mm point. However, the stems of palatable species, such as Limeum spp. and Salsola spp., are frequently grazed in excess of 2 mm and this probably accounts for their low abundances in this veld. Few measurements of the less palatable species exceeded 2 mm. At high stocking rates, where dry matter becomes limiting, the grazing of stems exceeding 1.5 mm can not be regarded as being voluntary because the animals are obviously under stress. This condition is more pronounced during dry seasons (Table 6.1).

During the 1990/91 season, the measured diameters levelled off with an increase in stocking rate. Precipitation during 1990/91, for the twelve months preceding the month during which the measurements were taken, was 261.9 mm (Immelman pers. comm.[9]). This is 36 % higher than the longterm median annual rainfall, which is 192 mm (Anonymous 1993). An abundance of succulent forage was available. Because of the succulence of the stems, fairly thick stems were grazed, but without severe grazing being evident. The abundance of succulent forage provided sufficient forage even at high stocking rates.

During 1991/92, only 50 % (94.3mm) and during 1992/93, only 41 % (78.5 mm) of the longterm median precipitation was recorded. This resulted in a slow

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9. Immelman, W.F. Carnarvon Research Station, P.O. Box 98, Carnarvon. 7060.

growth rate and low dry matter accumulation.

During both the 1991/92 and 1992/93 seasons, the measured diameters increased curvi-linearly with increasing stocking rate. However, the measurements made during 1991/92 were on the whole, lower than those during 1990/91, because the material dried out due to the drought and it was found that the overall stem dimensions decreased. The low mean diameters measured in the lower stocking rates, were influenced by the carry-over effect of dry matter. At the higher stocking rates, less dry matter is usually carried over to the next season and consequently the mean measured diameters increase. The mean diameters measured in the high stocking rate during 1991/92 were much higher than those during the 1990/91 season. In 1992/93 the effect of the second consecutive dry season became evident. Animals grazed very intensively in order to satisfy their dry matter requirements, especially in the high stocking rate treatments, due to the low amount of dry matter carried over from the previous season and the low production during the current season. Grazed stem diameters increased sharply with increasing stocking rate (Figure 6.1 & Table 6.1).

6.3 Discussion

6.3.1 Grazed stem diameter as an indicator of Stocking Rate

For the purposes of this analysis, the data obtained for _Pentzia spinescens_ and _Rosenia humilis_ were pooled. These species are the most abundant of the forage species on this veld and belong to a group with the same palatability rating. These species were grazed to the same degree by the animals. As can be ascertained from Table 6.1, the stem diameters of these two species differ slightly, with the stems of _P. spinescens_ being thinner than those of _R. humilis_. For this reason it was decided to pool the data to illustrate the influence of stocking rate on the diameter of stems grazed, as illustrated in Figure 6.2. The expected stocking rate : grazed stem relation of the karoo bushes is a quadratic curve. As the stocking rate increases, the grazed diameters

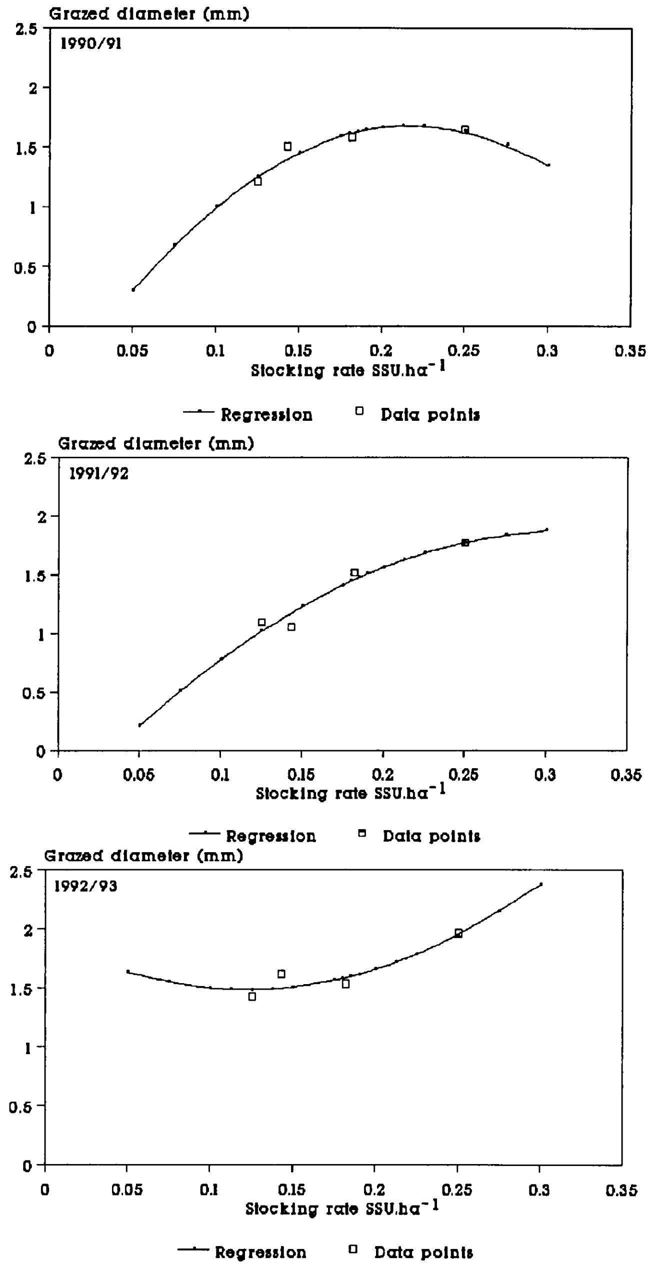

Figure 6.1 Regressions of measured pooled grazed stem diameters of the less palatable species, Pentzia spinescens and Rosenia humilis, over three seasons from 1990 to 1993. 1990/91, $Y=-0.6504+21.4X-49.13X^2$; 1991/92, $Y=-0.4757+14.91X-23.58X^2$; 1992/93, $Y=1.91-6.95X+28.41X^2$.

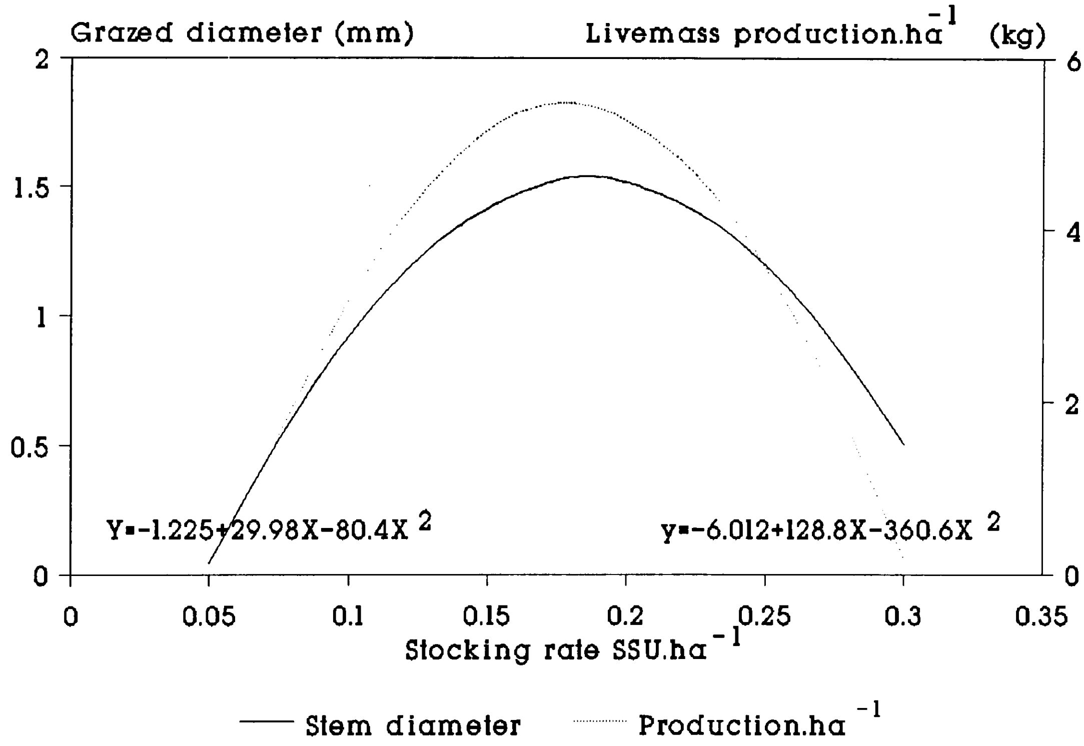

Figure 6.2 Comparisons of animal production.ha^{-1} and the intensity of grazing as gauged by the measurements of the mean grazed stem diameter

of the stems increase but levels off at the higher stocking rates. During the favourable rainfall season of 1990/91, with growth at its optimum and with young, succulent stems available, in the low stocking rate treatment, only thin stems were grazed off (mean diameters of respectively 1.01 mm for P. spinescens and 1.39 mm for R. humilis). With the increase in stocking rate thicker stems were grazed off. In the high stocking rate, the abundance of available forage influenced the thickness of the stems being grazed. There was sufficient forage available to the animals in the grazed stratum, making it unnecessary for the animals at the highest stocking rate to graze more severely in order to satisfy their dry matter requirements. The measured diameter of grazed stems decreased, from the second highest to the highest stocking rate in P. spinescens from 1.37 mm to 1.5 mm and in R. humilis from 1.77 mm to 1.78 mm. This indicated that in the quadratic relation, the stems grazed off in the highest stocking rate, were already beyond the asymptote on the quadratic curve.

The relation during the 1990/91 season was a convex parabola, in 1991/92 the relation was nearly linear and in 1992/93 the relation was a concave parabola. The shift in the slope and direction of the curve, is explained by the dry matter availability. Due to the low rainfall experienced during 1991/92 and 1992/93, dry matter production was very low. The bulk of available dry matter, usually available on the karoo bushes during favourable years, restricts the thickness of the stems being grazed, however, in order to obtain sufficient dry matter to satisfy their requirements during the dry years, the animals had to graze more severely. This led to their grazing off of thicker stems.

As the dry seasons progressed, the reserve dry matter produced during the favourable seasons became depleted. This was especially true for the higher stocking rate treatments. The higher diameter of stems being grazed at this stage, meant that the plants were overgrazed. The bushes diminish in size and they eventually die out with continued high stocking rates being applied. It was observed that individuals of R. humilis have been grazed down to such an extent in the high stocking rate treatments, that they could no longer provide sufficient forage. This leads to the less palatable species being overgrazed. Eventually the less palatable species group loses its ability to supply grazable dry matter. Their contribution to dry matter production in the system is replaced by unpalatable species, especially during the drought, which in this case is Eberlanzia ferox, a very fibrous, succulent plant. As a result of this change in species composition, animal production declines.

From this stocking rate : grazed stem relation the optimum stocking rate can be calculated.

A regression of mean grazed stem diameters on stocking rate (data of the three seasons were pooled for each stocking rate) yielded a quadratic curve similar to the Jones & Sandland curve (Jones & Sandland 1974; Edwards 1980, 1981) of gain per hectare on stocking rate, recalculated from data quoted by Meyer (1992). The optimum stocking rate calculated from the animal liveweight gain per hectare : stocking rate relation is 33.36 $ha.LSU^{-1}$. The optimum stocking rate calculated from the grazed stem diameter : stocking rate relation, for the pooled data, is 32.46 $ha.LSU^{-1}$ (Figure 3.2), while the official grazing capacity in the area, prescribed by the Department of Agriculture, is 30 $ha.LSU^{-1}$. It is clear that according to both methods of calculation of the optimum stocking rate, a lower grazing capacity is calculated for this area than is prescribed by the Department of Agriculture.

For the 1990/91 season only, the optimum stocking rate calculated from the P. spinescens data is 32.45 $ha.LSU^{-1}$, while in the case of R. humilis it is 36.62 $ha.LSU^{-1}$ (Figure 6.3). It is evident that the pooled data provided a more realistic estimate of the grazing capacity, when compared to both the official grazing capacity value and the grazing capacity value computed from the animal liveweight gains.

It is clear therefore that the grazed stem diameter is a useful

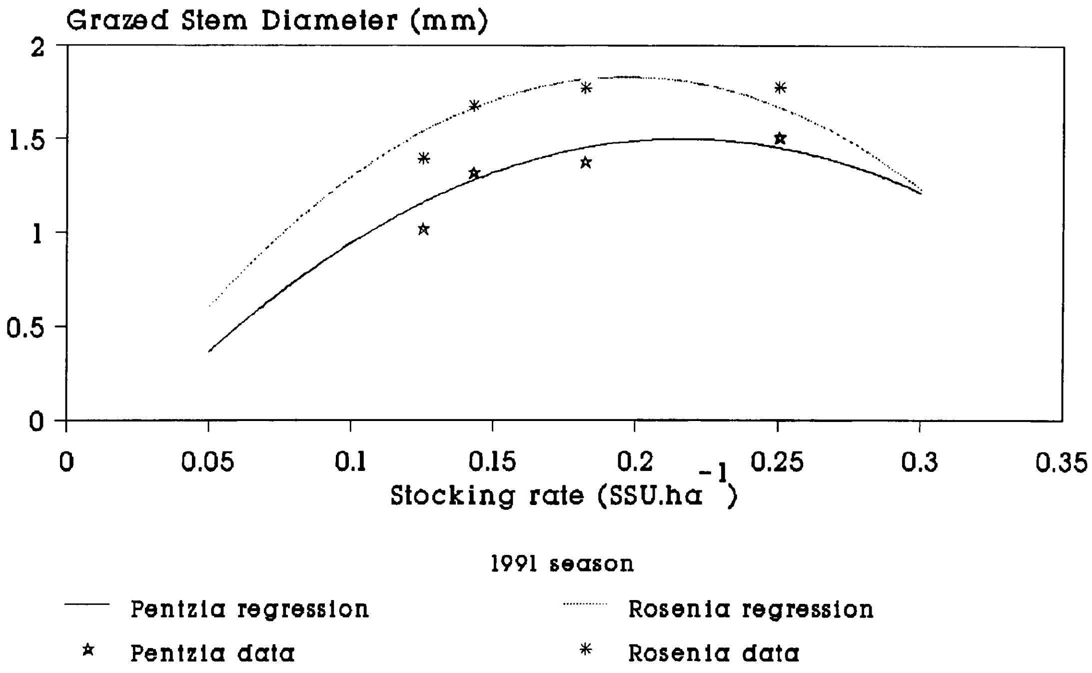

Figure 6.3 The optimum stocking rates calculated for Pentzia spinescens and Rosenia humilis from the data obtained duting the first season. The regression equation for P. spinescens is $Y = - 0.4258 + 17.82X - 41.21X^2$, with a coefficient of determination, $R^2 = 0.96$, while the regression equation for R. humilis is $Y = - 0.3775 + 22.45X - 56.99X^2$, with a coefficient of determination, $R^2 = 0.99$

parameter in the estimation of the optimum stocking rate.

6.3.2 Estimating stocking rate

The method employing stem thickness as a criterion in the estimation of grazable dry matter, often used to estimate the grazing capacity of an area, over-estimates the available forage component. The consequent over-estimate of the grazing capacity, leads to over-utilization of the vegetation. The criterion of using 2 mm to estimate forage may prove satisfactory where palatable to less palatable shrubs occur in a 50:50 ratio. The over-estimate of the less palatable forage component will be offset by the under-estimate of the palatable component. However, where the less palatable species contribute the major portion to the forage, the mean grazed stem diameter is 1.5 mm. This measurement is 25 % lower than the previous accepted yardstick. In terms of the overall accumulated dry matter, it may be lower by as much as 50 %. The tremendous impact that the over-estimate of the grazing capacity can have on dry matter removal is obvious.

During dry periods animals graze more severely than during favourable rainfall events in order to satisfy their dry matter requirements. Plant stems are not as succulent and tumescent as during good rainfall events and the measured diameter of the grazed twigs decreases, as a result of the physical drying out of the stems. It is postulated that although the measured diameter of grazed stems decreases at this time, the animals still graze to the same extent, removing the same amount of material as when the stems were tumescent. When animals graze stems as thick as, or thicker during dry periods, than during good rainfall seasons, the plants are overgrazed, this can be referred to as "hidden" overgrazing.

In order to avoid the hidden overgrazing alluded to above, stocking rates should be lighter than the optimum stocking rate calculated from stocking rate trials, for both the animal production per hectare and the grazed stem diameter. This recommendation is especially true in the light of the over-estimation of available forage. "Hidden" overgrazing results during drought conditions when little dry matter is carried over between grazing periods and production cannot keep up with removal, because of the low dry matter accumulation. Lenient stocking rates enable animals to satisfy their dry matter requirements with a relatively low negative impact on the veld, regardless of the prevailing climatic conditions. At present, the stock reduction advocated to offset the detrimental effects of drought, benefits the veld in that not all the dry matter is removed during grazing, but is carried over to be utilized during periods of low dry matter production and accumulation.

In the long run the hidden overgrazing results in a reduction in the vigour of the karoo bushes, ultimately leading to unfavourable species composition changes, with a consequent lower grazing capacity.

6.4 Conclusions

A rule of thumb exists that sheep graze off stems of karoo bushes with a diameter of 2 mm or less. For the purposes of grazing capacity calculation, plants are harvested at approximately ground level and the harvested material is then separated into potentially grazable and non-grazable fractions. By definition all the material thinner than 2 mm is regarded as grazable. It was established that sheep graze stems to a diameter of between 1.4 mm and 1.6 mm. The hypothesis that sheep voluntarily graze stems with a diameter of up to 2 mm must be rejected, on the grounds that the stems of the main source of forage, the less palatable species group, are seldom grazed as thick as 2 mm. From this reasoning it then follows that the method in which dry matter production is estimated for the purposes of determining grazing capacity must therefore be adjusted by some 25 %. This will of course affect the measurement of available dry matter to be used in the objective estimation of the grazing index values (OIV's) which will be used in the Grazing Index Method for the calculation of grazing capacity.

Measurements of grazed stems of the less palatable category of karoo shrubs in the Arid Karoo, can be used to calculate optimum stocking rates, to adjust stocking rates and to monitor applied stocking rates (Du Toit 1996).

CHAPTER 7

MODEL DEVELOPMENT FOR THE DETERMINATION OF THE GRAZING INDEX VALUES OF THE SPECIES

7.1 Introduction

7.1.1 Model development

The proposed model attempts to objectively allocate a grazing index value to each of the studied species, based on the size of the species (canopy spread cover), its' available dry matter and certain of the chemical properties of the species. These objectively estimated grazing index values will be compared to the subjectively estimated grazing index values which represent value judgements, based on experience, as to the potential grazing value of the plant species of the Karoo.

The criteria to be incorporated into the model was determined and selected after multiple stepwise regressions of the subjective grazing index values on the values obtained for the different parameters of the studied species (refer to Appendix 7). The regression results detailing the parameters, and their significance, to be selected for building the model by which the grazing index values are to be estimated, are presented in Appendix 7.

7.2 Methods

7.2.1 Proposed models

Three models were investigated:

1. **Grazing index value = 1.21 - (0.02 x available forage) - (1.80 x % N) + (0.12 x % TDN) - (0.61 x % Ether extract) + (0.24 x % Ash);**

2. **Grazing Index Value = - 21.56 - (0.02 x available forage) + (0.15 x % acid detergent fibre) + (0.40 x % TDN) - (2.45 x % K) + (1.32 x (K÷(Ca+Mg)) ratio) - (0.71 x % ether extract) + (0.21 x % ash) - (6.26 x % Na);** and

Models 3a and 3b were formulated after inspection of models 1 and 2, which were obtained after stepwise regressions, as discussed previously. It was felt that certain parameters could be excluded from the model, while it was felt that others should play a more prominent role in the final estimation of the grazing index value.

3a. **Grazing index value = ((available forage + TDN + cover + (K ÷ (Ca + Mg))) ÷ ether extract) ÷ 100,** for the karoo bushes; and

3b. **Grazing index value = ((available forage + TDN + cover + (K ÷ (Ca + Mg))) x ether extract) ÷ 100,** for the grasses.

The following selected parameters play significant roles in the equations:

Production (available forage),
Total digestible nutrients,
Ether extract,
Ash,
Potassium,
Nitrogen,
Acid detergent fibre,
Calcium,
Magnesium,
Sodium,
The K÷(Ca+Mg) ratio and
Cover (canopy spread cover).

Only three of these parameters play a role in all three of the models. The third model is preferred for reasons relating to the method of botanical survey for estimating grazing capacity because it takes into account the size of the plant (canopy spread cover). It is the only model incorporating canopy spread cover, which is one of the cornerstones of the Ecological Index Method, as one of the parameters. The percentage ash is eliminated from the chosen model, owing to the significantly high correlation it has with cover, potassium and phosphorus (Appendix 7). Of these excluded parameters, phosphorus is also highly significantly correlated with the parameter total digestible nutrients (TDN)(Appendix 7), which is included in the model. Sodium is excluded because it is highly significantly correlated with both cover and total digestible nutrients. Potassium, calcium and magnesium are included as the K÷(Ca+Mg) ratio, because they are found to have a direct individual influence on the grazing value and are important from the herbivore nutrition point of view (Chapter 5 & Appendix 7).

Owing to the significant influence that the parameter total digestible nutrients play in the equations, the prominence it receives in animal feeding ration formulations (Maynard & Loosli 1962), in the comparison of different feedstuffs (Swift 1957) and, in this case the comparison of different natural forages, it is included in the equations as a primary parameter. It is felt that the two variables incorporated in the determination of TDN (Glover & Duthie 1960; Bartholomew 1985; Bredon & Meaker undated) i.e. the percentages of nitrogen and acid detergent fibre, can therefore be excluded from the model, since their influence on the grazing index value is already taken into account by the variable, total digestible nutrients.

7.3 Testing the models

7.3.1 The Eastern Mixed Karoo

7.3.1.1 Model 1

Grazing index value = 1.21 - (0.02 x available forage) - (1.80 x % N) + (0.12 x % TDN) - (0.61 x % Ether extract) + (0.24 x % Ash).

Multiple stepwise regression showed that the percentage nitrogen, percentage TDN and available forage played the most important role in the subjective estimation of the grazing index values of the studied species (Du Toit et al. 1995). The percentages of ether extract and ash gleaned from the literature (Louw, Steenkamp & Steenkamp 1968a, 1968b & 1968c; Steenkamp & Hayward 1979; Botha, Becker & Van der Merwe 1990; Botha, Erasmus & Theron 1990; Botha & Nash 1990; Botha, Van Staden & Blom 1990), also seemed to play an important role in the subjective estimate of the grazing index value. By making use of these variables, the grazing index value of a plant can be estimated with a probability of 62% (Statistical Graphics Corporation 1991).

Employing cover and the percentages of acid detergent fibre, K, Ca, Mg, Na and P in the calculation of the grazing index value, results in a weaker prediction of the grazing index value. From the matrix produced during multiple stepwise regression, it is clear that cover is highly significantly correlated with mean forage production (Appendix 3), while K, Ca, Mg, P, acid detergent fibre and cover is highly significantly correlated with the percentage nitrogen. By employing mean forage production and percentage nitrogen in the calculation of the grazing index value, these factors are therefore already largely taken into account.

The fitted r^2 value is 0.62 and the standard error for the estimate of the subjective grazing index value is 1.38 (refer to Appendix 7). Compare the index values objectively calculated (OIV)(Table 7.3.1.1) according to this model, to the subjectively estimated grazing index value (GIV)(Du Toit et al. 1995).

Table 7.3.1.1 Grazing index values calculated according to model 1

1990/91

	OIV					GIV
	May	Aug	Nov	Jan	Mean	
Chrysocoma ciliata	0.99	1.92	1.83	3.09	1.96	1.50
Eriocephalus ericoides	2.62	2.93	4.49	0.36	2.60	5.00
Pentzia incana	5.29	4.69	6.01	6.09	5.52	5.70
Salsola calluna	6.76	8.65	6.51	6.47	7.10	7.20
Aristida congesta	8.12	10.46	9.28	8.53	9.10	1.30
Aristida diffusa	7.07	7.04	7.28	2.07	5.87	5.10
Digitaria eriantha	6.57	7.30	6.96	7.57	7.10	8.90
Eragrostis lehmanniana	7.22	6.87	6.96	6.00	6.76	5.40
Themeda triandra	7.27	7.41	7.72	7.68	7.52	9.30

1991/92

	May	Aug	Nov	Jan	Mean	GIV
Eriocephalus spinescens	6.01	4.92	5.32	4.65	5.23	4.50
Pentzia incana	5.57	4.48	5.27	5.45	5.19	5.70
Phymaspermum parvifolium	5.13	5.41	5.30	5.35	5.30	6.20
Pteronia glauca	4.71	3.94	3.67	4.02	4.09	3.20
Pterothrix spinescens	3.50	2.50	5.92	2.57	3.62	2.00
Rosenia humilis	7.31	5.76	5.84	6.46	6.34	3.50
Walafrida geniculata	5.96	5.26	4.13	5.26	5.15	7.00
Heteropogon contortus	8.66	7.44	7.84	8.08	8.01	7.20
Sporobolus fimbriatus	7.77	7.95	6.36	6.82	7.23	9.50
Stipagrostis ciliata	6.74	6.77	6.78	7.06	6.84	7.20
Stipagrostis obtusa	11.30	8.63	8.42	8.13	9.12	6.60

1992/93

	May	Aug	Nov	Jan	Mean	GIV
Eriocephalus ericoides	2.08	2.63	3.36	4.53	3.14	5.00
Helichrysum lucilioides	4.53	4.96	5.15	5.86	5.13	5.20
Pentzia incana	4.31	4.23	5.38	4.87	4.69	5.70
Phymaspermum parvifolium	3.65	4.43	4.71	5.35	4.54	6.20
Plinthus karrooicus	6.94	6.85	6.12	6.09	6.53	6.40
Rosenia humilis	5.19	4.83	5.04	6.27	5.33	3.50
Aristida congesta	6.96	9.66	8.35	7.76	8.18	1.30
Eragrostis lehmanniana	6.22	6.50	6.65	6.87	6.56	5.40
Heteropogon contortus	7.75	7.28	7.48	7.64	7.54	7.20
Themeda triandra	7.30	6.41	7.08	7.50	7.07	9.30

7.3.1.2 Model 2

Grazing Index Value = - 21.56 - (0.02 x available forage) + (0.15 x % acid detergent fibre) + (0.40 x % TDN) - (2.45 x % K) + (1.32 x (K÷(Ca+Mg)) ratio) - (0.71 x % ether extract) + (0.21 x % ash) - (6.26 x % Na).

This equation renders a r^2 value of 0.78 and a standard error for the calculation of the grazing index value of 1.24 (refer to Appendix 7). This represents an improvement of 26 % (Statistical Graphics Corporation 1991) in the description of the variation of the objective estimation of the grazing index value over the subjective estimation of the grazing index value. The standard error declines by 11 %.

The following grazing index values (Table 7.3.1.2) were estimated by means of this regression.

Table 7.3.1.2 Grazing index values calculated according to model 2

1990/91

	OIV					GIV
	May	Aug	Nov	Jan	Mean	
Chrysocoma ciliata	0.52	1.14	0.79	1.19	0.91	1.50
Eriocephalus ericoides	0.61	1.15	2.72		1.49	5.00
Pentzia incana	2.89	2.38	4.55	-0.12	3.27	5.70
Salsola calluna	5.93	4.06	4.42	5.17	4.90	7.20
Aristida congesta	7.83	10.06	8.49	8.35	8.68	1.30
Aristida diffusa	7.00	7.44	6.61		7.02	5.10
Digitaria eriantha	5.91	7.14	6.92	9.03	7.25	8.90
Eragrostis lehmanniana	6.42	6.51	6.21	5.20	6.09	5.40
Themeda triandra	7.18	8.70	7.27	7.93	7.77	9.30

1991/92

	May	Aug	Nov	Jan	Mean	GIV
Eriocephalus spinescens	3.59	3.69	2.93	2.75	3.24	4.50
Pentzia incana	2.82	1.83	2.51	2.38	2.39	5.70
Phymaspermum parvifolium	-0.42	3.84	2.78	2.27	2.96	6.20
Pteronia glauca	3.43	2.70	2.96	2.14	2.81	3.20
Pterothrix spinescens	1.66	1.81	4.25	1.51	2.31	2.00
Rosenia humilis	6.53	4.05	3.90	4.63	4.78	3.50
Walafrida geniculata	4.53	4.76	3.45	4.45	4.30	7.00
Heteropogon contortus	7.09	6.30	7.48	6.99	6.97	7.20
Sporobolus fimbriatus	6.18	7.09	7.01	7.26	6.89	9.50
Stipagrostis ciliata	4.55	5.49	5.71	5.42	5.29	7.20
Stipagrostis obtusa	9.07	6.94	7.40	6.23	7.41	6.60

1992/93

	May	Aug	Nov	Jan	Mean	GIV
Eriocephalus ericoides	-2.26	-1.14	0.15	2.84	1.50	5.00
Helichrysum lucilioides	2.76	2.76	2.87	3.98	3.09	5.20
Pentzia incana	0.50	0.51	1.66	1.41	1.02	5.70
Phymaspermum parvifolium	-1.26	0.69	-0.28	1.72	1.21	6.20
Plinthus karrooicus	1.66	3.77	2.27	3.02	2.68	6.40
Rosenia humilis	0.97	1.52	1.59	3.83	1.98	3.50
Aristida congesta	6.36	7.19	5.80	5.23	6.12	1.30
Eragrostis lehmanniana	4.48	5.93	4.93	6.17	5.38	5.40
Heteropogon contortus	5.62	4.83	5.41	5.63	5.37	7.20
Themeda triandra	5.68	3.40	4.73	6.15	4.99	9.30

7.3.1.3 Model 3a (Karoo bushes)(Table 7.3.1.3)

Grazing index value = ((available forage + TDN + cover + (K ÷ (Ca + Mg))) ÷ ether extract) ÷ 100.

In the case of the karoo bushes the ether extract value is taken as a negative variable. The higher the ether extract value of the karoo bush, the higher the content of resins and aromatic oils. From experience, it is known that the higher the resin and aromatic oil content of the plants, the more unpalatable the karoo bushes are i.e. compare the unpalatable karoo bush Chrysocoma ciliata with a ether extract values of 8.9 in summer and 9.2 in winter to the less palatable karoo bush Pentzia incana with ether extract values of 2.3 and 3.9 in summer and winter respectively (Botha, Van Staden & Blom 1990). Cook et al. (1952) found that the higher the ether extract value of certain shrubs, the higher the loss of energy rich esters, ethers and aldehydes through the urine of sheep. Therefore the usable energy of these forages was not as high as their calculated TDN values indicated. Therefore the sum of the calculated values of the different variables is divided by the ether extract value, in order to penalize the karoo bushes and to consequently estimate a relatively lower grazing index value, which will be in accordance with the relatively low energy they provide.

7.3.1.4 Model 3b (Grasses)(Table 7.3.1.3)

Grazing index value = ((available forage + TDN + cover + (K ÷ (Ca + Mg))) x ether extract) ÷ 100.

In the case of the grasses, the ether extract value is regarded as a variable exerting a positive influence on the feeding value, through the carotene content. The higher the ether extract value, the higher the carotene content of the grasses and the more favourable the vitamins A, B, E and probably D content of the grasses (McDonald, Edwards & Greenhalgh 1973). Therefore the sum of the calculated values of the different variables is multiplied by the ether extract value. In this way, grasses with a high ether extract value are favoured. It was found that the late successional grasses *Digitaria eriantha* and *Themeda triandra* have the highest ether extract values, 1.92 (winter) and 2.02 (summer) as opposed to the early successional grasses *Aristida congesta* and *A. adscensionis* with a content of 1.34 in both summer and winter (Botha, Van Staden & Blom 1990).

Table 7.3.1.3 Grazing index values calculated according to model 3

1990/91	OIV					GIV
	May	Aug	Nov	Jan	Mean	
Chrysocoma ciliata	1.22	0.31	1.29	0.51	0.83	1.50
Eriocephalus ericoides	2.44	1.67	3.44	4.16	2.93	5.00
Pentzia incana	1.64	1.33	2.01	1.94	1.73	5.70
Salsola calluna	5.69	4.24	5.71	4.80	5.11	7.20
Aristida congesta	3.36	1.92	0.94	1.07	1.82	1.30
Aristida diffusa	11.00	6.78	7.12	8.69	8.40	5.10
Digitaria eriantha	19.59	7.72	13.51	6.46	11.82	8.90
Eragrostis lehmanniana	3.74	2.17	2.03	2.32	2.56	5.40
Themeda triandra	15.04	10.19	8.31	6.69	10.06	9.30

1991/92	May	Aug	Nov	Jan	Mean	GIV
Eriocephalus spinescens	3.09	2.75	0.29	2.73	2.22	4.50
Pentzia incana	1.67	1.17	1.42	1.93	1.55	5.70
Phymaspermum parvifolium	0.58	0.62	0.54	0.43	0.54	6.20
Pteronia glauca	3.28	1.89	3.81	2.08	2.77	3.20
Pterothrix spinescens	1.91	1.66	0.11	1.47	1.29	2.00
Rosenia humilis	3.28	2.90	3.99	3.03	3.30	3.50
Walafrida geniculata	3.14	3.28	3.58	2.01	3.00	7.00
Heteropogon contortus	4.17	5.36	4.37	3.77	4.42	7.20
Sporobolus fimbriatus	6.16	5.22	10.02	6.92	7.08	9.50
Stipagrostis ciliata	3.78	4.48	2.38	3.61	3.56	7.20
Stipagrostis obtusa	3.49	4.46	1.01	2.34	2.83	6.60

1992/93	May	Aug	Nov	Jan	Mean	GIV
Eriocephalus ericoides	1.48	1.78	2.85	2.63	2.18	5.00
Helichrysum lucilioides	2.09	1.63	1.45	1.62	1.70	5.20
Pentzia incana	1.19	0.97	1.16	1.57	1.22	5.70
Phymaspermum parvifolium	0.51	0.61	0.58	0.39	0.52	6.20
Plinthus karrooicus	2.64	3.06	1.63	2.69	2.50	6.40
Rosenia humilis	3.16	4.56	4.60	3.65	3.99	3.50
Aristida congesta	1.82	1.58	0.78	0.85	1.26	1.30
Eragrostis lehmanniana	2.70	2.02	2.05	1.87	2.16	5.40
Heteropogon contortus	3.77	5.06	4.15	3.98	4.24	7.20
Themeda triandra	6.64	6.26	5.65	4.70	5.81	9.30

7.3.2 The Karoo Mountain areas

7.3.2.1 Model 1

Grazing index value = 1.21 - (0.02 x available forage) - (1.80 x % N) + (0.12 x % TDN) - (0.61 x % Ether extract) + (0.24 x % Ash) (Table 7.3.2.1).

Table 7.3.2.1 Grazing index values calculated according to model 1

1990/91	OIV					GIV
	Apr	Jul	Nov	Jan	Mean	
Aristida diffusa	6.22	4.75	6.27	6.65	5.97	5.10
Merxmuellera disticha	3.50	2.14	4.07	4.63	3.58	5.00
Pentzia globosa	3.30	3.20	4.07	3.47	3.51	4.80
Phymaspermum parvifolium	4.15	5.13	5.70	4.28	4.82	6.20
Themeda triandra	7.67	6.76	6.94	7.70	7.27	9.30
Walafrida saxatilis	1.62	1.58	2.13	2.93	2.06	2.00
1991/92						
	May	Jul	Nov	Feb		
Digitaria eriantha	6.25	6.46	5.58	6.45	6.19	8.90
Eragrostis curvula conferta	6.59	6.67	6.39	5.88	6.38	6.90
Hyparrhenia hirta	4.50	4.69	5.16	5.93	5.07	6.30
Eriocephalus ericoides	2.52	1.87	3.77	4.81	3.24	5.00
Felicia fascicularis	5.36	3.01	6.43	4.28	4.77	6.20
Felicia filifolia	3.26	3.80	3.45	3.54	3.51	5.90
Nenax microphylla	5.32	3.57	3.70	3.84	4.11	7.00
Pentzia globosa	3.46	3.19	3.82	3.98	3.61	4.80
1992/93						
	May	Aug	Oct	Jan		
Digitaria eriantha	7.28	7.13	6.80	6.96	7.04	8.90
Eragrostis curvula conferta	7.64	7.38	7.47	6.96	7.36	6.90
Eriocephalus ericoides	3.15	3.09	4.55	4.68	3.87	5.00
Helichrysum dregeanum	6.57	7.45	7.85	7.76	7.41	6.30
Nenax microphylla	5.67	3.40	4.66	4.68	4.60	7.00
Pentzia globosa	3.76	3.75	4.40	4.56	4.12	4.80
Phymaspermum parvifolium	4.61	4.51	6.22	4.89	5.06	6.20
Rosenia oppositifolia	1.98	0.85	1.50	1.04	1.34	3.10
Themeda triandra	8.58	7.52	7.58	8.19	7.97	9.30

7.3.2.2 Model 2

Grazing Index Value = - 21.56 - (0.02 x available forage) + (0.15 x % acid detergent fibre) + (0.40 x % TDN) - (2.45 x % K) + (1.32 x (K÷(Ca+Mg)) ratio) - (0.71 x % ether extract) + (0.21 x % ash) - (6.26 x % Na). (Table 7.3.2.2).

Table 7.3.2.2 Grazing index values calculated according to model 2

1990/91	OIV					GIV
	Apr	Jul	Nov	Jan	Mean	
Aristida diffusa	5.87	4.30	6.88	6.12	5.79	5.10
Merxmuellera disticha	7.33	6.36	7.08	6.53	6.83	5.00
Pentzia globosa	2.16	1.92	2.66	1.32	2.02	4.80
Phymaspermum parvifolium	3.46	3.42	3.39	3.26	3.43	6.20
Themeda triandra	6.07	4.81	5.09	5.94	5.48	9.30
Walafrida saxatilis	0.43	-0.43	0.57	1.34	0.48	2.00
1991/92						
	May	Jul	Nov	Feb		
Digitaria eriantha	4.70	5.09	4.12	4.10	4.50	8.90
Eragrostis curvula conferta	5.42	5.61	6.85	4.84	5.68	6.90
Hyparrhenia hirta	4.96	4.58	4.34	4.23	4.53	6.30
Eriocephalus ericoides	-0.11	-0.63	1.94	1.96	0.79	5.00
Felicia fascicularis	2.67	0.45	3.59	1.83	2.13	6.20
Felicia filifolia	3.62	2.32	1.78	1.84	2.39	5.90
Nenax microphylla	2.17	0.94	1.00	0.01	1.03	7.00
Pentzia globosa	1.61	1.53	2.54	1.67	1.84	4.80
1992/93						
	May	Aug	Oct	Jan		
Digitaria eriantha	6.39	6.36	6.72	3.16	5.66	8.90
Eragrostis curvula conferta	7.51	7.39	7.77	6.78	7.36	6.90
Eriocephalus ericoides	2.38	2.59	3.29	4.42	3.17	5.00
Helichrysum dregeanum	5.85	7.12	7.47	6.60	6.76	6.30
Nenax microphylla	4.25	3.45	3.54	3.49	3.68	7.00
Pentzia globosa	3.63	3.54	5.05	3.07	3.82	4.80
Phymaspermum parvifolium	4.64	4.40	6.08	4.57	4.92	6.20
Rosenia oppositifolia	-5.83	0.21	-0.00	-0.74	-1.59	3.10
Themeda triandra	7.53	7.26	7.51	7.69	7.50	9.30

7.3.2.3 Model 3a (Karoobushes)(Table 7.3.2.3)

Grazing index value = ((available forage + TDN + cover + (K ÷ (Ca + Mg))) ÷ ether extract) ÷ 100.

6.3.2.4 Model 3b (Grasses)(Table 7.3.2.3)

Grazing index value = ((available forage + TDN + cover + (K ÷ (Ca + Mg))) x ether extract) ÷ 100.

Table 7.3.2.3 Grazing index values calculated according to model 3

	OIV					GIV
1990/91	Apr	Jul	Nov	Jan	Mean	
Aristida diffusa	3.79	2.67	4.85	2.56	3.47	5.10
Merxmuellera disticha	6.40	12.24	6.31	4.91	7.47	5.00
Pentzia globosa	1.73	1.44	1.05	1.08	1.32	4.80
Phymaspermum parvifolium	2.56	2.19	2.47	2.82	2.51	6.20
Themeda triandra	3.44	3.02	3.27	2.32	3.01	9.30
Walafrida saxatilis	0.86	0.54	0.64	0.72	0.69	2.00
1991/92	May	Jul	Nov	Feb		
Digitaria eriantha	8.19	6.66	9.37	4.87	7.27	8.90
Eragrostis curvula conferta	4.98	3.37	3.80	4.16	4.08	6.90
Hyparrhenia hirta	7.74	8.03	10.78	8.29	8.71	6.30
Eriocephalus ericoides	1.73	1.43	2.84	1.79	1.95	5.00
Felicia fascicularis	0.95	0.30	0.61	0.36	0.56	6.20
Felicia filifolia	4.23	2.30	2.04	1.94	2.63	5.90
Nenax microphylla	1.39	1.41	1.31	1.49	1.40	7.00
Pentzia globosa	1.46	1.21	1.60	0.78	1.26	4.80
1992/93	May	Aug	Oct	Jan		
Digitaria eriantha	7.35	4.82	6.31	5.13	5.90	8.90
Eragrostis curvula conferta	1.89	0.95	1.42	1.50	1.44	6.90
Eriocephalus ericoides	1.40	1.32	2.43	2.58	1.93	5.00
Helichrysum dregeanum	0.47	0.47	0.43	0.53	0.48	6.30
Nenax microphylla	1.37	4.07	1.16	1.25	1.97	7.00
Pentzia globosa	1.30	1.26	1.46	0.71	1.18	4.80
Phymaspermum parvifolium	2.75	2.19	3.71	2.65	2.82	6.20
Rosenia oppositifolia	0.97	1.24	0.50	0.57	0.82	3.10
Themeda triandra	5.05	7.47	6.01	3.59	5.53	9.30

7.3.3 The Arid Karoo

7.3.3.1 Model 1

Grazing index value = 1.21 - (0.02 x available forage) - (1.80 x % N) + (0.12 x % TDN) - (0.61 x % Ether extract) + (0.24 x % Ash) (Table 7.3.3.1).

Table 7.3.3.1 Grazing index values calculated according to model 1

1990/91	OIV					GIV
	Apr	Jul	Oct	Jan	Mean	
Eberlanzia ferox	2.98	3.92	4.03	3.91	3.71	2.70
Fingerhuthia africana	7.46	6.70	6.68	6.62	6.86	6.60
Monechma incanum	3.35	3.97	4.20	3.04	3.64	5.40
Pentzia spinescens B[1]	4.56	4.34	4.95	3.99	4.46	4.80
Pentzia spinescens G[2]	2.26	2.27	1.91	1.92	2.09	4.80
Plinthus cryptocarpus	7.61	6.44	6.52	6.63	6.80	6.70
Pterothrix spinescens	2.53	2.29	1.26	0.67	1.69	2.00
Salsola tuberculata	4.60	5.94	7.03	7.09	6.16	6.90
Stipagrostis ciliata	6.00	5.96	5.71	5.17	5.71	7.20
Stipagrostis obtusa B	10.97	6.59	7.19	6.79	7.88	6.60
Stipagrostis obtusa G	7.97	6.96	7.00	7.32	7.31	6.60
1991/92						
	May	Aug	Nov	Feb		
Aristida diffusa	7.04	6.65	6.36	6.79	6.71	5.10
Eragrostis lehmanniana	6.27	6.45	7.47	6.70	6.72	5.40
Eriocephalus ericoides G	3.36	4.32	2.61	2.34	3.16	5.00
Eriocephalus ericoides B	3.56	1.28	1.69	1.41	1.98	5.00
Eriocephalus spinescens	3.92	3.85	3.73	2.49	3.49	4.50
Felicia macrorrhiza	6.26	6.11	6.21	5.76	6.09	5.70
Osteospermum spinescens	1.95	1.72	0.51	2.16	1.58	6.00
Pentzia spinescens	4.59	4.11	3.59	2.99	3.82	4.80
Plinthus karooicus	7.67	6.41	5.47	5.78	6.33	6.40
Pteronia adenocarpa	3.99	3.80	3.42	4.18	3.85	3.90
Pteronia glomerata	1.80	1.78	0.49	1.83	1.48	3.90
Rosenia humilis	4.32	3.38	3.88	4.38	3.99	3.50
1992/93						
	Apr	Jul	Oct	Jan		
Eberlanzia ferox	5.22	5.39	3.95	4.66	4.80	2.70
Eragrostis lehmanniana	7.03	6.81	7.29	7.38	7.13	5.40
Eriocephalus ericoides	4.19	4.87	4.91	5.84	4.95	5.00
Helichrysum lucilioides	5.09	4.72	4.71	4.80	4.83	5.20
Pentzia spinescens	4.01	4.07	5.10	4.38	4.39	4.80
Plinthus cryptocarpus	7.74	7.66	8.11	8.06	7.89	6.70
Pteronia adenocarpa	3.67	4.69	4.95	5.14	4.61	3.90
Pterothrix spinescens	2.85	3.34	4.80	-0.85	2.53	2.00
Rosenia humilis	5.10	3.74	5.63	5.57	5.01	3.50
Stipagrostis ciliata	6.63	5.19	4.05	6.03	5.47	7.20
Stipagrostis obtusa	8.31	8.63	9.40	9.17	8.88	6.60
Zygophyllum lichtensteinianum	3.53	4.30	3.14	4.03	3.75	7.00

[1] B = Karoo bushveld on stony shale veld
[2] G = Bushman grassveld on red sandy soil

7.3.3.2 Model 2

Grazing Index Value = - 21.56 - (0.02 x available forage) + (0.15 x % acid detergent fibre) + (0.40 x % TDN) - (2.45 x % K) + (1.32 x (K÷(Ca+Mg)) ratio) - (0.71 x % ether extract) + (0.21 x % ash) - (6.26 x % Na). (Table 7.3.3.2).

Table 7.3.3.2 Grazing index values calculated according to model 2

1990/91	OIV					GIV
	Apr	Jul	Oct	Jan	Mean	
Eberlanzia ferox	-4.10	-3.19	-2.78	-2.91	-3.24	2.70
Fingerhuthia africana	6.13	4.38	4.71	4.97	5.05	6.60
Monechma incanum	1.27	1.45	1.63	0.76	1.28	5.40
Pentzia spinescens B[1]	-0.47	-0.90	0.38	-0.36	-0.34	4.80
Pentzia spinescens G[2]	-2.97	-2.98	-4.54	-3.88	-3.59	4.80
Plinthus cryptocarpus	3.64	2.13	2.31	2.87	2.74	6.70
Pterothrix spinescens	-0.03	-0.99	-3.45	-1.81	-1.57	2.00
Salsola tuberculata	-0.57	0.22	0.45	0.40	0.13	6.90
Stipagrostis ciliata	3.55	3.51	3.24	2.67	3.24	7.20
Stipagrostis obtusa B	8.18	4.41	4.95	5.24	5.69	6.60
Stipagrostis obtusa G	5.59	4.46	4.47	4.83	4.84	6.60
1991/92	May	Aug	Nov	Feb		
Aristida diffusa	4.77	4.17	3.69	4.63	4.31	5.10
Eragrostis lehmanniana	5.59	4.06	9.51	5.12	6.07	5.40
Eriocephalus ericoides G	-1.19	-0.69	-4.91	-3.87	-2.67	5.00
Eriocephalus ericoides B	-3.07	-4.74	-5.18	-4.77	-4.44	5.00
Eriocephalus spinescens	-0.51	-0.18	0.67	2.17	0.54	4.50
Felicia macrorrhiza	4.79	3.85	4.26	3.69	4.15	5.70
Osteospermum spinescens	-1.94	-1.87	-2.92	-0.61	-1.83	6.00
Pentzia spinescens	0.78	-0.10	0.20	-0.80	0.02	4.80
Plinthus karooicus	1.45	2.23	2.42	1.84	1.98	6.40
Pteronia adenocarpa	-1.69	-1.53	-3.23	-3.29	-2.43	3.90
Pteronia glomerata	-0.64	-1.92	-5.63	-4.36	-3.13	3.90
Rosenia humilis	0.61	-0.09	1.25	0.70	0.62	3.50
1992/93	Apr	Jul	Oct	Jan		
Eberlanzia ferox	-0.42	0.53	-1.60	-0.61	-0.53	2.70
Eragrostis lehmanniana	6.51	6.84	6.57	7.12	6.76	5.40
Eriocephalus ericoides	2.11	0.69	1.08	1.51	1.35	5.00
Helichrysum lucilioides	3.72	3.49	3.15	3.54	3.48	5.20
Pentzia spinescens	-1.86	2.03	2.93	2.71	1.46	4.80
Plinthus cryptocarpus	6.00	6.32	5.68	6.58	6.14	6.70
Pteronia adenocarpa	-0.26	-0.32	-1.88	1.95	-0.12	3.90
Pterothrix spinescens	1.57	2.67	3.42	-2.44	1.31	2.00
Rosenia humilis	1.79	2.16	3.70	4.84	3.12	3.50
Stipagrostis ciliata	6.60	4.51	2.95	4.78	4.71	7.20
Stipagrostis obtusa	7.59	7.86	8.75	8.51	8.18	6.60
Zygophyllum lichtensteinianum	0.20	1.24	-0.96	0.42	0.22	7.00

[1] B = Karoo bushveld on stony shale veld
[2] G = Bushman grassveld on red sandy soil

7.3.3.3 Model 3a (Karoo bushes)(Table 7.3.3.3)

Grazing index value = ((available forage + TDN + cover + (K ÷ (Ca + Mg))) ÷ ether extract) ÷ 100.

7.3.3.4 Model 3b (Grasses)(Table 7.3.3.3)

Grazing index value = ((available forage + TDN + cover + (K ÷ (Ca + Mg))) x ether extract) ÷ 100.

Table 7.3.3.3 Grazing index values calculated according to model 3

	OIV					GIV
1990/91	Apr	Jul	Oct	Jan	Mean	
Eberlanzia ferox	3.68	2.50	2.66	2.30	2.78	2.70
Fingerhuthia africana	2.07	3.11	2.14	2.93	2.56	6.60
Monechma incanum	6.01	6.53	7.82	18.69	9.76	5.40
Pentzia spinescens B[1]	1.41	0.44	2.28	2.04	1.54	4.80
Pentzia spinescens G[2]	6.16	5.39	2.69	3.00	4.31	4.80
Plinthus cryptocarpus	1.34	4.70	3.56	1.90	2.87	6.70
Pterothrix spinescens	1.93	2.12	2.03	3.03	2.28	2.00
Salsola tuberculata	6.88	5.22	5.76	6.80	6.17	6.90
Stipagrostis ciliata	1.87	5.70	3.57	6.87	4.50	7.20
Stipagrostis obtusa B	2.01	3.94	1.06	3.02	2.51	6.60
Stipagrostis obtusa G	1.17	5.65	3.78	2.95	3.39	6.60
1991/92						
	May	Aug	Nov	Feb		
Aristida diffusa	5.81	6.12	5.76	3.91	5.40	5.10
Eragrostis lehmanniana	2.89	5.64	2.99	2.13	3.41	5.40
Eriocephalus ericoides G	5.50	6.24	5.45	7.64	6.21	5.00
Eriocephalus ericoides B	2.84	3.30	1.01	1.04	2.05	5.00
Eriocephalus spinescens	4.26	3.97	4.87	4.51	4.41	4.50
Felicia macrorrhiza	2.03	2.37	2.10	1.70	2.05	5.70
Osteospermum spinescens	3.74	2.92	6.03	5.85	4.64	6.00
Pentzia spinescens	2.15	2.48	3.54	2.74	2.73	4.80
Plinthus karooicus	2.44	1.81	0.81	1.36	1.61	6.40
Pteronia adenocarpa	2.09	3.18	1.95	1.50	2.18	3.90
Pteronia glomerata	2.28	2.63	2.19	1.15	2.06	3.90
Rosenia humilis	4.78	4.33	5.88	3.31	4.58	3.50
1992/93						
	Apr	Jul	Oct	Jan		
Eberlanzia ferox	2.16	2.04	2.45	1.62	2.07	2.70
Eragrostis lehmanniana	2.67	2.89	2.69	2.39	2.66	5.40
Eriocephalus ericoides	1.34	2.97	2.82	2.46	2.40	5.00
Helichrysum lucilioides	2.23	2.22	1.56	3.09	2.27	5.20
Pentzia spinescens	2.82	1.97	2.09	3.04	2.48	4.80
Plinthus cryptocarpus	1.59	0.92	0.54	1.02	1.02	6.70
Pteronia adenocarpa	1.30	1.58	1.78	1.19	1.46	3.90
Pterothrix spinescens	2.08	1.66	1.96	3.00	2.18	2.00
Rosenia humilis	3.34	4.35	4.36	3.66	3.93	3.50
Stipagrostis ciliata	8.65	6.56	12.93	9.46	9.40	7.20
Stipagrostis obtusa	1.21	0.62	1.97	0.82	1.15	6.60
Zygophyllum lichtensteinianum	1.34	1.62	1.20	1.56	1.43	7.00

[1] B = Karoo bushveld on stony shale veld
[2] G = Bushman grassveld on red sandy soil

7.3.4 The Great Karoo

7.3.4.1 Model 1

Grazing index value = 1.21 - (0.02 x available forage) - (1.80 x % N) + (0.12 x % TDN) - (0.61 x % Ether extract) + (0.24 x % Ash) (Table 7.3.4.1).

Table 7.3.4.1 Grazing index values calculated according to model 1

1990/91	OIV					GIV
	Apr	Jul	Oct	Jan	Mean	
Eberlanzia ferox	4.61	3.52	3.91	4.09	4.03	2.70
Eriocephalus spinescens	4.36	4.06	3.80	3.64	3.97	4.50
Pentzia spinescens	4.48	3.62	4.23	3.57	3.98	4.80
Rosenia humilis	3.06	3.55	3.03	3.10	3.18	3.50
Salsola tuberculata	7.89	8.08	8.86	9.28	8.53	6.90
Zygophyllum microphyllum	4.85	4.19	4.97	4.51	4.63	4.00
Fingerhuthia africana	6.18	6.56	6.99	5.97	6.43	6.60
Stipagrostis obtusa	10.18	6.57	7.17	7.36	7.82	6.60
1991/92						
	Apr	Jul	Oct	Feb		
Eriocephalus ericoides	4.11	4.46	4.56	3.61	4.19	5.00
Felicia fascicularis	5.83	3.63	6.91	3.98	5.09	6.20
Galenia secunda	5.17	5.49	5.91	4.16	5.18	4.70
Nenax microphylla	5.47	4.39	4.90	4.20	4.74	7.00
Osteospermum microphyllum	5.73	5.93	6.33	5.69	5.92	7.00
Pentzia spinescens	3.64	3.71	5.11	2.63	3.77	4.80
Pteronia staehelinoides	-20.17	-20.44	-17.54	-17.70	-18.96	4.00
Salsola rabieana	6.70	5.86	7.19	5.65	6.35	6.70
Walafrida geniculata	4.29	5.02	4.66	3.52	4.37	7.00
1992/93						
	Apr	Jul	Oct	Jan		
Eberlanzia ferox	4.17	5.44	4.45	5.19	4.81	2.70
Eriocephalus spinescens	5.24	4.73	5.20	3.98	4.79	4.50
Felicia fascicularis	6.57	4.42	7.21	5.59	5.95	6.20
Fingerhuthia africana	6.82	7.19	7.33	6.59	6.98	6.60
Helichrysum lucilioides	5.21	5.68	5.75	6.11	5.69	5.20
Hermannia desertorum	5.39	5.54	5.65	4.96	5.39	5.90
Nenax microphylla	5.68	4.89	4.96	5.32	5.21	7.00
Pentzia spinescens	5.01	4.20	5.35	4.95	4.88	4.80
Rosenia humilis	4.06	4.58	4.52	5.46	4.66	3.50
Salsola rabieana	5.17	6.83	6.61	6.68	6.32	6.70
Stipagrostis obtusa	11.13	7.39	7.52	8.05	8.52	6.60

7.3.4.2 Model 2

Grazing Index Value = - 21.56 - (0.02 x available forage) + (0.15 x % acid detergent fibre) + (0.40 x % TDN) - (2.45 x % K) + (1.32 x (K÷(Ca+Mg)) ratio) - (0.71 x % ether extract) + (0.21 x % ash) - (6.26 x % Na). (Table 7.3.4.2).

Table 7.3.4.2 Grazing index values calculated according to model 2

1990/91	OIV					GIV
	Apr	Jul	Oct	Jan	Mean	
Eberlanzia ferox	-6.64	-5.07	-3.99	-2.76	-4.61	2.70
Eriocephalus spinescens	-1.89	-0.14	-1.38	-0.24	-0.91	4.50
Pentzia spinescens	-0.39	-0.66	-0.37	-0.09	-0.38	4.80
Rosenia humilis	-1.16	-0.24	-0.20	-0.79	-0.60	3.50
Salsola tuberculata	1.35	0.34	1.80	4.68	2.04	6.90
Zygophyllum microphyllum	-0.25	-0.75	-0.21	0.92	-0.07	4.00
Fingerhuthia africana	3.18	3.26	4.52	4.68	3.91	6.60
Stipagrostis obtusa	7.82	4.83	5.98	5.68	6.08	6.60
1991/92						
	Apr	Jul	Oct	Feb		
Eriocephalus ericoides	-1.33	-0.49	-0.75	00.89	-0.86	5.00
Felicia fascicularis	1.97	-0.13	4.40	-0.55	1.42	6.20
Galenia secunda	-0.23	-12.82	-3.36	-1.88	-4.57	4.70
Nenax microphylla	0.74	-3.21	0.48	-0.64	-0.66	7.00
Osteospermum microphyllum	1.66	2.78	2.56	2.10	2.27	7.00
Pentzia spinescens	0.25	-0.40	1.20	-1.60	-0.14	4.80
Pteronia staehelinoides	-29.28	-29.07	-26.34	-27.90	-28.15	4.00
Salsola rabieana	1.95	-1.18	3.28	-0.90	0.79	6.70
Walafrida geniculata	0.36	3.19	1.34	-0.05	1.21	7.00
1992/93						
	Apr	Jul	Oct	Jan		
Eberlanzia ferox	-4.85	-0.44	-4.03	-2.99	-3.08	2.70
Eriocephalus spinescens	2.31	1.74	2.92	0.53	1.88	4.50
Felicia fascicularis	3.96	2.17	5.38	2.72	3.56	6.20
Fingerhuthia africana	7.12	6.43	7.05	5.16	6.44	6.60
Helichrysum lucilioides	2.41	3.98	2.75	3.90	3.26	5.20
Hermannia desertorum	3.09	3.66	3.79	3.08	3.41	5.90
Nenax microphylla	2.48	1.37	1.45	1.76	1.77	7.00
Pentzia spinescens	0.76	1.98	2.72	2.22	1.92	4.80
Rosenia humilis	3.43	3.02	2.75	2.50	2.92	3.50
Salsola rabieana	-1.83	0.70	3.28	-1.43	0.18	6.70
Stipagrostis obtusa	10.17	6.76	7.25	7.13	7.83	6.60

7.3.4.3 Model 3a (Karoo bushes)(Table 7.3.4.3)

Grazing index value = ((available forage + TDN + cover + (K ÷ (Ca + Mg))) ÷ ether extract) ÷ 100.

7.3.4.4 Model 3b (Grasses)(Table 7.3.4.3)

Grazing index value = ((available forage + TDN + cover + (K ÷ (Ca + Mg))) x ether extract) ÷ 100.

Table 7.3.4.3 Grazing index values calculated according to model 3

1990/91	OIV					GIV
	Apr	Jul	Oct	Jan	Mean	
Eberlanzia ferox	2.21	1.66	1.35	1.18	1.60	2.70
Eriocephalus spinescens	4.44	3.35	5.77	3.70	4.31	4.50
Pentzia spinescens	2.56	2.70	2.12	2.04	2.36	4.80
Rosenia humilis	5.01	3.68	6.06	4.49	4.81	3.50
Salsola tuberculata	2.22	1.64	2.72	2.44	2.25	6.90
Zygophyllum microphyllum	4.52	2.91	3.80	3.91	3.78	4.00
Fingerhuthia africana	4.96	3.33	2.62	4.59	3.88	6.60
Stipagrostis obtusa	3.12	3.46	0.75	2.55	2.47	6.60
1991/92	Apr	Jul	Oct	Feb		
Eriocephalus ericoides	0.64	0.84	0.57	0.65	0.67	5.00
Felicia fascicularis	0.64	0.22	0.62	0.23	0.43	6.20
Galenia secunda	2.53	5.98	6.21	4.96	4.92	4.70
Nenax microphylla	0.89	0.50	0.50	0.77	0.66	7.00
Osteospermum microphyllum	1.51	1.79	1.66	1.66	1.66	7.00
Pentzia spinescens	2.37	1.98	1.92	2.06	2.08	4.80
Pteronia staehelinoides	0.17	0.17	0.22	0.14	0.17	4.00
Salsola rabieana	3.01	2.79	3.52	3.06	3.09	6.70
Walafrida geniculata	4.07	4.29	3.92	2.39	3.67	7.00
1992/93	Apr	Jul	Oct	Jan		
Eberlanzia ferox	1.85	1.24	1.33	1.07	1.37	2.70
Eriocephalus spinescens	3.20	3.54	4.80	3.08	3.66	4.50
Felicia fascicularis	0.63	0.28	0.68	0.26	0.46	6.20
Fingerhuthia africana	2.55	5.19	2.62	4.82	3.80	6.60
Helichrysum lucilioides	1.30	1.82	1.03	0.94	1.27	5.20
Hermannia desertorum	1.18	1.35	1.20	1.09	1.21	5.90
Nenax microphylla	0.75	0.59	0.58	0.58	0.62	7.00
Pentzia spinescens	1.50	1.48	1.79	1.32	1.52	4.80
Rosenia humilis	3.75	3.03	4.32	2.44	3.38	3.50
Salsola rabieana	3.88	3.25	3.49	4.09	3.68	6.70
Stipagrostis obtusa	2.65	2.23	1.19	2.34	2.10	6.60

7.4 Discussion

The separate equations of the third model (3a & 3b) developed for the individual estimation of the grazing index values of the grasses and karoo bushes, seem to be the most appropriate to be used in the estimation of the grazing index values (Table 7.4). In the case of the Eastern Mixed Karoo, this model estimated objective grazing index values in fairly close agreement with the subjectively estimated grazing index values, as measured by the d statistic. The d statistic is the index of agreement between two sets of values (Willmott & Wicks 1980; Willmott 1981, 1982; Booysen 1990), and the closer the value approaches 1, the better the agreement between the two sets of values being compared. In the case of the Eastern Mixed Karoo the d statistics are 0.69 for model 3, 0.62 for model 1 and 0.60 for model 2.

The d statistics in the case of the grazing index values of the Great Karoo is 0.40 for model 2, 0.33 for model 3 and 0.32 for model 1. These values are relatively low and signifies that there is little agreement between the two sets of values. The higher value calculated for model 2 is of little consequence, since most of the estimated values are negative and since a plant cannot have a negative grazing value, these values cannot be used for the estimation of grazing capacity. The second highest value belongs to model 3, the model most likely to render acceptable grazing index values.

For the grazing index values of both the Karoo Mountain areas and the Arid Karoo, model 1 yields the best results, with d statistics of 0.81 and 0.74 respectively. Model 2 is the second best with d statistics of 0.63 and 0.55 respectively, but once again in the case of the Arid Karoo model 2 estimates negative values, which cannot be used. The d statistics for model 3 are still fairly high, 0.53 in the case of the Karoo Mountain areas and 0.49 in the case of the Arid Karoo.

7.5 Conclusions

It seems likely therefore, that despite some low calculated d statistics,

Table 7.4 Mean objective grazing index values (O.I.V.) calculated according to model 3 and derived from the tables above, compared to the G.I.V.

Karoo bushes	OIV				GIV
	Min	Max	Mean[1]	Std dev	
Chrysocoma ciliata	0.83	-	0.83	0	1.50
Eberlanzia ferox	1.37	2.78	1.96	0.54	2.70
Eriocephalus ericoides	0.67	2.40	2.54	1.51	5.00
Eriocephalus spinescens	2.22	4.41	3.65	0.87	4.50
Felicia fascicularis	0.43	0.56	0.48	0.06	6.20
Felicia filifolia	2.63	-	2.63	0	5.90
Felicia macrorrhiza	2.05	-	2.05	0	5.70
Galenia secunda	4.92	-	4.92	0	4.70
Helichrysum dregeanum	0.48	-	0.48	0	6.30
Helichrysum lucilioides	1.27	2.27	1.75	0.41	5.20
Hermannia desertorum	1.21	-	1.21	0	5.90
Monechma incanum	9.76	-	9.76	0	5.40
Nenax microphylla	0.62	1.97	1.16	0.56	7.00
Osteospermum microphyllum	1.66	-	1.66	0	7.00
Osteospermum spinescens	4.64	-	4.64	0	6.00
Pentzia incana	1.22	1.73	1.50	0.21	5.70
Pentzia globosa	1.18	1.32	1.25	0.06	4.80
Pentzia spinescens	1.52	4.31	2.43	0.88	4.80
Plinthus cryptocarpus	1.02	2.87	1.95	0.92	6.70
Plinthus karooicus	1.61	2.50	2.06	0.44	6.40
Phymaspermum parvifolium	0.52	2.82	1.60	1.07	6.20
Pteronia adenocarpa	1.46	2.18	1.82	0.36	3.90
Pteronia glauca	2.77	-	2.77	0	3.20
Pteronia glomerata	2.06	-	2.06	0	3.90
Pteronia staehelinoides	0.17	-	0.17	0	4.00
Pterothrix spinescens	1.29	2.28	1.92	0.44	2.00

Table 7.4 (continued)

Rosenia humilis	3.30	4.81	4.00	0.56	3.50
Rosenia oppositifolia	0.82	-	0.82	0	3.10
Salsola calluna	5.11	-	5.11	0	7.20
Salsola rabieana	3.09	3.68	3.39	0.29	6.70
Salsola tuberculata	2.25	6.17	4.21	1.96	6.90
Walafrida geniculata	3.00	3.67	3.34	0.34	7.00
Walafrida saxatilis	0.69	-	0.69	0	2.00
Zygophyllum microphyllum	3.78	-	3.78	0	4.00
Zygophyllum lichtensteinianum	1.43	-	1.43	0	4.00
Grasses					
Aristida congesta	1.26	1.82	1.54	0.28	1.30
Aristida diffusa	3.47	8.40	5.76	2.03	5.10
Digitaria eriantha	5.90	11.82	8.33	2.53	8.90
Eragrostis lehmanniana	2.16	3.41	2.70	0.45	5.40
Eragrostis curvula conferta	1.44	4.08	2.76	1.32	6.90
Fingerhuthia africana	2.56	3.88	3.41	0.60	6.60
Heteropogon contortus	4.24	4.42	4.33	0.09	7.20
Hyparrhenia hirta	8.71	-	8.71	0	6.30
Merxmuellera disticha	7.47	-	7.47	0	5.00
Themeda triandra	5.53	10.06	6.10	2.53	9.30
Sporobolus fimbriatus	7.08	-	7.08	0	9.50
Stipagrostis ciliata	3.56	9.40	5.82	2.56	7.20
Stipagrostis obtusa	1.15	3.39	2.41	0.69	6.60

The mean, was calculated as the sum of all the values obtained for a particular species and divided by n.

model 3 will consistently yield the best results when estimating grazing index values. It must also be borne in mind that the values against which the objectively estimated grazing index values were compared, represent subjective value judgements, and that there is no way in which one can be sure that they indeed represent the true grazing value of the species (Table 7.4). Insofar, the d statistics are merely indicators of how well the two sets of values correspond to each other. Not too much reliance must be placed on the d statistic as representing the true value of the grazing index values of any of the two sets of values. The preferred model at least takes into account palatability, as expressed by the chemical constituents of the species as well as the vegetative characteristics, such as canopy spread cover and available forage production of the different plant species. It may be possible to further refine this model to yield better results, by incorporating some of the parameters excluded from the model at the moment.

With this model it is possible to compute the grazing index value for any species. By employing the relation between canopy spread cover, the aboveground available forage production and the quality variables of the species concerned, the grazing index value of any species can be estimated. Quality parameters can be gleaned from the literature, mentioned previously, or be determined empirically for species where such data do not exist at the moment. It then still remains for the canopy spread cover and the aboveground available forage production to be estimated for the species concerned.

CHAPTER 8

THE GRAZING INDEX METHOD

8.1 The Grazing Index Method, data collection

The theory of succession has been poorly tested in the Karoo (Hoffman 1988). The Ecological Index Method (Vorster 1982), based on Quantitative Climax Principles (Dijksterhuis 1949), therefore, needs to be replaced by a method which will objectively estimate current agronomic grazing capacities. The Grazing Index Method, where the grazing index values are to be used in the estimation of the current grazing capacity, is such a method. With both the subjective and objective scoring methods, departures from the old ecological index values are frequent, with many species scoring either higher or lower than previously. It therefore serves no practical purpose in retaining the concepts associated with succession and used previously, except in broad discussions regarding the vegetation, it's reaction to grazing and probably in discussions on trend in veld condition, the following classificatory terminology: decreasers, increasers, invaders, climax -, sub-climax and pioneer plants, have also been abandoned for the purposes of allocating grazing index values to plant species.

The Grazing Index Method (GIM) was therefore developed in an effort to overcome the problems referred to above. Its mode of operation is independent of succession theory, since it depends upon the agronomic attributes of the species, with each species playing its own unique role in the estimation of the grazing capacity. Furthermore the Grazing Index Method was developed in an attempt to forestall confusion between the applications of the EIV's and the GIV's. The GIV's will henceforth be used in the applications of the Grazing Index Method.

8.1.1 Data collection to test the Grazing Index Method

Data collected by Botha (1991) were analysed by means of the EIM using the EIV's and by means of the GIM using the GIV's, in order to assess their relative efficiencies in estimating the current grazing capacity. When reference is made to Chapter 2, Table 2.2, the advantage in using the GIM becomes clear.

8.1.2 Sampling procedure

An estimate of the botanical species composition of the sampling site is obtained by recording the canopy spread cover according to the descending point method described by Roux (1963). This method is favoured due to the shortcomings in the measurement of basal cover (Daubenmire 1959; Mentis 1982; Vorster 1982; Palmer *et al*. 1990) and the recording of frequency (nearest plant method)(Vorster 1982). In order to obtain an estimate of plant cover and the botanical species composition, only primary strikes on canopy spread cover are recorded. The strike on a particular species was found to represent a function of it's productivity (personal observation; Chapter 9 and Appendix 8; cover being highly significantly correllated with mean forage production). The more individuals of a particular species that occur at a site and the higher the density and the dry matter production of the species, the higher the probability of that particular species being recorded (Novellie & Strydom 1987). Two hundred points per sample plot were assessed in plots laid out in apparently homogeneous vegetation. Four parallel lines were laid out, with the lines six metres apart and the sampling points in the line spaced one metre apart. The total number of strikes per species is summed and expressed as a percentage of the total number of point observations. The botanical composition recorded from cover strikes was not converted to proportional species composition (Foran *et al*. 1978; Tainton *et al*. 1980; Barnes *et al*. 1985) nor was it necessary to group the species (Bement & Davis 1958), prior to the computation of a veld condition index. The results of the surveys are presented later in Table 8.1.

8.1.3 Study area and Veld Types sampled during this study

Veld condition assessments were carried out at Pofadder in the Arid Karoo (Veld Type no. 29, Acocks 1988), at Beaufort West in the Central Lower Karoo (Veld Type no. 30), at Victoria West in the Central Upper Karoo (Veld Type no. 27) and at Burgersdorp, Middelburg and Petrusville in the False Upper Karoo (Veld Type no. 36). Sample sites include a wide variety of veld types and rainfall zones (Table 2.2), from arid late successional grassland through veld dominated by karoo bushes, through degraded grassland with a large percentage of karoo bushes (Raper & Boucher 1988, quoted by Hoffman & Cowling 1990), to medium to high rainfall late successional stage grassland. The rainfall varies from 80 $mm.a^{-1}$ in the northwest, through 200 $mm.a^{-1}$ in the south, through 300 $mm.a^{-1}$ up to 450 $mm.a^{-1}$ in the north east.

8.2 Development of the Grazing Index Method

8.2.1 Ecological Index Values

The construction of a single series of index values based on different value systems applicable to different plant groups is inappropriate and it follows that the application of such a series, is fraught with difficulties. The condition scores computed by means of the EIM is indicative of the ecological state of health of the grasses on the one hand, but of the agronomic state of health of the karoo bushes on the other (Tainton 1981). The EIV's are therefore incorrectly used when the agronomic potential of the veld is assessed, with a view to estimate grazing capacity.

The EIM assumes that all late succession grasses are equally productive and acceptable to stock. This is not the case and it soon became apparent that the late succession grasses played too significant a role in the computation of a veld condition index (Botha 1991). When the EIV's are used in the computation of the veld condition scores in both the arid and the high rainfall late succession grassland areas, current grazing capacities are over-estimated, due to the ecological index value of 10 accorded the late succession grasses (Botha 1991). Similar conclusions were reached by Hardy & Hurt (1989), but from a different perspective. A degree of under-estimation of the current grazing capacity occurs in karoo bushveld, due to the low index values accorded most of the karoo bushes. This is compounded by the nature of the series, which does not allow for fine distinctions to be drawn between closely related species and where the karoo bushes are forced into the lower ranks of the series.

8.2.2 Grazing Index Values

The grazing index values enable fine distinctions to be drawn between the grazing values of related species (Botha et al. 1993; Du Toit et al. 1995). In the case of the Eragrostis species, not all the species are equally valuable as forage and this fact is acknowledged in the new series. Instead of the EIV of seven, E. superba now has a GIV of 4.7, E. plana, 4.8, E. lehmanniana, 5.4, E. chloromelas, 5.5 and E. curvula, 6.7. The karoo bushes are affected similarly, although there is a tendency towards a slightly higher index value, for instance, in the case of Pentzia species. The following species all had an EIV of 4, but P. tortuosa now has a GIV of 2.9, P. elegans, 3.8, P. dentata, 4.2, P. pinnatisecta, 4.5, P. globosa, 4.8, P. spinescens, 4.8, P. incana, 5.7 and P. lanata, 5.7.

The latest nomenclatural practices accept P. lanata as a synonymn of P. spinescens, however, due to growth form differences and the variation in palatability between these two species, they are kept separate for the purposes of this treatise as well as in the allocation of a grazing index value (refer to section 3.6).

There is an overall tendency for the grasses to score somewhat lower while the karoo bushes score slightly higher, than was the case with the previous series of index values. Where grasses are found to be abundant, this significantly affects the computation of a veld condition score and hence the estimated current grazing capacity.

Since the GIV's comprise mainly agronomic features of the species, the computed veld condition score therefore represents an objective agronomic value. This enables the calculation of a realistic estimate of the current grazing capacity of a sample of veld which is indicative of the potential of the site to support livestock.

This agronomic classification of the veld, coincides with popular American usage of range condition, where range condition is indicative of the current season's forage production (Sampson 1952; Bement & Davis 1958). With the EIV's the calculation of such a value was not possible, since the veld condition score, derived from the EIM partly indicated the ecological status of the veld, being based on the successional stage of the grass species and partly it's agronomic status, being based on the palatability of the karoo bush species. In this instance the estimate of the current grazing capacity involved a value judgement as to the potential of the site to support livestock. Hence, the estimate of the current grazing capacity based on the ecological veld condition score was inappropriate.

8.2.3 Application of the Grazing Index Method

The Grazing Index Method is applied to the results of a botanical survey, in exactly the same way as the Ecological Index Method, described by Vorster (1982), used to be applied (Vorster et al. 1984). The most noteworthy exception is that the ecological index values are replaced by the grazing index values. Since the GIV's comprise mainly agronomic features of the species, it is reasoned that their use in the computation of veld condition scores, will render more acceptable results, than will the use of the EIV's. The grazing index values were therefore applied through the Grazing Index Method.

Current grazing capacities were estimated from the veld condition scores for the sample sites, mentioned earlier. The current grazing capacities estimated for these areas by means of the GIM, correspond more closely to the grazing capacity norms advocated by the Department of Agriculture and applied to these areas, than is found with the use of the EIM. Regressing the grazing capacity norms, advocated by the South African Department of Agriculture, on median annual precipitation renders a coefficient of determination of $r^2 = 0.98$ ($Y = 46.94 - 0.08X$, the correlation coefficient = 0.99 and the standard error of the Y - estimate = 0.99). The median annual precipitation was chosen because it more accurately estimates long-term precipitation (Sneva & Hyder 1962) and because it is less influenced by single extreme rainfall events than the mean (Daubenmire 1956). Employing the GIM to estimate current grazing capacities, a coefficient of determination of $r^2 = 0.96$ is computed ($Y = 42.96 - 0.07X$, the correlation coefficient = 0.96 and the standard error of the Y - estimate = 2.07), whereas employing the EIM to estimate the current grazing capacities, a coefficient of determination of $r^2 = 0.68$, is computed ($Y = 37.43 - 0.06X$, the correlation coefficient = 0.83 and the standard error of the Y - estimate = 5.66).

The index of agreement (Willmott & Wicks 1980; Willmott 1981, 1982; Booysen 1990) of the regression of estimated grazing capacities employing the EIV's, on the estimated grazing capacities employing the GIV's, is d = 0.89. This represents a degree of convergence between the two sets of index values. However, the low coefficient of determination, $r^2 = 0.67$, indicates that the individual use of the two sets of index values will result in relatively large differences in the computation of the veld condition scores, and hence in the calculated current grazing capacities.

8.3 Comparison of the Grazing Index Method with other methods

8.3.1 Recording of canopy spread cover and basal cover

An estimate of plant cover is obtained from primary strikes on canopy spread cover (Roux 1963). This method is favoured due to the shortcomings in the measurement of basal cover (Mentis 1982; Vorster 1982; Hofman and Cowling 1990; Palmer et al. 1990). It was found in the Karoo, that the basal cover measurement favours the perennial grass component over the annual grasses, ephemerals and karoo bushes (Vorster 1982; Palmer et al. 1990), owing to the larger basal area covered by the perennial grasses. Daubenmire (1959) came to the same conclusion in the United States of America. Although basal cover used to be recorded in the benchmark method (BM) (Tainton et al. 1980), the botanical species composition was not based on the basal cover strikes, but on records of nearest plant data (Foran et al. 1978) in order to arrive at the proportional species composition. No estimate of canopy spread cover is therefore available.

8.3.2 Recording of nearest plant

In order to estimate the botanical species composition, the recording of primary strikes on the canopy spread cover are favoured, due to the shortcomings in the recording of the nearest plant technique (frequency) (Vorster 1982). In the Karoo it was found that, owing to their smaller size and higher density, nearest plant measurement favours the annual grasses and ephemeral forbs over perennial grasses and karoo bushes (Vorster 1982). Correlations of nearest plant data with cover strike data, yielded an $r^2 = 0.97$. Therefore, in excess of 98 % of the variation in the botanical composition of the sites was explained by the canopy spread cover strike data only (Botha pers. comm.[10]), and it was subsequently decided to abandon the recording of the nearest plant in

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10. Botha, W. Van D., Grootfontein Agricultural Development Institute, Private Bag X 529, Middelburg. 5900. Eastern Cape Province.

favour of the canopy spread cover strike only. In order to be recorded as the nearest plant, the plant had to be as close or closer to the observed point, than the mean diameter of the plants found in the area, otherwise no nearest plant was recorded. A further problem was that when the nearest plant was an annual plant or forb, it was ignored and the nearest perennial plant was recorded. This practice introduce bias into the data set. Furthermore, it was established subsequently that canopy spread cover provided a realistic estimate of both the visual botanical species composition, the aerial cover of the site (Roux 1963; Vorster 1982) as well as forage abundance (Daubenmire 1959; Novellie & Strydom 1987; Jonasson 1988; personal experience and observation this study, cf. Appendix 8).

The fact that the botanical species composition data are not converted to proportional species composition (species frequencies totalling to 100), but are used in the computations as the actual cover percentages recorded (species abundances)(Novellie & Strydom 1987), stands in sharp contrast to the Benchmark Method described by Foran et al. (1978), refined by Tainton et al. (1980) and used extensively by Barnes, Rethman, Beukes & Kotze (1984); Barnes, Beukes & Kotze (1985); Heard, Tainton, Clayton & Hardy (1986); Hardy & Hurt (1989) and Hurt & Bosch (1991). The single most important difference between the two methods is the fact that the Benchmark Method always records 100 % cover (nearest plant irrespective of distance from the observed point), whereas the GIM records variable cover (canopy spread cover), only rarely approaching 100 %.

The fact that botanical species composition data, recorded from cover strikes, are not converted to proportional species composition, significantly affects the computation of the veld condition score for the sample site and the eventual estimate of the current grazing capacity for that site. It follows that where nearest plant data is recorded, i.e. 100 % proportional species composition, the computed sample site score will be higher than is the case where the score is computed from strike (species abundance) data only. It is therefore apparent that this will significantly affect the estimation of the current grazing capacity. In the case of the farm Grappies (Table 2.2A), the use of proportional species composition data increases the estimated grazing capacity from 38.2 ha.Large Stock Unit^{-1} (LSU) to 34.6 ha.LSU^{-1}, while on the farm Knolepark (Table 2.2A), the estimated grazing capacity increases from 12.5 ha.LSU^{-1} to 11.2 ha.LSU^{-1}. This represents an increase of 9 to 10 %, however, these values are still in fair agreement with the established grazing capacities and the Department of Agriculture's grazing capacity norms. In instances where the cover score is very low, proportional data significantly over-estimates the current grazing capacity. In the case of the farm Swartgrond (Table 2.2C), the estimated grazing capacity increases from 34.2 ha.LSU^{-1} to 13 ha.LSU^{-1}, this represents a threefold increase in the estimated grazing capacity which is quite unacceptable when compared to the Department of Agriculture's grazing capacity norm of 32 ha.LSU^{-1}.

A second significant difference between the GIM and the BM is the fact that the nearest plant data recorded in the BM, provides no indication of the production potential, nor of the dominance of the plant species. The canopy spread cover data, as used by the GIM is similar to the EIM and is an expression of the production potential of the species recorded (Daubenmire 1959; Novellie & Strydom 1987; Jonasson 1988; personal experience this study), contrary to the views expressed by Hurt & Bosch (1991) who favoured the Weighted Key Species Method. The fact that only primary strikes on canopy spread cover are recorded, signifies that the dominant species at each sampling point is recorded, this is linked to the forage production potential of the particular species (Novellie & Strydom 1987; personal observation this study) and finds expression in the computation of the condition score. Nearest plant data, unlike the canopy spread cover estimate of the GIM, may provide an erroneous representation of plant dominance and productivity, if extreme care is not exercised in the recording of the nearest plant. This can lead to undue subjectivity in obtaining realistic estimates of the species composition and incorrect grazing capacity estimation.

8.3.3 Forage value ratings

In the case of the forage value rating of the karoo bushes, the GIM is similar to the Weighted Palatability Composition Method of estimating grazing capacity described by Barnes et al. (1984). However, the two methods differ in their application. The Weighted Palatability Composition Method, like the BM provides no estimate of herbage on offer.

8.3.4 Weighted species scores

The GIM is a weighted species method in sofar as weighted scores are assigned to species, it is however, not comparable to the Weighted Key Species Methods described by Heard et al. (1986), Hurt & Hardy (1989) and Hurt, Hardy & Tainton (1993). It differs in the first instance from these methods in that the weights are derived from agronomic attributes of the species (Du Toit et al. 1995) and not from relativized ecological attributes, obtained during multivariate analyses of the species abundances on various environmental variables (Heard et al. 1986; Hurt & Hardy 1989; Hurt et al. 1993). In the second instance the GIM does not allow for the use of key species. Owing to the diverse nature of the Karoo flora (refer to Table 2.2), it is virtually impossible to select key species, which will ensure the meaningfull extrapolation of estimates of grazing capacities across the boundaries of the agro-ecological areas. All the commonly occurring species are weighted and each species has it's own unique GIV (Du Toit et al. 1995) through which a species makes a definite but unique contribution to the final computed score. It follows therefore that it is valid to estimate the current grazing capacity from the veld condition score computed for a sample site. Because in this case, the veld condition score is linked to the potential of the site to support livestock, through the various attributes contributing to the GIV's of the species (Botha et al. 1993; Du Toit et al. 1995) and through the method of recording.

These GIV's were applied to veld condition assessments carried out over a wide variety of veld types, from markedly different rainfall zones (Table 2.2). Current grazing capacities were estimated from the veld condition scores computed for these sample sites. These grazing capacities are in line with the grazing capacity norms applicable to these areas (Figure 8.1) and as propounded by the South African Department of Agriculture.

8.3.5 Use of the Veld Condition Index

Lower indices of veld condition are generally computed for veld dominated by climax grasses, when the GIV's are used, than when the EIV's are used in the computations of the veld condition scores (Table 2.2, Pofadder and Burgersdorp sample sites). Where karoo bushes dominate the vegetation (Table 2.2, Beaufort West, Victoria West and Middelburg sample sites) the computed veld condition scores are higher. In one sample site in Victoria West where the veld is composed of both karoo bushes and a late successional grass species (Stipagrostis species), the veld condition score and the estimated current grazing capacity remains virtually unchanged. This condition comes about because of the lower index values of the grass species, but the slightly higher index values accorded the karoo bushes.

The index of veld condition can be employed to monitor trend and change in condition between treatments, due to treatment effect and due to seasonal effects, at the same sample site (Table 8.1). From Table 8.1 it can be inferred that the camp grazed in summer, was the most susceptible to the drought experienced during 1993. Approximately 50 % of the precipitation, for that season, was measured during the growing season. Apparent is the fairly low score of the grass camp, where it was found that many of the late successional grasses had died during the drought. During the previous season (1992), more than 60 % of the precipitation was measured during the growing season and this found expression in a

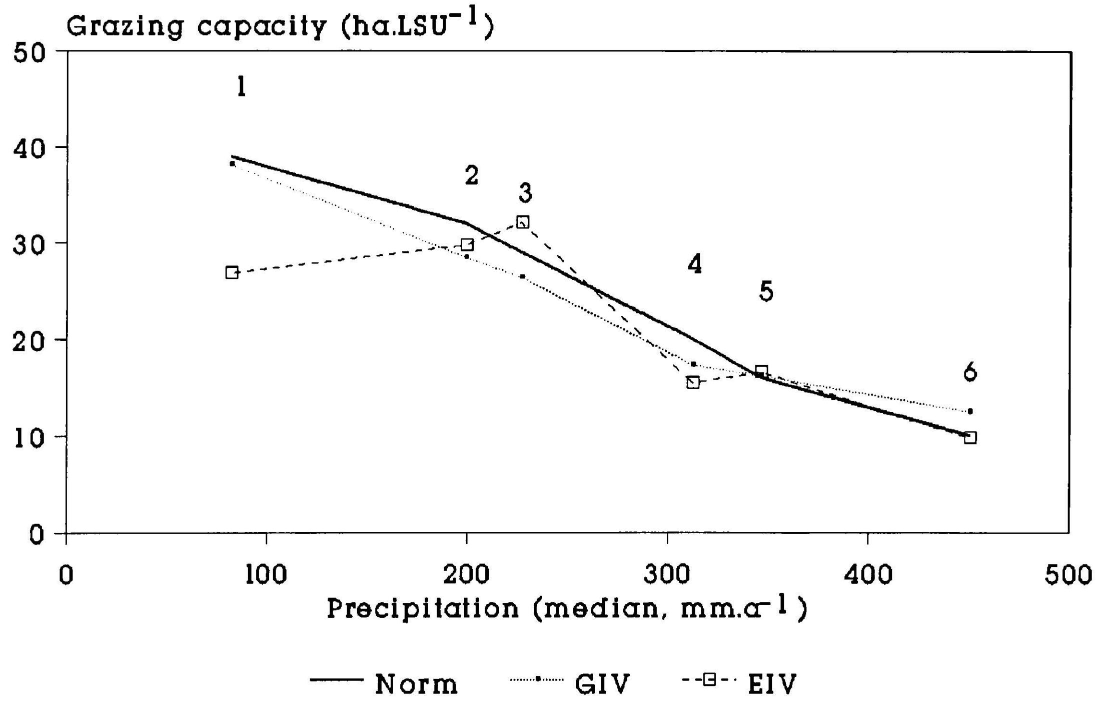

Figure 8.1 Grazing capacities regressed on median rainfall for 6 sample sites, also refer to Table 2.2. Sites 1 and 6 (A), represent late successional stage grasslands, sites 4 and 5 (B), are in degraded grasslands (Raper & Boucher 1988 quoted by Hoffman & Cowling 1990) with varying percentages of karoo bush present , while sites 2 and 3 (C), are in karoo bushveld. Site 1 is at Pofadder, 2 at Beaufort West, 3 at Victoria West, 4 at Petrusville, 5 at Middelburg and 6 at Burgersdorp. The grazing capacity norm has a coefficient of determination, r^2=0.9825, the grazing capacities determined by means of: the GIV has an r^2 = 0.9628 and the EIV has an r^2 = 0.6846, indicating the "good fit" of the GIV-regression on the regression of the grazing capacity norm

Table 8.1 A comparison of the veld condition scores of three camps grazed continuously in late winter and spring (karoo bush, camp 1), summer (mixed karoo bush and early successional grass, camp 2) and autumn and early winter (grass camp, camp 3); and the previous 12 months' precipitation, 50 % of the measured precipitation fell during the active growth stages of the karoo bushes. Data from Du Toit (1993b, 1994).

	camps				
season	1	2	3	mean	precipitation (mm)
1989	165.3	232.3	251.1	216.2	576
1990	173.9	162.5	326.4	220.9	457
1991	221.4	204.3	207.6	211.1	372
1992	120.2	170.0	153.0	147.7	260
1993	105.8	64.6	126.9	99.1	179
mean	157.3	166.7	213.0	179.0	

flush of low successional stage grasses adding to the high cover score and subsequently to the high condition score of the camp grazed in summer. In this case the percentage cover measured was 33.5 % for treatment 1, 49 % for treatment 2 and 38 % for treatment 3, an indication that the cover - and veld condition scores operate independently of each other. In the low successional stage grass camp a much higher cover score is needed to produce a condition score similar to the one computed for the mid-successional stage grass camp.

8.3.6 Use of the Cover estimate

The percentage canopy spread cover is a valuable criterion that can be used in the monitoring of veld condition between different sites, at a specific site between treatments, and between seasons within a treatment (Table 8.2). It has been stated that values of cover data and the condition scores computed for sample sites are similar, follow the same trend and vary in the magnitude of the computed value only (Tainton pers. comm.[11]). A regression of veld condition score on percentage cover (Figure 8.2), yields a coefficient of determination of r^2 = 0.45 and a d-statistic (Willmott & Wicks 1980; Willmott 1981, 1982; Booysen 1990), i.e. the index of agreement of d = 0.15. It is clear that although there is a similar trend in the cover and condition indices, as can be ascertained from Figure 8.2, they are not convergent, as established by the low index of agreement. Both the low coeficient of determination and the low d-statistic confirms that the cover and condition scores operate independently of one another. The fact that the species have unique index values, ensure their independence from the cover of the community as a whole. The cover value is therefore seen as a valuable additional criterion to be used in the monitoring of the condition of different sample sites (Figure 8.3), especially where the cover value is read in conjunction with the species abundances and the condition score of the sample site. From Figure 8.3 it is clear that the cover

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11. Tainton, N.M., 28 Collins Road, Hayfields. 3201.Kwazulu-Natal.

Table 8.2 A comparison of the cover of two camps grazed continuously in winter and spring (karoo bush camp, 1) and grazed continuously in summer and autumn (grass camp, 2); precipitation as in Table 7.1. Data from Du Toit (1993b, 1994)

	camps		
season	1	2	precipitation (mm)
1989	66	48	576
1990	41.5	53	457
1991	60.5	63	372
1992	32.5	45	260
1993	35.5	48.5	179
mean	46.6	51.5	

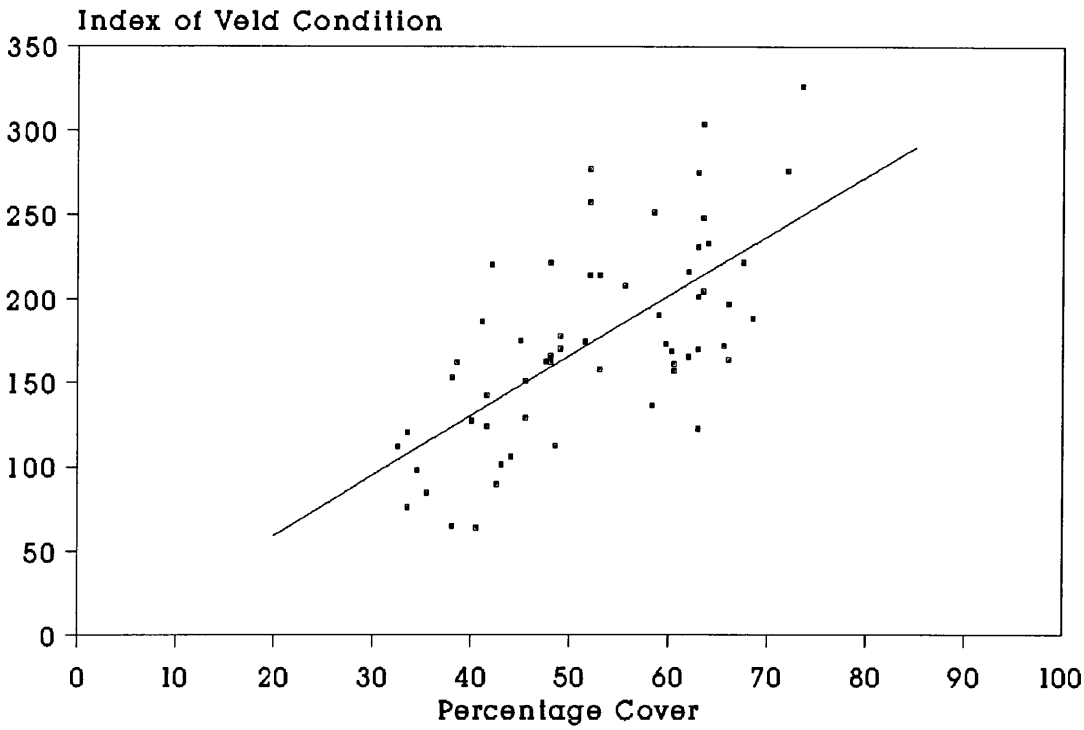

Figure 8.2 A regression of the veld condition scores on percentage cover, determined for 12 sample sites over five years (1989 to 1993), in the **Camp 6** experiment at Grootfontein.

Analysis: **$Y = -11.8862 + 3.5565X$**

$r^2 = 0.4463$

Correlation coefficient = 0.6681

Standard error of the estimate = 44.2243

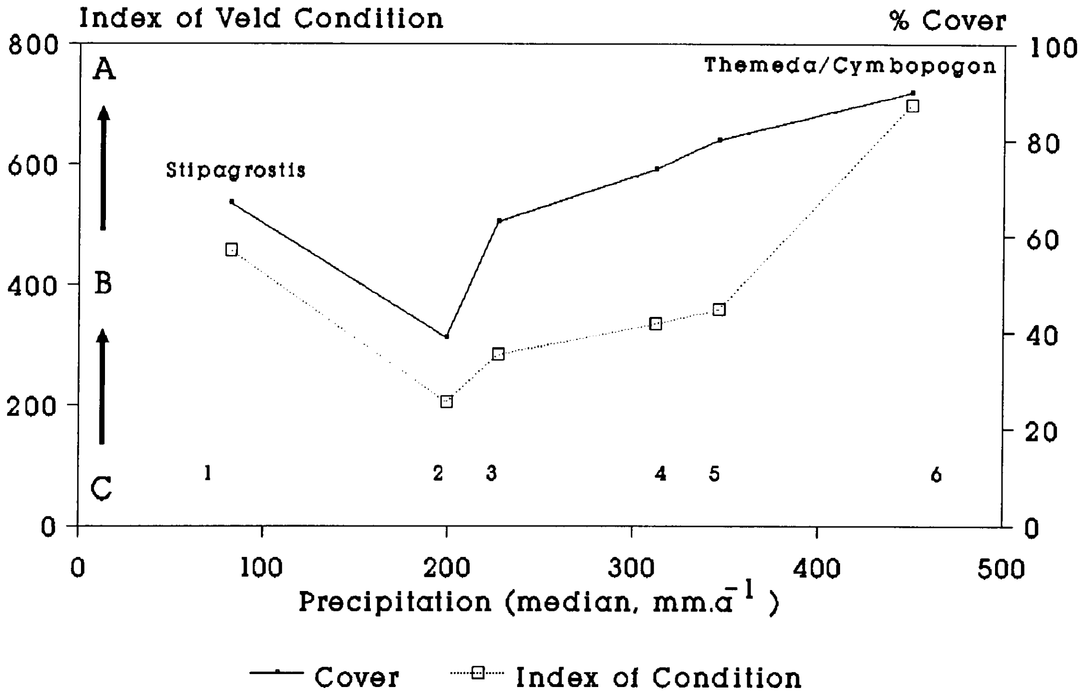

Figure 8.3 Veld condition - and cover indices for six sample sites from four reasonably homogeneous areas in the Karoo, as indicated in Figure 1, plotted on the median precipitation for these areas. A maximum veld condition index of 1000 is possible. The divergence between the cover and veld condition indices for sites 3, 4 & 5 is attributable to the nature of the botanical composition, refer to Table 2.2. Sites 1 and 6 (A), represent late successional stage grasslands, sites 4 and 5 (B), are in degraded grasslands (Raper & Boucher 1988 quoted by Hoffman & Cowling 1990) with varying percentages of karoo bush present , while sites 2 and 3 (C), are in karoo bushveld

value is generally high in the grassland areas while it is low in karoo bush areas. Degraded grassland with a fairly large percentage of karoo bushes (Raper & Boucher 1988, as quoted by Hoffman & Cowling 1990), occupies a somewhat intermediate position owing to the presence of fairly large proportions of early and mid-successional grasses. From Table 8.2 it can be seen that the grass camp, grazed during the dormant phase of the grass, tends to have a higher canopy spread cover than the karoo bush camp, grazed during the active growth phase of the grass, except during the very high rainfall season. This can be explained by the high number of karoo bush seedlings produced during the favourable season. The high cover value reported for the karoo bush camp during 1989 is a reflection of the large number of seedlings, rather than exceptional growth of the karoo bushes.

8.4 Conclusions

The Grazing Index Method provides useful agronomic indices of the veld condition, on which to base estimates of grazing capacities. Where the GIV's have been used in the computation of veld condition indices and the subsequent calculation of the current grazing capacities, these have been found to vary only slightly from the Department of Agriculture's grazing capacity norms established for the different grazing capacity zones. Estimates of the current grazing capacity in the case of the GIM reflects the grazing capacity as at that moment, because the amount of grazable forage has been taken into account, through both the method of recording strikes on canopy spread cover, as well as through the index values accorded the species.

The most significant conclusion is the fact that the GIM enables the direct estimation of a realistic current grazing capacity, since it is based on agronomic principles. None of the other methods discussed can lay claim to this requirement. Owing to the nature of the GIM and the attributes used, the method has the advantage that "before and after" grazing capacities can be estimated. This condition has research and other implications (Du Toit 1995a).

It is clear that changes in both the veld condition scores (Table 8.1) and canopy spread cover scores (Table 8.2) of veld in the Karoo, as single variables, or in combination, are amenable to interpretation in terms of changes in biotic and climatic conditions (Novellie & Strydom 1987; present study). Therefore, where veld is used exclusively as grazing for livestock, the grazing index method lends itself to the monitoring of trend in veld condition. This conclusion contradicts the view expressed by Hurt & Bosch (1991) that only the weighted key species method and the degradation gradient model can adequately monitor species change in the veld.

Veld condition scores estimated by making use of the grazing index values, results in a better fit, when regressing veld condition on rainfall, than when veld condition is estimated by using the EIM index values (refer to the r^2 values for the regressions in Figures 2.1 & 2.2).

The GIV's, have a better predictive value than the EIV's when estimating current grazing capacities.

CHAPTER 9

USE OF THE GRAZING INDEX VALUES AND OTHER PARAMETERS DETERMINED DURING THE STUDY IN THE CALCULATION OF THE CURRENT GRAZING CAPACITY OF AN AREA

9.1 Introduction

The relation between canopy spread cover, available forage production and it's presumed relation with the number of strikes observed during a botanical survey, was investigated. An attempt was made to estimate the amount of forage (standing crop) from a line point survey. According to the literature (Mueller-Dombois & Ellenberg 1974) this is not possible and therefore calls for speculation. In order to estimate the current grazing capacity, the amount of forage estimated to be available on the veld and the annual dry matter requirements of the animals were taken into account.

9.2 Method

The relations mentioned above were investigated in the 60 year old Camp number 6 trial at Grootfontein in 1991 (refer to Appendix 8). Line point surveys comprising 200 points per survey were undertaken and only primary strikes on canopy spread cover were noted (Daubenmire 1959, 1968; Roux 1963). During these investigations the diameter of the plants struck by the recording pin was measured (Evans & Jones 1958), as well as the height of all the plants struck by the pin (Evans & Jones 1958; Alexander et al. 1962; Charlton 1968). All the plants struck by the recording pin were subsequently harvested at ground level, in order to obtain the mass of dry matter produced (Pechanec & Pickford 1937) in the area represented by the pin position (Payne 1974). The area represented by the pin was taken as that area only, where living plant material was engaged and not as the 1 m^2, when observing the line point as consisting of a string of 1 m^2 areas, arranged end to end. In this last instance all the material occurring in that 1 m^2 should be harvested. However, this method would introduce bias and it would be impossible to calculate the number of plants occurring per hectare.

9.3 Results

Refer to Appendix 8 for tables, containing the results of the surveys. In these tables the species names are noted, as are the actual number of strikes on the particular species, the total mass of the particular species harvested and the individual diameter measurements.

9.3.1 Calculations

1. The global average of all the diameters was obtained and divided by the number of actual strikes recorded, in order to obtain an average diameter per strike. This would also represent the average diameter of the plants found in the survey area.

2. In order to obtain the number of plants per hectare represented by each of these surveys, 10 000 (a value representing 1 hectare) was divided by the square root of the final value obtained in 1. This formula was adapted from the formulae presented by Cottam & Curtis (1956), Oosting (1956), Greig-Smith (1964) and Joubert (1986).

3. However, in order to obtain the actual number of plants per hectare in each of the sites represented by the surveys, the value obtained in 2, was multiplied by the actual number of strikes and divided by the total number of point observations read.

4. The value obtained in 3, was multiplied by the mass recorded per strike (g).

5. The value obtained in 4, was divided by 1 000, to express the mass in kg.

6. The value obtained in 5, was divided by the product of the total dry matter requirement per sheep per day (3 kg) with the number of days in a year (365), in order to obtain the number of sheep that

can be run per ha, on the dry matter produced.

7. Calculate the reciprocal of the value obtained in 6, in order to adjust the number of sheep per ha, to ha per sheep.

8. Multiply the value obtained in 7, by 7.14, this is the number of average sized small stock units per defined large stock unit (Meissner et al. 1983), in order to express the grazing capacity in ha per large stock unit (cf. Table 9.1 and refer to Chapter 6, section 6.1.1, footnote no. 8).

9.3.2 Discussion

Estimating grazing capacity from clipped quadrats (Pechanec & Pickford 1937) and line point surveys (Vorster 1982)

From Table 8.1 the large differences in the grazing capacity, resulting from the calculations according to the two different methods are obvious. When cognizance is taken of the fact that the official grazing capacity norm in the area is 16 ha/LSU, it immediately becomes clear that the method of estimating grazing capacity as outlined above is superior to that of estimating grazing capacity by harvesting the forage in quadrats and calculating the grazing capacity from the dry matter produced per unit area. Poor correlations between height and harvested herbage mass, and height and diameter (cover) were calculated. Conversely, good correlations were calculated between plant diameter and harvested herbage mass (Mason & Hutchings 1967). Indeed the method to be used to calculate grazing capacity, is based on the relation between plant diameter (canopy spread cover) and the available forage produced by the plant. This would seem to refute the claims by Mueller-Dombois & Ellenberg (1974) to a certain extent.

Recognizing this fact, the Grazing Index Method (Du Toit 1995b),

Table 9.1. Camp 6 production measured by harvesting forage in quadrats, the mean was obtained for the two years' data and converted to grazing capacity in $ha.LSU^{-1}$, indicated in column 5; in column 6, 1991a, the grazing capacity resulting from the method outlined in section 8.3.1 is presented; in column 7, 1991b, is presented the grazing capacity results of a linepoint survey of the sites in Camp number 6 where the grazing capacity is calculated according to the GIM employing the GIV's

	1989	1994		Mean	1991a	1991b
site	$kg.ha^{-1}$	$kg.ha^{-1}$	grazing period	1 $ha.LSU^{-1}$	2 $ha.LSU^{-1}$	3 $ha.LSU^{-1}$
camp 1a	1863	2043	15Aug–15Feb	4.0	16.5	29.0
camp 1b	1563	1773	15Feb–15Aug	4.7	15.7	20.1
camp 2a	1607	1111	Continuous 1:1	5.8	44.4	26.5
camp 2b	1635	1789	Continuous 1:1.5	4.6	19.4	24.5
camp 3a	1275	1421	15Aug–15Dec	5.8	20.2	21.0
camp 3b	1095	1343	15Dec–15Apr	6.4	9.5	22.7
camp 3c	1059	1764	15Apr–15Aug	5.5	28.3	22.4
camp 4a	1485	1722	15Aug–15Aug	4.9	22.5	21.8
camp 4b	1798	1300	15Aug–15Aug	5.1	22.3	20.4
camp 5 (upper)	1028	2269	Continuous 1:1.5	4.7	19.5	32.1
camp 5 (lower)	2457	1714	Continuous 1:1	3.7	32.1	24.1

1 = Quadrat harvest method

2 = Line point harvest method

3 = G.I.M.

as adapted from the Ecological Index Method (Vorster 1982), can be applied with a great degree of certainty. The diameter of the individual plants measured in this investigation, then becomes redundant, as diameter is replaced by the grazing index values which include diameter as one of the different parameters used to estimate the grazing index values (Du Toit et al. 1995).

Estimating grazing capacity by making use of the OIV's

When calculating a grazing capacity, using the EIV's and the GIV's, there are some adjustments that must be made to the veld condition score so that the current grazing capacity will accurately reflect the grazing capacity of the accepted norm, because as can be seen in Table 9.2, the grazing capacities never coincide 100 %.

These adjustments include a lowering of the veld condition score by 20 %. This makes up for the overestimate of 20 % in the canopy spread cover, produced by the line point botanical survey method. Also, it is necessary to take into account the actual growing season as defined by the main rainfall season. In this case the veld condition score is adjusted to reflect only the actual number of months per year during which rain was received and the veld produced available forage for grazing. The combined results of these adjustments on the estimated grazing capacity values, are indicated between brackets in Table 9.2.

It will be seen that although not all the plant species have OIV's, the straight score where the OIV's have been used in the calculation of the grazing capacities are, in many cases, closer to the accepted norm than where the GIV's only, have been used.

Referring to Appendix 8, the r^2 and d statistics of the regressions of the grazing capacities using the EIV's, the GIV's and the

Table 9.2 Botanical composition, percentage canopy spread cover (CS), veld condition scores (VCS) and the respective estimated current grazing capacities (CGC) presented for seven sample sites from four reasonably homogeneous areas in the Karoo. Sites follow a gradient from the arid north west through the south and central Karoo to the relatively moist north eastern Karoo. The ecological -, subjective grazing index - and objective grazing index values of the different species are compared, as well as the results of their respective products with the percentage strikes on the species. Where no OIV was available for a plant species, the GIV was included as the OIV score, this is indicated by an asterisk next to the species name. CGC is given in $ha.LSU^{-1}$. EIV = ecological index value, GIV = subjective grazing index value and OIV = obective grazing index value. For an explanation of A, B and C, refer to Chapter 8, Figures 8.1 & 8.3. The combined effects of the adjustments made to the Veld Condition Scores, on the estimated grazing capacity values, as discussed earlier, are indicated between brackets in the Table. Data from Botha (1991)

A J Kruger, Grappies Farm (29° 25'S, 19° 57'E), Pofadder district; June 1992, median rainfall 82 $mm.a^{-1}$, grazing capacity norm 39 $ha.LSU^{-1}$.

	%	EIV	Score	GIV	Score	OIV	Score
Aristida congesta	1	1	1	1.3	1.3	1.5	1.5
Eriocephalus spinescens	2	4	8	4.5	9.0	3.7	7.4
Stipagrostis ciliata	39	10	390	7.2	280.8	5.8	226.2
Stipagrostis obtusa	25	10	250	6.6	165.0	2.4	60.0
CS	67	VCS	649	VCS	456	VCS	295.1
		CGC	7.2 (26.8)	CGC	10.2 (38.2)	CGC	15.7 (47.2)

S Durandt, Knolepark Farm (30° 38'S, 26° 20'E), Burgersdorp district; February 1992, median rainfall 450 $mm.a^{-1}$, grazing capacity norm 10 $ha.LSU^{-1}$.

	%	EIV	Score	GIV	Score	OIV	Score
Cymbopogon plurinodis*	78	10	780	7.6	592.8	7.6	592.8
Digitaria eriantha	2	10	20	8.9	17.8	8.3	16.6
Pentzia globosa	1	4	4	4.8	4.8	1.3	1.3
Themeda triandra	9	10	90	9.3	83.7	6.1	54.9
CS	90	VCS	894	VCS	699	VCS	665.6
		CGC	5.2 (9.7)	CGC	6.6 (12.5)	CGC	7.0 (10.5)

Table 9.2 (continued)

B J J Zwiegers, Diephoek Farm (30° 07'S, 24° 15'E), Petrusville district; July 1992, median rainfall 312 mm.a^{-1}, grazing capacity norm 20 ha.LSU^{-1}.

	%	EIV	Score	GIV	Score	OIV	Score
Eragrostis lehmanniana	30	7	210	5.4	162.0	2.7	81.0
Pentzia globosa	15	4	60	4.8	72.0	1.3	19.5
Aristida congesta	4	1	4	1.3	5.2	1.5	6.0
Plinthus karooicus	8	7	56	6.4	51.2	2.1	16.8
Enneapogon desvauxii*[12]	1	1	1	1.0	1.0	1.0	1.0
Hertia pallens*	2	1	2	1.2	2.4	1.2	2.4
Lycium cinereum*	1	1	1	3.0	3.0	3.0	3.0
Protasparagus suaveolens*	4	1	4	1.0	4.0	1.0	4.0
Eriocephalus aspalathoides*	1	4	4	4.0	4.0	4.0	4.0
Galenia procumbens*	5	4	20	4.3	21.5	4.3	21.5
Eragrostis bergiana*	3	4	12	2.8	8.4	2.8	8.4
CS	74	VCS	374	VCS	335	VCS	167.6
		CGC	12.4 (15.5)	CGC	13.9 (20.8)	CGC	27.7 (41.5)

P J J Southey, Hillstone Farm (31° 20'S, 25° 31'E), Middelburg district; July 1992, median rainfall 346 mm.a^{-1}, grazing capacity norm 16 ha.LSU^{-1}.

	%	EIV	Score	GIV	Score	OIV	Score
Sporobolus fimbriatus	14	10	140	9.5	133.0	7.1	99.4
Eragrostis obtusa*	9	7	63	4.0	36.0	4.0	36.0
Eragrostis lehmanniana	1	7	7	5.4	5.4	2.7	2.7
Eriocephalus ericoides	15	4	60	5.0	75.0	2.5	37.5
Pentzia globosa	6	4	24	4.8	28.8	1.3	7.8
Aristida congesta	20	1	20	1.3	26.0	1.5	30.0
Cynodon dactylon*	4	4	16	4.5	18.0	4.5	18.0
Lycium cinereum*	8	1	8	3.0	24.0	3.0	24.0
Eragrostis chloromelas*	1	7	7	5.5	5.5	5.5	5.5
Eriocephalus spinescens	1	4	4	4.5	4.5	3.7	3.7
Chrysocoma cilata	1	1	1	1.5	1.5	0.8	0.8
CS	80	VCS	350	VCS	358	VCS	265.4
		CGC	13.3 (16.6)	CGC	13.0 (19.5)	CGC	17.5 (26.2)

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12. The asterisk denotes that the Grazing Index Value (GIV) of the species was used because no Objective Grazing Index Value was calculated for that species

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Table 9.2 (continued)
F Schoeman, Swartgrond Farm (33° 04'S, 22° 56'E), Beaufort West district; August 1992, median rainfall 199 $mm.a^{-1}$, grazing capacity norm 32 $ha.LSU^{-1}$.

	%	EIV	Score	GIV	Score	OIV	Score
Aristida congesta	2	1	2	1.3	2.6	1.5	3.0
Protasparagus suaveolens*	1	1	1	1.0	1.0	1.0	1.0
Pentzia incana	14	4	56	5.7	79.8	1.5	21.0
Rhigozum obovatum*	2	7	14	. 6.6	13.2	6.6	13.2
Eberlanzia ferox	1	1	1	2.7	2.7	2.0	2.0
Hermannia desertorum	5	7	35	5.9	29.5	1.2	6.0
Stipagrostis obtusa	2	10	20	6.6	13.2	2.4	4.8
Eriocephalus ericoides	1	4	4	5.0	5.0	2.5	2.5
Felicia muricata*	3	7	21	6.5	19.5	6.5	19.5
Lycium cinereum*	1	1	1	3.0	3.0	3.0	3.0
Pteronia sordida*	1	4	4	4.5	4.5	4.5	4.5
Eriocephalus spinescens	1	4	4	4.5	4.5	3.7	3.7
Enneapogon desvauxii*	1	1	1	1.0	1.0	1.0	1.0
Stipagrostis ciliata	2	10	20	7.2	14.4	5.8	11.6
Felicia filifolia	1	7	7	5.9	5.9	2.6	2.6
Zygophyllum microphyllum	1	4	4	4.0	4.0	3.8	3.8
CS	39	VCS	195	VCS	204	VCS	103.2
		CGC	23.8 (29.8)	CGC	22.8 (34.2)	CGC	45.0 (67.5)

Table 9.2 (continued)

C A de Villiers, Abrahamskraal Farm (31° 46'S, 22° 40'E), Victoria West district; February 1992, median rainfall 227 mm.a^{-1}, grazing capacity norm 26 ha.LSU^{-1}.

Karoo bush range	%	EIV	Score	GIV	Score	OIV	Score
Chrysocoma ciliata	7	1	7	1.5	10.5	0.8	5.6
Eriocephalus ericoides	9	4	36	5.0	45.0	2.5	22.5
Eriocephalus spinescens	4	4	16	4.5	18.0	3.7	14.8
Lycium cinereum*	3	1	3	3.0	9.0	3.0	9.0
Pentzia incana	21	4	84	5.7	119.7	1.5	31.5
Plinthus karooicus	1	7	7	6.4	6.4	2.1	2.1
Pteronia sordida*	11	4	44	4.5	49.5	4.5	49.5
Rosenia humilis	7	1	7	3.5	24.5	4.0	28.0
CS	63	VCS	204	VCS	283	VCS	163
		CGC	22.8 (42.7)	CGC	16.4 (30.8)	CGC	28.5 (42.7)

Grass/karoo bush range	%	EIV	Score	GIV	Score	OIV	Score
Eberlanzia ferox	1	1	1	2.9	2.9	2.0	2.0
Eriocephalus spinescens	1	4	4	4.5	4.5	3.7	3.7
Felicia filifolia	2	7	14	5.9	11.8	2.6	5.2
Pentzia incana	34	4	136	5.7	193.8	1.5	51.0
Pteronia glauca	1	4	4	3.2	3.2	2.8	2.8
Pteronia sordida*	4	4	16	4.5	18.0	4.5	18.0
Rosenia humilis	1	1	1	3.5	3.5	4.0	4.0
Salsola tuberculata	1	7	7	6.9	6.9	4.2	4.2
Stipagrostis obtusa	20	10	200	6.6	132.0	2.4	4.8
Walafrida geniculata	1	7	7	7.0	7.0	3.3	3.3
Zygophyllum gilfillanii*	2	7	14	5.9	11.8	5.9	11.8
CS	68	VCS	404	VCS	395	VCS	154
		CGC	11.5 (21.5)	CGC	11.7 (22.0)	CGC	30.0 (45.2)
Mean CGC of Abrahamskraal farm			17.2 (32.1)		14.1 (26.4)		29.3 (44.0)

OIV's, on the accepted norms for the areas mentioned in Table 8.2 can be compared. The EIV renders a r^2 of 0.0884 and a d statistic of 0.4850. The GIV renders a r^2 of 0.1767 and a d statistic of 0.4251. On the other hand, the OIV has the highest r^2 and d statistic, 0.2209 and 0.7052 respectively. Although the r^2 value is low, the high d statistic indicates a close agreement between the two sets of values being compared.

9.4 Conclusion

The conclusion that can be reached therefore, is that the objectively calculated grazing index values are more advantageous to use in the estimate of the current grazing capacity, than either the ecological index values (Vorster 1982) or the subjectively estimated grazing index values (Du Toit et al. 1995). It can be stated without hesitation that the use of the objectively estimated grazing index values will result in the calculation of more realistic estimates of the current grazing capacity of the karoo veld, since they are based on agronomic parameters of the different species. The estimated current grazing capacity in this case is truly representative of the agronomic potential of the site, at the moment of estimation.

CHAPTER 10

GENERAL DISCUSSION

10.1 The Grazing Index Method

The Grazing Index Method (GIM) provides useful agronomic indices of veld condition, on which estimates of current grazing capacities can be based. Where the objective grazing index values (OIV's) have been used in the computation of veld condition indices and the subsequent calculation of the current grazing capacities, these have been found to vary only slightly from the grazing capacity norms, established for the different grazing capacity zones by the Department of Agriculture in the Karoo Region. Estimates of the current grazing capacity of a specific site, in the case of the GIM reflects the grazing capacity as at that moment, because the amount of grazable herbage has been taken into account, through both the method of recording strikes on canopy spread cover, as well as through the index values accorded the species.

Most significant, is the fact that the GIM enables the objective estimation of a realistic current grazing capacity for a site, since the method is based on agronomic principles. None of the other methods used elsewhere can lay claim to this requirement. Owing to the nature of the GIM and the attributes used, the method has the added advantage that "before and after" grazing capacities can be estimated. This condition has research and other i.e. managerial, implications.

It is clear that changes in both the condition - and cover scores of veld in the Karoo, as single variables, or in combination with the botanical analyses of the sites, are amenable to interpretation in terms of changes in biotic and climatic conditions (Novellie & Strydom 1987; present study). Therefore, where veld is used exclusively for grazing animals, the GIM lends itself to the monitoring of trend in veld condition. This conclusion contradicts the view expressed by Hurt & Bosch (1991), that only the Weighted Key Species Method and the Degradation Gradient Model can be used to monitor trends in veld condition.

10.2 Timing of botanical surveys

Coefficients of determination was calculated for the regressions of available forage on canopy spread cover, for the different seasons. In the summer rainfall areas of the Karoo, the data presented in the previous chapters suggest that the best time in which to carry out the botanical surveys for the purposes of grazing capacity estimation in the Karoo Region, is at the start of and during the season when root reserve storage takes place i.e. March, April and May. At this time the highest coefficients of determination are calculated for the relation between canopy spread cover and the amount of grazable forage. It therefore follows that line transects, where the descending point method of botanical survey is employed (Roux 1963), will at this time provide the best indication of available forage, from which the grazing capacity can be estimated by making use of the objective grazing index values. This feature is unique to the method and has implications as far as stock management for the following season is concerned.

10.3 The subjectively estimated grazing index values

The GIV's comprise mainly agronomic features of the species such as the forage value in different seasons and the available forage production and it is reasoned that their use in the computation of the veld condition scores, will yield more reliable and acceptable estimates of the grazing capacities than was realised with the use of the ecological index values (EIV's). In regressions of veld condition on rainfall, veld condition scores estimated by making use of the GIV's, resulted in a better fit, than when veld condition was estimated by using the EIV's. The GIV's, therefore, have a better predictive value than the EIV's when estimating current grazing capacities.

When the GIV's are used to estimate the current grazing capacity, there are some adjustments that have to be made to the veld condition score, in order for the estimated current grazing capacity to reasonably accurately reflect the grazing capacity of the accepted norm. These adjustments include firstly, a lowering of the veld condition score by 20 %, to eliminate the overestimate of 20 % produced by the line point method of botanical survey (Vorster 1982), in the canopy spread cover. Secondly, the actual growing season as defined by the main rainfall season, must be taken into account. The veld condition score must be adjusted to reflect only the actual number of rainy or growing season months per year, during which available forage was produced. The combined result of these adjustments on the estimated current grazing capacity values, are indicated between brackets in Table 9.2 of Chapter 9.

These GIV's are, however, subjective value judgements of the actual grazing value of the Karoo plant species. The proposed model attempts to objectively allocate a grazing value to a species, based on certain dry matter production and chemical properties of the species. These properties have been studied and analyzed over a period of three years for various species from four distinct agro-ecological regions (Botha pers. comm.[13]). An attempt has been made to study the same species, or related species within the same genus in the different regions, in order to ascertain the differences in grazing value within and between species, but also between related species of different areas so as to be in a position to extrapolate findings over a larger area. The GIV's will be used according to the methodology described in the Ecological Index Method (EIM) (Vorster 1982) of grazing capacity calculation. These GIV's will replace the EIV's (10, 7, 4 and 1). The method has been well tried and tested in the Karoo areas, it is well known and provides reasonably accurate estimates, of the current grazing capacity. These results can be used in the setting of stocking rates as well as for research purposes. However, because the GIV's are to be used in the method, the method will be referred to as the Grazing Index Method (GIM).

10.4 The objectively estimated grazing index values

It will be seen that although not all the plant species, represented in the

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13. Botha, W. Van D., Grootfontein Agricultural Development Institute, Private Bag X 529, Middelburg. 5900. Eastern Cape Province.

botanical surveys (quoted in Table 9.2) have objectively estimated grazing index values (OIV's), the straight scores where the OIV's have been used are, in many instances, closer to the accepted norm than where the GIV's have been used. Few adjustments to the veld condition scores have had to be made, as outlined above.

Referring to Chapter 9 and Appendix 8, the coefficient of determination (r^2) and d statistic can be compared where the grazing capacity estimates using the EIV's, the GIV's and the OIV's, have been regressed on the accepted norms for the areas mentioned in Table 9.2. The EIV renders a r^2 of 0.0884 and a d statistic of 0.4850. The GIV renders a r^2 of 0.1767 and a d statistic of 0.4251. On the other hand, the OIV has the highest r^2 and d statistic, 0.2209 and 0.7052 respectively. Although the r^2 value is low, the high d statistic indicates a good agreement between the two sets of values being compared.

It seems likely therefore, that despite some low calculated d statistics, model 3 (see Chapter 7) will consistently yield the best results when estimating grazing index values. It must also be borne in mind that the values against which the objectively estimated grazing index values were compared, represent subjective value judgements. As a result of the methods used, there is no way in which one can be sure that the GIV's indeed represent the true grazing value of the species. Insofar, the d indices are merely indicators of how well the two sets of values correspond to each other. Not too much reliance must be placed on the d statistic as representing the true value of the grazing index values of any of the two sets of values. The preferred model at least takes into account palatability, as expressed by the chemical constituents of the species and vegetative characteristics, such as canopy spread cover and available forage production, of the plant species.

The conclusion that can be reached therefore, is that it is more appropriate to use the objectively estimated grazing index values in the estimate of the grazing capacity, than either the EIV's or the GIV's. It can further be stated without hesitation that the use of the OIV's will result in more realistic estimates of the current grazing capacity of the veld. The OIV's arrived at by means of the model, should enable verification of the GIV's, arrived at by means of the subjective scoring method.

With this model, i.e. a species grazing index value computed from the relation between canopy spread cover, the aboveground available forage production and the quality variables of the species; the grazing index value of any species can be estimated with a degree of confidence. Quality parameters can be gleaned from the literature, mentioned previously, or be determined empirically for species where such data do not exist at present. It may be possible to further refine this model to yield better results, by incorporating some of the parameters excluded from the model at the moment. It is also possible to estimate a different grazing index value for a species for any specific season. This in turn will shed more light on the concept of palatable and unpalatable species, as well as the seasonal palatability of species.

10.5 Estimation of aboveground available forage production

A rule of thumb exists that sheep graze off stems of karoo bushes with a diameter of up to 2 mm. For the purposes of grazing capacity calculation, plants are harvested almost at ground level and the harvested material is then separated into potentially grazable and non-grazable fractions. By definition all the material thinner than 2 mm is regarded as grazable. It was established that sheep graze stems to a mean diameter of only 1.4 mm to 1.6 mm. The hypothesis that sheep voluntarily graze stems with a diameter of up to 2 mm must be rejected, on the grounds that stems of the main source of forage, the less palatable species, are seldom grazed that thick. From this it then follows that the results of the method in which the available dry matter production is used for the purposes of estimating the current grazing capacity, must therefore be adjusted downwards by some 25 %.

10.6 The index value scale

The fact that fairly poor coefficients of determination and d values are obtained with the use of the GIV's at the moment, as well as the adjustments that have to be made for the estimated grazing capacities to "fit" the norm, indicates to some degree that the individual GIV's of the species are still too high. This becomes clear when the results of the OIV's are compared to the results of the GIV's. It is furthermore questionable whether the top of the grazing index value scale should be 10. The use of a scale with values ranging from 1 to 10 has become customary and is often proposed in biological work (cf. Curtis & McIntosh 1951; Brown & Curtis 1952; Vorster 1982; Hurt & Bosch 1991). It is clear that unbeknown to the estimators of the GIV's and quite subconsciously, the old EIM scale (Vorster 1982) and the climax adaptation values (Curtis & McIntosh 1951; Brown & Curtis 1952) played an important role in the positioning of the subjective estimates of the grazing index values. From this it then becomes clear, that all the subjectively estimated grazing index values (GIV's) will have to be adjusted downwards, so as to fall into line with the objectively estimated grazing index values (OIV's). Once this action is accomplished, current grazing capacities can be estimated much more reliably and realistically and different homogeneous areas can be directly compared to each other on a realistic and agriculturally sound scientific basis.

10.7 Conclusion

From the above it is clear that the objective as stated in the introduction has been fulfilled. It is possible to objectively estimate grazing index values for the Karoo plant species by means of a suitable model. In the estimates used in the model, certain plant parameters such as the canopy spread cover, the available forage on the plant at that instant and the chemical content of the available forage play significant roles. These objective grazing index values have been successfully used in the computation of veld condition scores and in the calculation of the current grazing capacities from these veld condition scores. These current grazing capacities have been estimated for widely differing areas. It is clear that these grazing capacities closely approximated the long-term grazing capacity norms applicable to these areas, norms prescribed by the South African Department of Agriculture.

SUMMARY

The ecological index values used during the Ecological Index Method of veld condition assessment were found to be inappropriate for the estimation of current grazing capacities in the Karoo, because on the one hand the index values were too high in many instances, while on the other hand two different value systems were combined to provide one set of index values, which tended to exacerbate the problem. Estimated subjective grazing index values of plant species based on the same set of variables for all species, provided more acceptable estimates of current grazing capacities. It was decided subsequently to investigate the possibility of objectively estimating grazing index values for the plant species by making use of various agronomic i.e. chemical and physical attributes of the plant species and to apply these grazing index values through the Grazing Index Method, which is largely based on the older Ecological Index Method.

The studies were carried out in the Eastern Mixed Karoo, the Karoo Mountainous Areas, the Arid Karoo and the Great Karoo. Various closely related species were studied at the different sites in order to be in a position to compare the values estimated for a specific species or genus in the different areas and to extrapolate findings over a wide area. After measurements of the canopy spread cover of the plants, they were harvested and divided into grazable and non-grazable fractions on the basis that all the stems less than 2 mm thick are deemed to be grazable. This fraction was analyzed for its various chemical constituents.

A model for the objective estimation of the grazing index value is proposed. This model employs the agronomic parameters; production, canopy spread cover, total digestible nutrients, the values for potassium, calcium and magnesium, and the ether extract value in the estimate of the grazing index value. The model differentiates between karoo bushes and grasses on the basis of the ether extract value. In the case of the grasses the ether extract value is taken as a variable with a positive influence on the index value of the grass, while in the case of the karoo bushes the value detracts from the grazing

value of the karoo bushes, the higher the ether extract value of the karoo bush species, the lower its grazing index value. The use of these objective grazing index values yields better estimates of the current grazing capacities than either of the ecological index values or the subjectively estimated grazing index values. Estimating the current grazing capacities by means of the objectively estimated grazing index values results in values closely approximating the grazing capacity norms, as set by the Department of Agriculture.

OPSOMMING

Daar is gevind dat die ekologiese indeks waardes wat gedurende die Ekologiese Indeks Metode gebruik word, nie geskik is vir die beraming van die huidige weikapasiteite in die Karoo nie, omdat die indekswaardes aan die een kant te hoog is, terwyl aan die ander kant, twee verskillende waarde sisteme gebruik word om een indekswaarde reeks op te stel. Subjektief beraamde weidings-indeks waardes van die plantspesies het meer aanvaarbare huidige weikapasiteite beraam. Daar is vervolgens besluit om die moontlikheid te ondersoek om die weidings-indeks waardes van die verskillende plantspesies objektief te beraam deur gebruik te maak van verskeie agronomiese d.i. fisiese en chemiese veranderlikes van die plante en om die indekswaardes deur die Weidingsindekswaarde Metode toe te pas. Die Weidingsindekswaarde Metode is grootliks gebaseer op die Ekologiese Indeks Metode.

Die studie is in die Oostelike Gemengde Karoo, die Karoo Berggebiede, die Ariede Karoo en die Groot Karoo uitgevoer. Verskeie naverwante spesies is in die verskeie gebiede bestudeer, sodat die resultate wyd ge-ekstrapoleer kan word deur verwysing na verwante spesies en genera. Na afloop van die meting van die kroonuitgestrektheidsbedekking van die plante, is hulle afgesny en in benutbare en onvreetbare gedeeltes geskei op grond van die feit dat alle stingels dunner as 2 mm as vreetbaar beskou is. Die vreetbare fraksie is chemies ontleed.

'n Model vir die objektiewe beraming van die weidings-indeks waarde is voorgestel. Die model maak gebruik van die volgende veranderlikes; produksie, kroonuitgestrektheidsbedekking, waardes vir kalium, kalsium en magnesium en die eter ekstrak waarde om die weidings-indeks waarde te beraam. Die model maak 'n verskil tussen die karoobossies en die grasse op grond van hulle eter-ekstrak waarde. In die geval van die grasse word die eter-ekstrak waarde as 'n positiewe waarde gesien wat die indekswaarde van die grasse verhoog. Aan die ander kant verlaag die eter-ekstrak waarde die indekswaarde van die karoobossies, hoe hoër die eter-ekstrak waarde van die karoobossies, hoe laer is die weidingsindekswaarde van die bossie. Die gebruik van hierdie objektief

beraamde weidings-indeks waardes het beter beramings van die huidige weikapasiteit opgelewer as enige van die ekologiese indeks waardes of die subjektief beraamde weidings-indeks waardes. Deur gebruik te maak van die objektief beraamde weidingsindekswaardes in die beraming van die huidige weikapasiteite, word waardes beraam wat baie met die norms soos deur die Departement van Landbou neergelê, ooreenkom.

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APPENDICES

Appendix 1 Grazing index values (GIV's) for some of the most common Karoo plant species, compared to their Ecological Index Values (EIV's)

Species names and synonyms	GIV	EIV
Trees, shrubs and climbers		
Acacia erioloba	5,5	7,0
A. haematoxylon	5,1	7,0
A. karroo	6,9	7,0
A. mellifera subsp detinens	2,9	4,0
A. tortilis	3,4	4,0
Agave americana	3,9	4,0
Atriplex canescens	6,4	7,0
A. nummularia	6,2	7,0
Boscia albitrunca	7,4	7,0
Buddleja glomerata	2,6	1,0
B. saligna	2,6	1,0
Carissa haematocarpa	4,1	4,0
C. macrocarpa	4,3	4,0
Celtis africana	2,8	1,0
Ceratonia siliqua	6,6	10,0
Cissampelos capensis	1,0	1,0
Clematis brachiata	1,7	1,0
Colpoon compressum	1,6	1,0
Cussonia paniculata	1,2	1,0
Cyphostemma cirrhosum	1,3	1,0
Diospyros austro-africana	4,7	7,0
D. lycioides	3,7	1,0
Dodonaea angustifolia	1,7	1,0
Ehretia rigida	6,1	7,0
Elytropappus rhinocerotis	1,0	1,0
Euclea coriacea	4,8	7,0
E. undulata	4,6	7,0
Grewia flava	6,5	7,0
G. occidentalis	7,4	7,0
G. robusta	6,9	7,0
Heeria argentea	4,1	4,0
Lantana camara	1,0	1,0
L. rugosa	1,0	1,0
Leucosidea sericea	1,3	1,0
Lycium hirsutum	2,0	1,0
L. oxycarpum (L. austrinum)	1,8	1,0
L. prunus-spinosa	1,6	1,0
Maytenus capitata	2,5	4,0
M. heterophylla	2,6	4,0
M. undata	1,0	1,0
Nicotiana glauca	1,0	1,0
Nymania capensis	6,7	7,0
Olea europaea subsp africana (Olea africana)	6,5	7,0
Pappea capensis	7,1	7,0
Phaeoptilum spinosum	6,0	7,0
Portulacaria afra	5.8	7,0
Prosopis glandulosa	2,6	1,0

(P. juliflora)		
Putterlickia pyracantha	2,5	1,0
Rhamnus prinoides	2,0	1,0
Rhigozum obovatum	6,6	7,0
R. trichotomum	2,1	1,0
Rhoicissus digitata	3,4	4,0
R. tomentosa	3,1	4,0
Rhus ciliata	1,3	1,0
R. dentata	3,2	4,0
R. erosa	1,5	1,0
R. glauca	2,3	1,0
R. lancea	3,6	4,0
R. longispina	2,2	1,0
R. lucida	3,1	1,0
R. pendulina	3,4	1,0
(R. viminalis)		
R. populifolia	2,5	1,0
R. undulata	3,2	1,0
Schotia afra	6,7	7,0
S. latifolia	5,5	1,0
Tamarix usneoides	2,0	1,0
Tarchonanthus camphoratus	3,3	4,0
Ziziphus mucronata	3,5	1,0

Karoo bushes

Acanthospermum hispidum	0,9	1,0
Aizoon burchellii	1,9	4,0
Amphiglossa tomentosa	4,4	7,0
Anthospermum dregei	4,5	4,0
A. pumilum subsp rigidum	4,7	7,0
(A. rigidum)		
A. spathulatum subsp spathulatum	4,9	7,0
(A. tricostatum)		
Aptosimum albomarginatum	3,5	4,0
A. indivisum	2,3	4,0
A. marlothii	3,5	4,0
A. procumbens var procumbens	2,0	4,0
(A. depressum)		
A. spinescens	1,7	1,0
(A. steingroeveri)		
A. spinescens	1,9	1,0
Artemisia afra	2,0	4,0
Asaemia minuta subsp minuta	1,2	1,0
(A. axillaris)		
Asclepias burchellii	2,3	1,0
A. crispa	2,6	1,0
A. fruticosa	2,6	1,0
Aspalathus acicularis	5,3	7,0
A. arida	3,0	4,0
A. recurva	5,1	7,0
Atriplex lindleyi subsp inflata	1,5	1,0
(Blackiella inflata)		
(A. halimoides)		
A. semibaccata	4,9	7,0
A. suberecta	4,4	7,0
A. vestita	3,0	7,0
Barleria lichtensteiniana	1,1	1,0
B. rigida	1,0	1,0
Becium burchellianum	2,7	1,0
Blumea gariepina	0,9	1,0
Cadaba aphylla	3,2	4,0

Cassia italica subsp *arachoides*	2,3	4,0
Cheilanthes eckloniana	1,0	1,0
Chrysocoma ciliata	1,5	1,0
(=*C. tenuifolia*)		
C. coma-aurea	2,4	1,0
C. obtusata	3,0	1,0
(=*C. polygalifolia*)		
Cineraria aspera	1,3	1,0
Deverra aphylla	3,5	4,0
D. burchellii	3,3	4,0
Dianthus micropetalus	1,8	1,0
D. thunbergii	2,5	7,0
Dicoma capensis	1,7	4,0
D. picta	2,3	4,0
D. spinosa	1,4	1,0
Didelta spinosa	2,6	4,0
Dimorphotheca cuneata	2,3	4,0
D. zeyheri	1,7	1,0
Dyerophytum africanum	3,1	4,0
Elytropappus rhinocerotis	1,0	1,0
Eriocephalus africanus	4,5	4,0
E. aspalathoides	4,0	4,0
E. ericoides	5,0	4,0
E. ericoides	4,0	4,0
(=*E. glaber*)		
E. pauperrimus	4,8	4,0
E. pubescens	4,5	4,0
E. punctulatus	4,9	4,0
E. spinescens	4,5	4,0
Eumorphia dregeana	1,1	1,0
Euryops anthemoides	4,8	7,0
E. asparagoides	2,6	1,0
E. floribundus	1,7	1,0
E. lateriflorus	2,4	1,0
E. multifidus	3,6	4,0
E. oligoglossus	2,0	1,0
E. tenuissimus	1,8	1,0
E. virgineus	2,1	1,0
Felicia bergerana	4,9	7,0
F. brevifolia	6,3	7,0
F. fascicularis	6,2	7,0
F. filifolia	5,9	7,0
F. macrorrhiza	5,7	7,0
F. muricata	6,5	7,0
F. namaquana	5,1	7,0
F. ovata	6,3	7,0
F. tenella	3,6	7,0
Fockea sinuata	2,6	7,0
Galenia africana	2,0	1,0
G. fruticosa	5,0	7,0
G. procumbens	4,3	4,0
G. pubescens	3,7	4,0
G. secunda	4,7	4,0
Garuleum bipinnatum	6,0	7,0
G. pinnatifidum	5,8	7,0
Geigeria ornativa	2,0	1,0
(=*G. africana*)		
Gnidia burchellii	2,8	1,0
G. deserticola	4,0	7,0
G. harveyiana	3,2	4,0
G. meyeri	2,3	1,0
G. polycephala	2,0	1,0
G. styphelioides	2,3	1,0
Helichrysum dregeanum	6,3	7,0

H. hamulosum	1,5	1,0
H. lucilioides	5,2	4,0
H. niveum	3,3	4,0
H. odoratissimum	1,7	1,0
H. oxybelium	1,6	1,0
H. pentzioides	4,8	4,0
H. psilolepis	1,1	1,0
H. rosum	3,0	4,0
H. rutilans	3,3	4,0
(H. parviflorum)		
H. zeyheri	4,1	4,0
Heliophila suavissima	2,2	1,0
Hermannia coccocarpa	2,2	1,0
H. comosa	2,0	1,0
H. cuneifolia var cuneifolia	5,7	7,0
H. cuneifolia var glabrescens	5,7	7,0
H. depressa	2,2	1,0
H. desertorum	5,9	7,0
H. filifolia	6,0	7,0
H. glabrata	4,1	7,0
H. gracilis	6,0	7,0
H. grandiflora	6,2	7,0
H. linearifolia	6,0	7,0
H. linifolia	5,9	7,0
H. multiflora	6,1	7,0
H. paucifolia	3,1	7,0
H. pulchella	2,7	1,0
H. pulverata	1,9	1,0
H. scordifolia	5,0	7,0
H. spinosa	3,4	4,0
H. vestita	2,3	1,0
Hertia cluytiifolia	2,7	1,0
H. pallens	2,1	1,0
Hirpicium alienatum	5,0	7,0
H. integrifolium	4,7	7,0
Indigofera alternans	1,9	4,0
I. denudata	4,5	7,0
I. disticha	4,7	7,0
I. humifusa	5,2	7,0
I. obcordata	5,0	7,0
I. sessilifolia	5,7	7,0
I. spinescens	3,8	7,0
Jatropha capensis	1,8	1,0
Justicia cuneata	4,3	7,0
Kochia salsoloides	5,3	4,0
(K. pubescens)		
Lebeckia spinescens	6,3	7,0
Leonotis leonurus	1,5	1,0
Lessertia herbacea	5,4	7,0
L. inflata	5,0	7,0
L. macrostachya	5,1	7,0
L. pauciflora	4,8	7,0
Leucas capensis	3,8	
(Lasiocorys capensis)		4,0
Lightfootia albens	3,3	4,0
L. tenella	3,0	4,0
Limeum aethiopicum	7,1	7,0
Lotononis brachyloba	3,2	7,0
L. laxa	3,3	7,0
L. pungens	3,4	7,0
Lycium cinerium	3,0	1,0
L. cinerium	2,0	1,0
(L. kraussii)		
Manochlamys albicans	3,6	1,0

Melianthus comosus	1,6	1,0
Melolobium candicans	1,5	1,0
M. microphyllum	1,6	1,0
Microloma glabratum	4,2	7,0
M. massonii	4,3	7,0
Monechma divaricatum (M. fimbriatum)	4,3	7,0
M. genistifolium subsp australe (M. australe)	5,6	7,0
M. incanum	5,4	7,0
M. spartioides (M. pseudopatulum)	7,0	7,0
Nemesia fruticans	1,5	1,0
Nenax cineria (N. dregei)	6,1	7,0
N. microphylla	7,0	7,0
Nolletia ciliaris	4,3	7,0
Oligomeris dipetala	3,2	7,0
Osteospermum armatum	2,8	1,0
O. leptolobum	6,6	7,0
O. muricatum	4,6	4,0
O. scariosum	5,0	7,0
O. sinuatum	7,2	7,0
O. spinescens	6,0	7,0
Othonna pavonia	1,8	1,0
O. retrorsa	3,1	4,0
O. sedifolia	4,2	7,0
O. spinescens	3,4	7,0
Passerina filiformis	1,9	1,0
P. glomerata	1,7	1,0
P. montana	2,0	1,0
P. obtusifolia	1,9	1,0
Pegolettia retrofracta	5,6	7,0
Pelargonium abrotanifolium	2,7	1,0
P. acetosum	2,6	7,0
P. anethifolium	3,3	4,0
P. magenteum	3,2	4,0
P. ramosissimum	3,2	1,0
Peliostomum leucorrhizum var leucorrhizum (Aptosimum leucorrhizum)	3,7	4,0
Pentzia argentea	6,9	7,0
P. calcarea	3,5	1,0
P. cooperi	2,9	1,0
P. dentata	4,2	4,0
P. elegans	3,8	4,0
P. globosa	4,8	4,0
P. incana	5,7	4,0
P. pinnatisecta	5,0	4,0
P. punctata	3,4	1,0
P. sphaerocephala	6,9	7,0
P. spinescens (P. lanata)	5,7	7,0
P. spinescens	4,8	4,0
P. tortuosa	2,9	4,0
Phyllanthus maderaspatensis	7,5	7,0
P. verrucosus	7,5	7,0
Phymaspermum aciculare	5,3	4,0
P. parvifolium	6,2	7,0
P. scoparium (Brachymeris scoparia)	4,0	7,0
Plexipus cuneifolius	5,2	7,0
Plinthus cryptocarpus	6,7	7,0
P. karooicus	6,4	7,0
Plumbago tristis	3,0	4,0
Pollichia campestris	5,2	7,0
Polygala asbestina	4,8	7,0

P. ephedroides	3,3	1,0
P. leptophylla	4,5	7,0
(P. seminuda)		
P. leptophylla	4,6	7,0
P. pungens	4,0	4,0
P. virgata	3,8	4,0
Protasparagus africanus	1,0	1,0
P. striatus	1,0	1,0
P. suaveolens	1,0	1,0
Pteronia acuminata	4,3	4,0
(P. feddeana)		
P. adenocarpa	3,9	4,0
P. elongata	3,9	4,0
P. empetrifolia	3,7	4,0
P. erythrochaeta	2,9	1,0
P. glabrata	3,4	1,0
P. glauca	3,2	4,0
P. glaucescens	4,1	4,0
P. glomerata	3,9	1,0
P. incana	2,7	1,0
P. inflexa	3,9	4,0
P. leucoclada	3,9	4,0
P. oblanceolata	3,0	4,0
P. onobromoides	3,7	4,0
P. pallens	1,4	1,0
P. punctata	5,1	4,0
P. scariosa	4,3	4,0
P. sordida	4,5	4,0
P. tricephala	1,7	1,0
P. viscosa	4,7	4,0
Pterothrix spinescens	2,0	1,0
Relhania genistifolia	2,0	1,0
Rosenia glandulosa	3,9	4,0
R. humilis	3,2	1,0
(Nestlera conferta)		
R. humilis	3,5	1,0
R. oppositifolia	3,1	1,0
Salsola aphylla	5,5	7,0
S. barbata	5,0	7,0
S. calluna	7,2	7,0
S. geminiflora	3,6	4,0
S. glabrescens	6,0	7,0
S. humifusa	4,5	7,0
S. rabieana	6,7	7,0
S. tuberculata	6,9	7,0
S. zeyheri	5,9	7,0
Sarcocaulon patersonii	1,3	1,0
S. salmoniflorum	1,4	1,0
S. vanderiettiae	1,3	1,0
Selago albida	5,7	4,0
S. corymbosa	1,7	1,0
S. speciosa	2,9	4,0
S. triquetra	4,5	4,0
Senecio acutifolius	4,0	4,0
S. asperulus	2,0	4,0
S. burchellii	1,6	1,0
S. linifolius	1,6	1,0
(S. longifolius)		
S. longiflorus	1,2	1,0
S. radicans	3,8	7,0
S. retrorsus	1,7	1,0
Sericocoma avolans	5,6	7,0
S. pungens	5,6	7,0
Solanum nigrum	1,3	1,0
S. supinum	1,0	1,0
Stachys aurea	1,4	1,0
S. linearis	1,0	1,0

S. rugosa	1,0	1,0
Suaeda fruticosa	5,2	7,0
Sutera asbestina	4,6	7,0
S. atropurpurea	5,5	7,0
S. canescens	4,5	7,0
S. halimifolia	4,5	7,0
S. pinnatifida	4,8	7,0
Sutherlandia frutescens	5,9	7,0
S. microphylla	6,3	7,0
Tetragonia arbuscula	7,7	7,0
T. reduplicata	7,0	7,0
Thesium flexuosum	4,6	4,0
T. hystrix	1,6	1,0
T. lineatum	3,4	1,0
T. namaquense	3,5	4,0
T. triflorum	3,2	1,0
Ursinia pilifera	2,6	1,0
Viscum capense	2,5	1,0
Walafrida articulata	1,5	1,0
W. densiflora	1,0	1,0
W. geniculata	7,0	7,0
W. paniculata	1,7	1,0
W. saxatilis	2,0	1,0
Wiborgia monoptera	4,1	1,0
W. sericea	4,0	4,0
Xerocladia viridiramus	2,0	1,0
Zygophyllum divaricatum	5,3	4,0
Z. flexuosum	6,2	7,0
Z. foetidum	3,9	4,0
Z. gilfillani	5.9	7,0
Z. incrustatum	2,0	1,0
Z. leptopetalum	5,1	7,0
Z. microcarpum	3,9	4,0
Z. microphyllum	4,0	4,0
Z. morgsana	4,0	4,0
Z. pygmaeum	5,6	7,0
Z. retrofractum	3,7	4,0
Z. suffruticosum	5,2	7,0

Grasses, sedges and reeds

Agrostis lachnantha	3,0	4,0
Andropogon appendiculatus	6,6	10,0
Anthephora pubescens	7,4	10,0
Aristida adscensionis	1,4	1,0
A. canescens	4,0	7,0
A. congesta	1,3	1,0
A. diffusa	5,1	7,0
Arundo donax	3,2	4,0
Avena fatua	4,0	10,0
Bothriochloa insculpta	4,4	10,0
Brachiaria eruciformis	2,2	1,0
Bromus catharticus	3,4	
(B. unioloides)		1,0
(B. willdenowii)		4,0
B. diandrus	1,0	1,0
B. pectinatus	1,0	
(B. japonicus)		1,0
Cenchrus ciliaris	7,9	10,0
Centropodia glauca	7,3	

(Asthenatherum glaucum)		7,0
Chaetobromus dregeanus	7,3	10,0
Chloris gayana	6,6	7,0
C. virgata	1,8	1,0
Cladoraphis spinosa	2,1	
(Eragrostis spinosa)		7,0
Cymbopogon plurinodis	7,6	10,0
Cynodon aethiopicus	5,0	7,0
C. dactylon	4,5	4,0
C. incompletus	4,1	4,0
Cyperus esculentus	1,2	1,0
C. marginatus	1,4	1,0
C. rotundus	1,2	1,0
C. textilis	1,6	1,0
C. usitatus	1,4	1,0
Digitaria argyrograpta	7,3	10,0
D. eriantha	8,9	10,0
D. sanguinalis	2,5	1,0
Diplachne fusca	4,8	7,0
Echinochloa crus-galli	2,4	1,0
E. crus-pavonis	2,5	1,0
E. holubii	2,3	7,0
Ehrharta calycina	6,4	10,0
E. melicoides	5,0	10,0
Eleusine indica	2,3	7,0
Elionurus mutica	3,6	7,0
Enneapogon desvauxii	1,0	1,0
E. scaber	4,3	4,0
E. scoparius	4,4	7,0
Eragrostis annulata	2,5	1,0
E. aspera	2,3	7,0
E. bergiana	2,8	4,0
E. bicolor	6,0	7,0
E. capensis	5,0	7,0
E. chloromelas	5,5	7,0
E. cilianensis	4,4	7,0
E. ciliaris	2,8	1,0
E. curvula	6,7	7,0
E. curvula var conferta	6,9	10,0
E. cylindriflora	3,7	1,0
E. echinochloidea	4,5	4,0
E. gummiflua	4,0	7,0
E. homomalla	2,0	1,0
E. lehmanniana	5,4	7,0
E. nindensis	3,3	7,0
E. obtusa	4,0	7,0
E. plana	4,8	7,0
E. planiculmis	6,0	7,0
E. porosa	2,5	7,0
E. superba	4,7	7,0
E. tef	5,4	7,0
E. trichophora	4,6	7,0
E. truncata	4,3	7,0
E. virescens	2,0	1,0
Eustachys paspaloides	7,4	
(E. mutica)		10,0
Festuca arundinacea	7,7	10,0
F. scabra	5,5	10,0
Fingerhuthia africana	6,6	10,0
F. sesleriiformis	8,5	10,0
Helictotrichon hirtulum	6,5	10,0
H. longifolium	6,5	10,0
H. turgidulum	6,8	10,0
Heteropogon contortus	7,2	10,0
Hordeum capense	0,8	1,0

H. murinum	0,9	1,0
Hyparrhenia hirta	6,3	10,0
Juncus inflexus	2,2	4,0
Karroochloa purpurea	2,6	7,0
Koeleria capensis	5,7	
(K. cristata)		10,0
Lagurus ovatus	1,7	1,0
Lolium multiflorum	4,5	1,0
L. perenne	5,4	7,0
L. temulentum	3,7	1,0
Mariscus capensis	1,3	1,0
M. usitatus	1,5	1,0
Melica decumbens	4,7	7,0
Melinis repens	4,0	
(Rhynchelytrum repens)		10,0
Merxmuellera disticha	5,0	7,0
M. dura	4,0	7,0
M. stricta	4,5	7,0
Microchloa caffra	1,8	1,0
Miscanthus capensis	4,8	
(Miscanthidium capense)		1,0
Monocymbium ceresiiforme	5,4	7,0
Nasella trichotoma	1,8	
(Stipa trichotoma)		1,0
Oropetium capense	1,3	1,0
Panicum coloratum	8,4	10,0
P. deustum	9,0	10,0
P. lanipes	5,9	10,0
P. maximum	8,1	10,0
P. stapfianum	7,1	10,0
Paspalum dilatatum	7,6	10,0
P. vaginatum	6,1	7,0
Pennisetum clandestinum	6,9	7,0
P. glaucum	6,7	
(P. americanum)		10,0
P. macrourum	7,1	10,0
P. setaceum	2,7	1,0
P. sphacelatum	7,4	10,0
P. thunbergii	5.4	10,0
Pentaschistis airoides	1,4	1,0
P. capillaris	1,6	1,0
P. rigidissima	1,9	1,0
P. tomentella	1,6	1,0
Phalaris aquatica	7,4	
(P. tuberosa)		10,0
Phragmites australis	4,3	1,0
P. communis	4,3	1,0
Poa annua	1,7	1,0
P. bulbosa	1,9	
(P. vivipara)		1,0
P. pratensis	2,3	7,0
Pogonarthria squarrosa	3,2	7,0
Schismus barbatus	1,4	1,0
Schmidtia kalihariensis	3,2	7,0
S. pappophoroides	6,0	10,0
Scirpus dioecus	1,6	1,0
S. inanus	1,3	1,0
S. nodosus	1,9	1,0
Setaria lindenbergiana	6,0	10,0
S. sphacelata	7,2	10,0
S. sphacelata	7,4	

(S. flabellata)		10,0
S. sphacelata	7,3	
(S. neglecta)		10,0
S. verticillata	1,6	1,0
Sporobolus discosporus	1,4	1,0
S. fimbriatus	9,5	10,0
S. ioclados	4,5	7,0
S. ludwigii	1,5	7,0
S. nervosus	4,8	7,0
S. tenellus	1,5	7,0
Stipa clandestina	3,5	7,0
S. dregeana	4,1	7,0
Stipagrostis amabilis	7,0	10,0
S. anomala	3,4	4,0
S. brevifolia	5,8	7,0
S. ciliata	7,2	10,0
S. namaquensis	3,8	7,0
S. obtusa	6,6	10,0
S. uniplumis	5,4	7,0
Tetrachne dregei	10,0	10,0
Themeda triandra	9,3	10,0
Tragus berteronianus	1,3	1,0
T. koelerioides	2,2	4,0
T. racemosus	1,3	1,0
Tribolium obtusifolium	2,7	4,0
(Lasiochloa longifolia)		
Tricholaena capensis	2,4	1,0
Trichoneura grandiglumis	2,0	4,0
Triraphis andropogonoides	3,5	7,0
Triticum aestivum	5,4	10,0
Typha capensis	2,2	1,0

Succulent plants

Adromischus maculatus	1,0	1,0
Aloe broomii	1,1	1,0
A. ciliaris	1,1	1,0
A. claviflora	1,3	1,0
A. dichotoma	1,0	1,0
A. ferox	1,1	1,0
A. longistyla	1,1	1,0
A. striata	1,0	1,0
A. variegata	1,0	1,0
Aloinopsis rubrolineata	1,8	1,0
Aridaria noctiflora	5,7	7,0
Augea capensis	2,1	1,0
Brownanthus ciliatus subsp ciliatus	2,4	1,0
(Psilocaulon ciliatum)		
Carpobrotus edulis	2,3	1,0
Ceropegia filiformis	2,7	4,0
Chasmatophyllum musculinum	2,3	4,0
Conophytum calculus	3,6	4,0
Cotyledon orbiculata	1,2	1,0
Crassula muscosa var muscosa	1,0	1,0
(C. lycopodioides)		
C. whiteheadii	1,1	7,0
Delosperma multiflora	5,7	7,0
D. robustum	5,7	7,0
Drosanthemum hispidum	5,4	7,0
D. lique	6,3	7,0
D. uniflorum	4,8	4,0
Eberlanzia ferox	2,7	1,0
E. spinosa	2,7	1,0

Euphorbia avasmontana	1,3	1,0
E. bothae	2,3	4,0
E. brachiata	2,4	1,0
E. caterviflora	2,4	1,0
E. clavarioides	1,8	1,0
E. coerulescens	2,7	4,0
E. decussata	3,0	4,0
E. enopla	1,6	1,0
E. esculenta	3,2	4,0
E. horrida	1,5	1,0
E. ledienii	1,8	1,0
E. mauritanica	1,1	1,0
E. obesa	1,5	1,0
E. stellispina	2,0	1,0
E. tuberculata	1,7	1,0
E. tuberosa	1,4	1,0
Gibbaeum heathii	2,7	4,0
Haworthia decipiens	1,2	1,0
H. sordida	1,2	1,0
H. truncata	1,8	4,0
Hoodia gordonii	1,1	1,0
Lampranthus ornatus	2,1	1,0
Lithops lesliei	1,2	1,0
Malephora latipetala	3,5	4,0
M. lutea	3,5	4,0
M. mollis	3,4	4,0
Mesembryanthemum crystallinum	1,8	1,0
M. nodiflorum	4,0	7,0
Mestoklema tuberosum (Delosperma tuberosum)	5,6	7,0
Mitrophyllum mitratum	3,0	4,0
Opuntia ficus-indica	1,4	1,0
Orbea cooperi (Stultitia cooperi)	1,0	1,0
Orbeopsis lutea subsp lutea (Caralluma lutea)	1,3	1,0
Pachypodium namaquanum	1,2	1,0
Piaranthus comptus	1,5	4,0
Pleiospilos simulans	1,7	1,0
Psilocaulon absimile	2,1	1,0
P. articulatum	2,7	1,0
P. junceum	4,5	1,0
P. mucronulatum	2,5	1,0
Rabiea albinota	1,6	1,0
Ruschia grisea	2,4	4,0
R. hamata	1,7	1,0
R. perfoliata	1,9	4,0
R. rigens	2,2	4,0
R. uncinata	1,5	1,0
Sceletium anatomicum		
Spalmanthus splendens	5,7	7,0
Stapelia grandiflora (S. flavirostris)	1,3	1,0
S. leendertziae	1,8	4,0
Stomatium erminum	3,2	4,0
Trichocaulon piliferum	1,5	1,0
T. simile	1,3	1,0
Trichodiadema barbatum	5,7	7,0
T. pomeridianum	6,5	7,0
Tylecodon paniculatus	1,5	1,0

(Cotyledon paniculata)		
T. ventricosus	1,0	1,0
(C. ventricosa)		
T. wallichii	1,4	1,0

Ephemeral plants, annuals and bulbous plants

Acrotome inflata	1,0	1,0
Aizoon glinoides	1,0	1,0
Alternanthera pungens	0,8	1,0
Amaranthus hybridus subsp cruentus	1,0	1,0
(A. cruentus)		
Amaryllis belladonna	0,7	1,0
Amellus strigosus	2,2	4,0
Androcymbium melanthioides var striatum	0,5	
(A. striatum)		1,0
Arctotheca calendula	1,4	1,0
Arctotis venusta	1,5	1,0
A. stoechadifolia	1,5	1,0
Argemone mexicana	0,5	1,0
Berkheya angustifolia	0,5	1,0
B. annectens	0,6	1,0
B. fruticosa	0,6	1,0
B. spinosa	0,6	1,0
Bidens bipinnata	0,7	1,0
B. pilosa	0,6	1,0
Blepharis capensis	1,0	1,0
Boophane disticha	0,7	1,0
Brunsvigia radulosa	0,9	1,0
Bulbine asphodeloides	0,9	1,0
B. frutescens	0,9	
(B caulescens)		1,0
Capsella bursa-pastoris	0,6	1,0
Castalis tragus var tragus	1,4	
(Dimorphotheca aurantiaca)		1,0
Centaurea calcitrapa	0,5	1,0
Chamaesyce prostrata	0,9	1,0
(Euphorbia chamaesyce)		
Chenopodium glaucum	1,1	1,0
Circium vulgare	0,5	1,0
Citrullus lanatus	0,9	1,0
Conyza bonariensis	0,7	1,0
C. canadensis	0,7	1,0
C. sumatrensis	0,7	1,0
(C. floribunda)		
Cucumis africanus	1,0	1,0
C. myriocarpus	0,3	1,0
Cuspidia cernua	0,9	1,0
Datura ferox	0,7	1,0
D. stramonium	0,8	1,0
Dicerocaryum eriocarpum	0.8	
(Dicerocaryum zanguebarium)		1,0
Didelta carnosa	0,9	1,0
Dipcadi glaucum	0,5	1,0
Emex australis	1,8	1,0
Erodium cicutarium	1,0	1,0
Exomis microphylla	3,0	1,0
Galenia sarcophylla	4,2	4,0
Gazania jurineifolia	1,2	1,0
G. krebsiana	1,6	1,0
G. linearis	1,3	1,0
Gethyllis ciliaris	0,7	1,0
Gisekia pharnacioides	0,8	1,0

Gnaphalium declinatum	0,6	1,0
Grielum humifusum	1,1	1,0
Harpagophytum procumbens	1,0	1,0
Helichrysum cerastoides	0,8	1,0
Herniaria schlechteri	0,7	1,0
Homeria pallida	0,6	1,0
(H. mossii)		
Hypertelis salsoloides	1,4	4,0
Ibicella lutea	0,7	1,0
Ifloga glomerata	0,8	1,0
(I. aristulata)		
I. paronychioides	0,8	1,0
Indigofera alternans	1,9	1,0
I. porrecta	1,0	1,0
Kleinia longiflorus	1,2	1,0
(Senecio longiflorus)	1,2	1,0
Kohautia cynanchica	0,7	1,0
Lasiopogon glomerulatus	1,0	1,0
Lasiospermum bipinnatum	1,0	1,0
L. pedunculare	1,1	1,0
Lepidium africanum	0,6	1,0
Leysera gnaphalodes	1,6	1,0
L. tenella	1,2	1,0
Malva parviflora	1,0	1,0
Medicago laciniata	2,1	4,0
Melilotus indica	1,1	1,0
Mentha longifolia	1,1	1,0
Moraea polystachya	0,6	1,0
Ornithoglossum viride	0,5	1,0
Osteospermum calendulaceum	1,0	1,0
Oxalis depressa	0,8	1,0
O. latifolia	0,8	1,0
O. smithiana	0,8	1,0
Pentzia albida	0,9	1,0
P. annua	1,2	1,0
Plantago lanceolata	0,6	1,0
P. major	0,7	1,0
Polygonum aviculare	0,8	1,0
P. lapathifolium	0,9	1,0
Portulaca oleracea	0,8	1,0
Radyera urens	1,0	1,0
Salsola kali	1,5	1,0
Salvia stenophylla	0,9	1,0
S. verbenaca	0,8	1,0
(S. clandestina)		
Sesamum capense	1,3	1,0
S. triphyllum	1,6	1,0
Silene undulata	1,0	1,0
Sinapis arvensis	1,0	1,0
Sisymbrium capense	0,8	1,0
Solanum hermannii	0,6	1,0
(S. sodomeum)		
Sonchus oleraceus	0,7	1,0
Tagetes minuta	0,7	1,0
Talinum caffrum	0,5	1,0
Thlaspeocarpa capensis	1,5	1,0
Tragopogon porrifolius	1,3	1,0
Tribulus cristatus	1,2	1,0
T. pterophorus	1,2	1,0

T. terrestris	0,5	1,0
T. zeyheri	0,8	1,0
Trifolium burchellianum	1,1	1,0
Turbina oenotheroides	1,0	1,0
Ursinia nana	0,7	1,0
Urtica dioica	0,6	1,0
Wahlenbergia androsacea	0,8	1,0
Xanthium spinosum	0,5	1,0
X. strumarium	0,5	1,0
Zantedeschia aethiopica	1,3	1,0
Zygophyllum simplex	0,9	1,0

Appendix 2 Regression of crude fibre (CF) on acid detergent fibre (ADF), including the following forage sources, saltbush, *Rhus ciliata* (besembos), lucerne, grass, karoo bushes, forage pills and rations.

Regression Output:		
Constant		-4.31823
Std Err of Y Est		3.031102
R Squared		0.976504
No. of Observations		116
Degrees of Freedom		114
X Coefficient(s)	0.920609	
Std Err of Coef.	0.013374	

5	0.284815
10	4.88786
15	9.490905
20	14.09395
25	18.69699
30	23.30004
35	27.90308
40	32.50613
45	37.10917
50	41.71222
55	46.31526
60	50.91831
65	55.52135
70	60.1244

ADF	CF	ADF	CF	ADF	CF
Saltbush,		54.08	44.78	Besembos, Vrede,	
12.18	5.95	54.33	48.51	38.66	31.34
12.55	6.68	55.16	46.76	39.3	31.5
12.77	6.69	55.26	48.25	37.83	32.65
12.92	5.86	55.34	52.13	Dorper forage pills,	
13.06	6.01	55.47	50.07	23.96	19
13.32	7.11	55.85	45.7	23.79	18.6
14.03	8.7	56.25	48.72	23.56	18.81
14.15	6.77	56.78	55.05	Karoo bush,	
14.16	9.61	57.34	52.8	24.35	20.01
14.21	7.08	57.76	52.76	25.76	21.85
14.26	6.63	58.11	44.86	26.13	21.37
14.37	6.41	58.45	45.39	Grass,	
14.39	8.52	59.14	56.3	15.06	12.39
14.5	7.58	59.67	53.25	14.78	12.36
14.79	7.7	60.23	46.52	15.13	12.46
15	6.9	61.26	50.48	Lucerne,	
15.18	7.45	61.49	53.93	28.64	20.89
15.26	7.85	61.49	54.29	29.22	20.45
15.34	7.44	61.66	54.27	29.47	20.36
15.44	10.37	61.94	53.38	Forage ex Cradock,	
15.54	8.48	62.03	54.98	26.52	19.84
15.78	7.87	62.12	57.37	25.52	19.91
15.92	8.92	62.69	51.38	25.76	18.88
16.06	8.6	62.81	44.98	35.36	27.28
16.16	10.15	65.58	58.47	35.4	27.41
16.18	8.62	66.43	49.39	35.29	28.19
16.47	8.41	66.95	50.25	Feed ex Wolmaranstad,	
16.76	10.13	67.67	51.49	3.68	1.68
17.08	7.67	67.89	51.91	3.81	2.08
18.29	9.96	69.33	51.88	4.11	1.98
47.71	43.69	18.53	9.71	Feed ex Clanwilliam,	
49.55	43.16	49.88	44.44	3.15	1.53
49.63	44.81	51.3	44.24	3.41	2.09
50.67	43.6	15.15	10.85	3.83	2.02
51.22	43.84	15.68	8.84		
51.65	46.83	52.66	44.41		
52.27	43.98	62.14	54.99		
52.46	46.94	63.15	51.37		
52.72	43.76	14.46	8.93		
52.76	47.09	16.53	8.89		
52.78	46.37	58.46	44.63		
52.95	44.15	57.07	53.06		
53.56	46.74	60.13	52.81		
53.77	50.2	67.8	51.21		

Appendix 3 Canopy spread cover, mean forage production, chemical analyses, climatic variables and canopy spread cover on available forage mass regressions of the species studied in the Eastern Mixed Karoo

TABLE 1 Mean canopy spread cover of the studied species, expressed in cm^2

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	124.5	64.4	54.0	47.3	72.6
Aristida diffusa	645.0	385.0	331.5	638.0	499.9
Digitaria eriantha	652.0	317.5	388.5	214.0	393.0
Eragrostis lehmanniana	135.6	79.9	69.6	88.4	93.4
Themeda triandra	702.0	365.5	286.5	275.5	407.4
Chrysocoma ciliata	1013.0	223.0	878.0	348.5	615.6
Eriocephalus ericoides	1064.5	740.0	878.0	914.0	899.1
Pentzia incana	447.5	446.5	496.5	375.5	441.5
Salsola calluna	761.0	484.0	682.5	636.5	641.0
Mean	616.1	345.1	154.7	393.1	451.5

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	207.5	196.5	181.0	172.5	189.4
Sporobolus fimbriatus	381.0	320.0	356.5	219.5	319.3
Stipagrostis ciliata	231.1	188.0	175.3	177.4	193.0
Stipagrostis obtusa	155.6	135.0	113.3	93.8	124.4
Eriocephalus spinescens	619.5	525.0	*	482.0	406.6
Pentzia incana	453.0	391.0	335.5	379.5	389.8
Phymaspermum parvifolium	325.5	355.0	335.0	253.0	317.1
Pteronia glauca	792.0	573.5	822.0	597.5	696.3
Pterothrix spinescens	791.0	713.5	*	596.5	525.3
Rosenia humilis	664.0	581.5	636.0	522.0	600.9
Walafrida geniculata	420.5	425.0	465.5	296.0	401.8
Mean	458.3	400.4	310.9	344.5	378.5

* missing data

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida contortus	56.0	46.9	39.1	30.9	43.2
Eragrostis lehmanniana	84.6	70.1	73.1	55.9	70.9
Heteropogon contortus	173.0	182.5	164.5	188.5	177.1
Themeda triandra	279.5	184.5	181.0	179.0	206.0
Eriocephalus erioides	647.5	815.5	734.5	531.0	682.1
Helicrysum lucilioides	292.5	208.0	193.0	213.5	226.8
Pentzia incana	320.0	316.5	267.0	303.5	301.8
Phymaspermum parvifolium	296.5	358.5	362.5	228.0	311.4
Plinthus karooicus	276.5	447.0	290.5	346.0	340.0
Rosenia humilis	649.0	934.5	721.5	626.0	732.8
Mean	307.5	356.4	302.7	270.2	309.2

TABLE 2 Mean aboveground phytomass production of the studied species (grammes per grass tuft/karoo bush)

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida contortus	19.22	4.56	2.54	2.30	7.16
Aristida diffusa	70.48	63.26	55.28	35.86	56.22
Digitaria eriantha	54.54	22.60	32.40	14.56	31.03
Eragrostis lehmanniana	7.26	6.68	5.92	3.24	5.78
Themeda triandra	78.82	31.18	42.54	34.22	46.69
Chrysocoma ciliata	61.74	9.26	51.02	11.76	33.45
Eriocephalus ericoides	73.34	49.54	51.02	41.94	53.96
Pentzia incana	17.72	16.70	13.82	13.42	15.42
Salsola calluna	69.62	18.32	31.8	32.40	38.04
Mean	50.30	24.68	31.82	21.08	31.97

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	4.00	12.10	5.32	10.90	8.08
Sporobolus fimbriatus	37.58	27.88	26.70	23.30	28.87
Stipagrostis ciliata	23.98	36.28	22.98	13.28	24.13
Stipagrostis obtusa	6.96	27.68	10.58	14.08	14.83
Eriocephalus spinescens	41.20	30.28	*	26.66	24.54
Pentzia incana	18.04	13.78	16.18	10.70	14.68
Phymaspermum parvifolium	21.80	19.28	17.64	13.44	18.04
Pteronia glauca	56.50	33.96	55.92	37.28	45.92
Pterothrix spinescens	68.24	93.18	*	61.60	55.76
Rosenia humilis	46.54	37.06	28.10	24.86	34.14
Walafrida geniculata	18.26	12.24	14.76	10.98	14.06
Mean	31.19	31.25	18.02	22.46	25.73

* missing data

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	1.92	3.18	5.50	4.42	3.76
Eragrostis lehmanniana	10.86	8.74	7.45	7.96	8.75
Heteropogon contortus	15.94	11.54	14.36	12.76	13.65
Themeda triandra	40.18	46.18	31.90	28.18	36.61
Eriocephalus ericoides	34.16	34.24	34.18	28.60	32.80
Helicrysum lucilioides	16.56	13.70	10.38	11.12	12.94
Pentzia incana	13.92	13.60	11.28	11.58	12.60
Phymaspermum parvifolium	22.18	19.38	26.26	13.74	20.39
Plinthus karooicus	18.92	28.36	18.94	21.38	21.90
Rosenia humilis	52.78	74.34	58.16	43.48	57.19
Mean	22.74	25.33	21.84	18.32	22.06

TABLE 3 Mean available forage production / hectare of the studied species (kg/ha), based on the mean production per mean area covered by the plants, calculated as though the plants occurred in a pure stand

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	15437.7	7083.4	4703.7	4867.7	8023.1
Aristida diffusa	10927.1	16431.2	16675.7	5620.7	12413.7
Digitaria eriantha	8365.0	7118.1	8339.8	6803.7	7656.7
Eragrostis lehmanniana	5353.0	8363.1	8502.7	3666.2	6471.3
Themeda triandra	11227.9	8530.8	14848.2	12421.1	11757.0
Chrysocoma ciliata	6094.8	4152.5	5810.9	3374.5	4858.2
Eriocephalus ericoides	6889.6	6694.6	5810.9	4588.6	5995.9
Pentzia incana	3959.8	3740.2	2783.5	3573.9	3514.4
Salsola calluna	9148.5	3785.1	4659.3	3676.4	5317.3
Mean	8600.4	7322.1	8015.0	5399.2	7334.2

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	1932.4	6157.8	2939.2	6318.8	4337.1
Sporobolus fimbriatus	9863.5	8712.5	7489.5	10615.0	9170.1
Stipagrostis ciliata	10375.3	19297.9	13112.7	7487.0	12568.2
Stipagrostis obtusa	6019.5	20503.7	9342.2	15018.7	12721.0
Eriocephalus spinescens	6650.5	5767.6	*	5531.1	5983.1
Pentzia incana	3982.3	3524.3	4822.7	2819.5	3787.2
Phymaspermum parvifolium	6184.4	5431.0	5265.7	5312.3	5548.4
Pteronia glauca	7133.8	5921.5	6802.9	6239.3	6524.4
Pterothrix spinescens	8627.1	13059.6	*	10326.9	10671.2
Rosenia humilis	7009.0	6373.2	4418.2	4781.6	6545.5
Walafrida geniculata	4342.4	2880.0	3170.8	3709.5	2877.7
Mean	6556.4	8639.7	6373.8	7105.4	7168.8

* missing data

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	3428.5	6784.0	14057.5	14315.7	9646.4
Eragrostis lehmanniana	12833.1	12463.5	10229.1	14246.1	12443.0
Heteropogon contortus	9213.9	6323.3	8729.5	6769.2	7759.0
Themeda triandra	14375.7	25029.8	17624.3	15743.0	18193.2
Eriocephalus ericoides	5275.7	4198.7	4653.5	5386.1	4878.5
Helicrysum lucilioides	5661.5	6586.5	5378.2	5208.4	5708.7
Pentzia incana	4350.0	4297.0	4224.7	3815.5	4171.8
Phymaspermum parvifolium	4780.6	5405.9	7244.1	6026.3	6539.2
Plinthus karooicus	6842.7	6344.5	6519.8	6179.2	6471.6
Rosenia humilis	8132.5	7955.1	8061.0	6945.7	7773.6
Mean	7559.4	8538.8	8672.2	8463.5	8358.5

TABLE 4 Percentage TDN of the studied species

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	53.55	51.42	54.73	54.17	53.47
Aristida diffusa	53.12	53.72	54.92	*	53.92
Digitaria eriantha	54.78	54.92	57.33	60.15	56.79
Eragrostis lehmanniana	54.24	52.77	53.83	53.25	53.52
Themeda triandra	53.92	55.52	57.00	55.31	55.44
Chrysocoma ciliata	55.52	54.10	52.34	53.73	53.92
Eriocephalus ericoides	48.95	47.56	49.87	*	48.79
Pentzia incana	48.73	49.42	53.99	50.37	50.63
Salsola calluna	59.28	61.54	69.56	70.47	65.21
Mean	53.56	53.44	55.95	56.78	54.93

* missing data

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	53.38	50.89	55.24	54.08	53.40
Sporobolus fimbriatus	53.89	53.14	51.68	56.00	53.68
Stipagrostis ciliata	48.68	50.27	49.24	47.68	48.97
Stipagrostis obtusa	50.89	58.36	55.27	50.76	53.82
Eriocephalus spinescens	50.92	48.53	42.24	43.84	46.38
Pentzia incana	52.90	48.83	46.29	48.76	49.20
Phymaspermum parvifolium	55.51	57.12	48.02	46.17	51.71
Pteronia glauca	48.19	47.59	46.43	46.18	47.10
Pterothrix spinescens	52.51	49.78	48.14	47.81	49.56
Rosenia humilis	60.76	54.90	50.58	50.48	54.18
Walafrida geniculata	57.91	46.58	47.13	47.10	49.68
Mean	53.23	51.45	49.11	48.99	50.70

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	48.46	48.58	48.01	47.21	48.07
Eragrostis lehmanniana	46.67	51.26	50.14	53.00	50.27
Heteropogon contortus	50.28	50.68	50.90	50.21	50.52
Themeda triandra	48.59	47.01	49.17	49.05	48.45
Eriocephalus ericoides	35.36	43.14	42.71	42.60	40.96
Helichrysum lucilioides	48.45	47.94	48.86	54.30	49.89
Pentzia incana	38.73	44.77	46.48	41.66	42.91
Phymaspermum parvifolium	37.52	44.92	41.07	44.30	41.95
Plinthus karooicus	44.78	51.19	44.78	44.05	46.20
Rosenia humilis	40.52	50.67	46.49	51.31	47.25
Mean	43.94	48.02	46.86	47.77	46.65

TABLE 5 Percentage N of the studied species

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	0.58	0.40	0.51	0.67	0.54
Aristida diffusa	0.58	0.45	0.43	*	0.49
Digitaria eriantha	0.71	0.69	0.65	0.95	0.92
Eragrostis lehmannian	0.71	0.70	0.82	1.45	0.75
Themeda triandra	0.51	0.55	0.52	0.77	0.59
Chrysocoma ciliata	1.17	0.59	0.81	0.95	0.88
Eriocephalus ericoides	0.92	0.68	0.72	*	0.77
Pentzia incana	0.91	0.90	1.01	0.69	0.88
Salsola calluna	1.78	0.91	2.39	2.88	1.99
Mean	0.87	0.65	0.87	1.19	0.90

* missing data

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	0.44	0.48	0.84	0.58	0.59
Sporobolus fimbriatus	0.61	0.57	0.79	0.86	0.71
Stipagrostis ciliata	0.35	0.51	0.65	0.50	0.50
Stipagrostis obtusa	0.47	0.35	0.58	0.41	0.45
Eriocephalus spinescens	0.85	0.96	0.76	0.75	0.83
Pentzia incana	1.03	1.01	0.88	0.97	0.97
Phymaspermum parvifolium	1.04	1.02	0.89	0.79	0.94
Pteronia glauca	1.03	1.02	1.27	0.88	1.05
Pterothrix spinescens	0.88	1.05	0.68	0.85	0.88
Rosenia humilis	1.01	1.11	1.09	1.03	1.06
Walafrida geniculata	1.23	1.04	1.50	0.84	0.90
Mean	0.81	0.83	0.81	0.77	0.81

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	1.08	0.67	0.55	0.61	0.73
Eragrostis lehmanniana	0.72	0.78	0.73	0.90	0.78
Heteropogon contortus	0.61	0.56	0.65	0.55	0.59
Themeda triandra	0.57	0.37	0.47	0.52	0.48
Eriocephalus ericoides	0.75	0.74	1.06	0.67	0.81
Helichrysum luciliodes	1.46	0.93	0.99	1.00	1.10
Pentzia incana	0.83	0.90	0.89	0.81	0.86
Phymaspermum parvifolium	0.66	0.75	0.66	0.66	0.68
Plinthus karooicus	0.93	1.04	0.85	0.78	0.90
Rosenia humilis	0.77	0.93	0.93	0.98	0.90
Mean	0.84	0.77	0.78	0.75	0.78

TABLE 6 Percentage ADF of the studied species

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	41.29	43.20	39.02	40.88	41.10
Aristida diffusa	41.96	40.11	38.11	*	40.06
Digitaria eriantha	40.98	43.17	41.28	43.56	37.83
Eragrostis lehmanniana	40.16	39.84	36.78	34.54	42.25
Themeda triandra	40.26	38.08	35.62	39.64	38.40
Chrysocoma ciliata	40.85	40.52	44.37	42.82	42.14
Eriocephalus ericoides	50.02	51.04	47.72	*	49.59
Pentzia incana	50.32	49.22	42.65	46.80	47.25
Salsola calluna	36.63	30.72	21.98	21.26	27.65
Mean	42.50	41.77	38.61	38.50	40.70

* missing data

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	40.54	44.67	40.07	40.49	41.44
Sporobolus fimbriatus	40.96	41.86	45.29	38.99	41.78
Stipagrostis ciliata	46.90	45.85	48.30	49.73	47.70
Stipagrostis obtusa	44.59	32.09	38.66	44.03	39.91
Eriocephalus spinescens	46.72	50.82	59.58	57.09	53.55
Pentzia incana	44.39	50.54	53.92	50.50	49.84
Phymaspermum parvifolium	40.43	37.89	51.32	53.72	45.84
Pteronia glauca	51.60	52.47	55.06	54.09	53.31
Pterothrix spinescens	44.41	49.43	50.16	51.48	48.87
Rosenia humilis	39.29	41.60	48.14	48.09	42.53
Walafrida geniculata	37.37	54.09	50.58	52.52	48.64
Mean	42.75	45.57	49.19	49.18	46.67

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	43.57	41.52	41.58	43.14	42.45
Eragrostis lehmanniana	44.57	38.24	39.61	36.28	39.68
Heteropogon contortus	38.70	37.78	38.04	38.39	38.23
Themeda triandra	40.88	41.46	39.28	39.85	40.37
Eriocephalus ericoides	61.11	49.79	51.83	50.18	53.23
Helichrysum lucilioides	44.78	43.74	42.66	34.81	41.50
Pentzia incana	56.64	48.21	45.68	52.29	50.71
Phymaspermum parvifolium	57.48	47.27	52.34	47.66	51.19
Plinthus karooicus	48.32	39.48	47.97	48.69	46.12
Rosenia humilis	53.75	39.79	45.84	39.07	44.61
Mean	48.98	42.73	44.48	43.04	44.81

TABLE 7 Percentage K of the studied species

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	0.2	0.23	0.14	0.22	0.20
Aristida diffusa	0.29	0.28	0.18	*	0.25
Digitaria eriantha	0.5	0.41	0.37	0.45	0.43
Eragrostis lehmanniana	0.26	0.42	0.35	0.52	0.39
Themeda triandra	0.42	0.47	0.34	0.42	0.41
Chrysocoma ciliata	0.89	1.0	0.04	0.59	0.63
Eriocephalus ericoides	1.9	2.7	1.48	*	2.03
Pentzia incana	1.17	1.33	0.88	1.41	1.20
Salsola calluna	1.65	2.5	2.95	2.9	2.50
Mean	0.81	1.04	0.75	0.93	0.88

* missing data

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	0.45	0.4	0.46	0.61	0.48
Sporobolus fimbriatus	0.81	0.31	0.63	1.47	0.81
Stipagrostis cilita	0.24	0.15	0.26	0.33	0.25
Stipagrostis obtusa	0.2	0.1	0.25	0.16	0.18
Eriocephalus spinescens	1.58	1.33	1.6	1.24	1.44
Pentzia incana	0.91	0.94	1.4	1.09	1.09
Phymaspermum parvifolium	1.78	1.18	1.72	1.69	1.59
Pteronia glauca	1.3	1.18	1.49	1.52	1.37
Pterothrix spinescens	1.56	0.21	0.46	0.5	0.68
Rosenia humilis	1.78	1.73	1.69	1.71	1.73
Walafrida geniculata	1.94	1.19	1.59	1.26	1.42
Mean	1.11	0.79	1.05	1.05	1.00

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	0.32	0.15	0.11	0.07	0.16
Eragrostis lehmanniana	0.44	0.32	0.29	0.42	0.37
Heteropogon contortus	0.49	0.31	0.26	0.28	0.34
Themeda triandra	0.44	0.31	0.34	0.31	0.35
Eriocephalus ericoides	1.75	1.31	1.36	1.40	1.46
Helichrysum lucilioides	0.87	0.57	0.70	0.67	0.70
Pentzia incana	0.95	0.93	0.99	1.00	0.97
Phymaspermum parvifolium	1.48	1.22	1.20	1.36	1.32
Plinthus karooicus	1.33	1.00	0.89	0.95	1.04
Rosenia humilis	1.43	1.25	1.19	1.41	1.32
Mean	0.95	0.74	0.73	0.79	0.80

TABLE 8 Percentage Ca of the studied species

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	0.12	0.08	0.16	0.19	0.14
Aristida diffusa	0.15	0.08	0.15	*	0.13
Digitaria eriantha	0.33	0.29	0.39	0.33	0.34
Eragrostis lehmanniana	0.28	0.21	0.27	0.37	0.28
Themeda triandra	0.16	0.12	0.19	0.2	0.17
Chrysocoma ciliata	0.4	0.28	0.36	0.38	0.36
Eriocephalus ericoides	0.48	0.38	0.44	*	0.43
Pentzia incana	0.68	0.54	0.74	2.6	1.14
Salsola calluna	0.94	1.29	1.34	1.5	1.27
Mean	0.39	0.36	0.45	0.80	0.50

* missing data

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	0.25	0.25	0.34	0.44	0.32
Sporobolus fimbriatus	0.33	0.29	0.19	0.3	0.28
Stipagrostis ciliata	0.47	0.12	0.22	0.36	0.29
Stipagrostis obtusa	0.23	0.14	0.17	0.18	0.18
Eriocephalus spinescens	0.69	0.55	0.58	0.55	0.59
Pentzia incana	0.66	0.62	0.56	0.64	0.62
Phymaspermum parvifolium	0.81	0.5	0.52	0.57	0.60
Pteronia glauca	0.52	0.48	0.49	0.55	0.51
Pterothrix spinescens	0.35	0.23	0.41	0.31	0.33
Rosenia humilis	0.67	0.78	0.76	0.63	0.71
Walafrida geniculata	0.49	0.36	0.41	0.33	0.40
Mean	0.50	0.39	0.42	0.44	0.44

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	0.15	0.24	0.30	0.25	0.24
Eragrostis lehmanniana	0.27	0.13	0.27	0.33	0.25
Heteropogon contortus	0.29	0.32	0.30	0.31	0.31
Themeda triandra	0.17	0.24	0.19	0.17	0.19
Eriocephalus ericoides	0.47	0.50	0.62	0.40	0.50
Helichrysum lucilioides	0.91	0.72	0.84	0.87	0.84
Pentzia incana	0.46	0.62	0.66	0.63	0.59
Phymaspermum parvifolium	0.49	0.49	0.59	0.51	0.52
Plinthus karooicus	0.92	0.91	1.16	0.71	0.93
Rosenia humilis	0.68	0.80	0.65	0.63	0.69
Mean	0.48	0.50	0.56	0.48	0.50

TABLE 9 Percentage Mg of the studied species

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	0.06	0.06	0.09	0.07	0.07
Aristida diffusa	0.06	0.07	0.05	*	0.06
Digitaria eriantha	0.18	0.16	0.17	0.16	0.17
Eragrostis lehmanniana	0.18	0.07	0.1	0.17	0.13
Themeda triandra	0.07	0.04	0.09	0.09	0.07
Chrysocoma ciliata	0.15	0.1	0.11	0.10	0.34
Eriocephalus ericoides	0.25	0.19	0.19	*	0.21
Pentzia incana	0.28	0.26	0.3	0.56	0.35
Salsola calluna	0.48	0.59	0.89	0.84	0.70
Mean	0.19	0.17	0.22	0.41	0.25

* missing data

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	0.13	0.1	0.17	0.11	0.13
Sporobolus fimbriatus	0.19	0.09	0.1	0.15	0.13
Stipagrostis ciliata	0.35	0.3	0.43	0.25	0.33
Stipagrostis obtusa	0.34	0.7	0.58	0.47	0.52
Eriocephalus spinescens	0.28	0.2	0.23	0.19	0.23
Pentzia incana	0.34	0.3	0.27	0.3	0.30
Phymaspermum parvifolium	0.25	0.17	0.18	0.2	0.20
Pteronia glauca	0.21	0.19	0.24	0.23	0.22
Pterothrix spinescens	0.38	0.39	0.26	0.35	0.35
Rosenia humilis	0.3	0.21	0.25	0.26	0.26
Walafrida geniculata	0.33	0.24	0.31	0.25	0.28
Mean	0.28	0.26	0.27	0.25	0.27

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	0.13	0.14	0.12	0.08	0.12
Eragrostis lehmanniana	0.1	0.09	0.12	0.27	0.15
Heteropogon contortus	0.14	0.10	0.31	0.14	0.17
Themeda triandra	0.09	0.12	0.11	0.11	0.11
Eriocephalus ericoides	0.27	0.24	0.30	0.22	0.26
Helichrysum lucilioides	0.29	0.24	0.26	0.31	0.28
Pentzia incana	0.22	0.29	0.34	0.31	0.29
Phymaspermum parvifolium	0.21	0.19	0.22	0.18	0.20
Plinthus karooicus	0.73	0.60	0.65	0.57	0.64
Rosenia humilis	0.29	0.35	0.32	0.33	0.32
Mean	0.25	0.24	0.28	0.25	0.25

TABLE 10 Percentage Na of the studied species

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	0.03	0.01	0.01	0.01	0.02
Aristida diffua	0.02	0.01	0.01	*	0.01
Digitaria eriantha	0.02	0.03	0.01	0.07	0.03
Eragrostis lehmanniana	0.03	0.03	0.01	0.05	0.03
Themeda triandra	0.03	0.06	0.02	0.02	0.03
Chrysocoma ciliata	0.04	0.04	0.02	0.05	0.04
Eriocephalus ericoides	0.03	0.03	0.07	*	0.03
Pentzia incana	0.10	0.11	0.07	0.40	0.17
Salsola calluna	0.03	0.07	0.07	0.09	0.07
Mean	0.04	0.04	0.03	0.08	0.05

* missing data

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	0.09	0.03	0.02	0.01	0.04
Sporobolus fimbriatus	0.12	0.02	0.01	0.01	0.04
Stipagrostis ciliata	0.03	0.01	0.01	0.01	0.02
Stipagrostis obtusa	0.05	0.01	0.01	0.02	0.02
Eriocephalus spinescens	0.03	0.01	0.02	0.02	0.02
Pentzia incana	0.27	0.22	0.14	0.27	0.23
Phymaspermum parvifolium	0.47	0.09	0.03	0.02	0.15
Pteronia glauca	0.03	0.06	0.01	0.01	0.03
Pterothrix spinescens	0.05	0.05	0.02	0.01	0.03
Rosenia humilis	0.03	0.02	0.02	0.01	0.02
Walafrida geniculata	0.04	0.02	0.02	0.01	0.02
Mean	0.11	0.05	0.03	0.04	0.06

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	0.01	0.02	0.01	0.02	0.02
Eragrostis lehmanniana	0.01	0.01	0.02	0.01	0.01
Heteropogon contortus	0.02	0.04	0.01	0.01	0.02
Themeda triandra	0.03	0.02	0.03	0.01	0.02
Eriocephalus ericoides	0.02	0.05	0.04	0.04	0.04
Helichrysum lucilioides	0.06	0.03	0.03	0.06	0.05
Pentzia incana	0.13	0.12	0.12	0.13	0.13
Phymaspermum parvifolium	0.07	0.03	0.07	0.03	0.05
Plinthus karooicus	0.02	0.05	0.04	0.03	0.04
Rosenia humilis	0.01	0.04	0.08	0.02	0.04
Mean	0.04	0.04	0.05	0.04	0.04

TABLE 11 Percentage P of the studied species

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	0.09	0.07	0.14	0.06	0.09
Aristida diffusa	0.08	0.04	0.04	*	0.05
Digitaria eriantha	0.12	0.07	0.09	0.14	0.11
Eragrostis lehmanniana	0.10	0.08	0.11	0.13	0.11
Themeda triandra	0.10	0.09	0.09	0.11	0.10
Chrysocoma ciliata	0.20	0.15	0.13	0.13	0.15
Eriocephalus ericoides	0.18	0.10	0.11	*	0.13
Pentzia incana	0.20	0.13	0.14	0.08	0.14
Salsola calluna	0.13	0.26	0.14	0.17	0.18
Mean	0.13	0.11	0.11	0.12	0.12

* missing data

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	0.07	0.06	0.13	0.16	0.11
Sporobolus fimbriatus	0.12	0.09	0.17	0.24	0.16
Stipagrostis ciliata	0.01	0.03	0.09	0.12	0.06
Stipagrostis obtusa	0.03	0.03	0.07	0.06	0.05
Eriocephalus spinescens	0.17	0.13	0.15	0.16	0.15
Pentzia incana	0.17	0.15	0.18	0.22	0.18
Phymaspermum parvifolium	0.15	0.14	0.20	0.19	0.17
Pteronia glauca	0.16	0.16	0.23	0.20	0.19
Pterothrix spinescens	0.07	0.07	0.11	0.09	0.09
Rosenia humilis	0.18	0.12	0.18	0.19	0.17
Walafrida geniculata	0.18	0.13	0.24	0.15	0.18
Mean	0.12	0.10	0.16	0.16	0.14

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	0.14	0.07	0.08	0.06	0.09
Eragrostis lehmanniana	0.15	0.07	0.10	0.11	0.11
Heteropogon contortus	0.14	0.06	0.09	0.08	0.09
Themeda triandra	0.11	0.09	0.09	0.06	0.09
Eriocephalus ericoides	0.15	0.09	0.11	0.14	0.12
Helichrysum lucilioides	0.11	0.09	0.12	0.11	0.11
Pentzia incana	0.19	0.16	0.16	0.17	0.17
Phymaspermum parvifolium	0.14	0.16	0.21	0.18	0.17
Plinthus karooicus	0.22	0.08	0.08	0.07	0.11
Rosenia humilis	0.12	0.11	0.18	0.18	0.15
Mean	0.15	0.10	0.12	0.12	0.12

TABLE 12K/Ca+Mg ratio of the studied species

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	1.11	1.64	0.56	0.85	2.08
Aristida diffusa	1.38	1.87	0.90	*	2.77
Digitaria eriantha	0.98	0.91	0.66	0.92	1.74
Eragrostis lehmanniana	0.57	1.5	0.95	0.96	1.99
Themeda triandra	1.83	2.94	1.21	1.45	3.71
Chrysocoma ciliata	1.62	2.63	0.09	0.43	2.38
Eriocephalus ericoides	2.60	4.74	2.35	*	6.46
Pentzia incana	1.22	1.66	0.85	0.45	1.67
Salsola calluna	1.16	1.33	1.32	1.24	2.19
Mean	2.77	3.94	1.97	1.80	2.62

* missing data

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	1.18	1.14	0.90	1.10	2.17
Sporobolus fimbriatus	1.56	0.82	2.17	3.27	3.91
Stipagrostis ciliata	0.29	0.36	0.40	0.54	0.80
Stipagrostis obtusa	0.35	0.12	0.33	0.25	0.52
Eriocephalus spinescens	1.63	1.77	1.98	1.68	3.53
Pentzia incana	0.91	1.02	1.69	1.16	2.10
Phymaspermum parvifolium	1.68	1.76	2.46	2.19	4.05
Pteronia glauca	1.78	1.76	2.04	1.95	3.26
Pterothrix spinescens	2.14	0.34	0.69	0.76	1.96
Rosenia humilis	1.84	1.75	1.67	1.92	3.59
Walafrida geniculata	2.00	1.98	2.21	2.17	4.18
Mean	2.79	2.33	2.82	2.98	2.73

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	1.14	0.39	0.26	0.14	0.36
Eragrostis lehmanniana	1.19	1.45	0.74	1.27	1.61
Heteropogon contortus	1.14	0.74	0.60	0.90	1.11
Themeda triandra	1.69	0.86	1.13	1.63	1.74
Eriocephalus ericoides	2.36	1.77	1.48	3.41	2.94
Helichrysum lucilioides	0.73	0.59	0.64	0.76	0.82
Pentzia incana	1.40	1.02	0.99	1.56	1.60
Phymaspermum parvifolium	2.11	1.79	1.48	2.47	2.38
Plinthus karooicus	0.81	0.66	0.49	1.23	1.10
Rosenia humilis	1.47	1.09	1.23	1.86	1.63
Mean	2.81	1.04	0.90	1.52	1.53

TABLE 13 The Ca/P ratio of the studied species

1990/91

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	1.33	1.14	1.14	3.17	1.07
Aristida diffusa	1.88	2.00	3.75	*	1.91
Digitaria eriantha	2.75	4.14	4.33	2.36	3.40
Eragrostis lehmanniana	2.80	2.63	2.45	2.85	2.68
Themeda triandra	1.60	1.33	2.11	1.72	1.69
Chrysocoma ciliata	2.00	1.87	2.77	2.92	2.39
Eriocephalus ericoides	2.67	3.80	4.00	*	2.62
Pentzia incana	3.40	4.15	3.36	3.25	3.54
Salsola calluna	7.23	4.96	9.57	8.82	7.65
Mean	2.85	2.89	3.72	2.79	3.06

* missing data

1991/92

Species	May	Aug	Nov	Feb	Mean
Heteropogon contortus	3.57	4.17	2.62	2.75	3.28
Sporobolus fimbriatus	2.75	3.22	1.12	1.25	2.09
Stipagrostis ciliata	47.00	4.00	2.44	3.00	3.54
Stipagrostis obtusa	7.67	4.67	2.43	3.00	4.44
Eriocephalus spinescens	4.06	1.23	3.87	3.74	3.23
Pentzia incana	3.88	4.13	3.11	2.91	3.51
Phymaspermum parvifolium	5.40	3.57	2.60	3.00	3.64
Pteronia glauca	3.25	3.00	2.13	2.75	2.78
Pterothrix spinescens	5.00	3.29	3.73	3.44	3.87
Rosenia humilis	3.72	6.50	4.20	3.32	4.44
Walafrida geniculata	2.72	2.77	2.71	2.20	2.60
Mean	4.25	3.69	2.81	2.85	3.40

1992/93

Species	May	Aug	Nov	Jan	Mean
Aristida congesta	1.07	3.43	3.75	4.17	3.10
Eragrostis lehmanniana	1.80	1.86	2.70	3.00	2.34
Heteropogon contortus	2.07	5.33	3.33	3.88	3.65
Themeda triandra	1.55	2.67	2.11	2.83	2.29
Eriocephalus ericoides	3.13	5.56	5.64	2.86	4.30
Helichrysum lucilioides	8.27	8.00	7.00	7.91	7.80
Pentzia incana	2.42	3.88	4.13	3.71	3.53
Phymaspermum parvifolium	3.50	3.06	2.81	2.83	3.05
Plinthus karooicus	4.18	11.38	14.50	10.14	10.05
Rosenia humilis	5.67	7.27	3.61	3.50	5.01
Mean	3.37	5.24	4.96	4.48	4.51

TABLE 14 Percentage ether extract and ash of the studied species, adapted from Botha, van Staden & Blom (1990), Botha, Becker & van der Merwe (1990), Botha, Erasmus & Theron (1990), Botha & Nash (1990), Steenkamp & Hayward (1979) and Louw, Steenkamp & Steenkamp (1968b)

Ether extract	Apr/May	Jul/Aug	Oct/Nov	Jan/Feb	Mean
Aristida congesta	1.70	1.59	0.84	0.00	1.03
Aristida diffusa	1.43	1.35	1.61	1.29	1.42
Digitaria eriantha	2.57	1.95	2.82	2.23	2.39
Eragrostis lehmanniana	1.89	1.55	1.56	1.59	1.65
Heteropogon contortus	1.57	2.06	1.80	1.58	1.75
Sporobolus fimbriatus		1.30		2.30	1.80
Stipagrostis ciliata	1.24	1.63	0.96	1.51	1.34
Stipagrostis obtusa	1.63	2.01	0.56	1.47	1.42
Themeda triandra	1.80	2.25	2.15	1.83	2.01
Chrysocoma ciliata	9.24	9.25	7.6	8.19	8.57
Eriocephalus ericoides	4.87	5.03	2.85	2.3	3.76
Eriocephalus spinescens	2.31	2.20	1.55	2.03	2.02
Helichrysum lucilioides	1.72	1.66	1.75	1.73	1.72
Pentzia incana	3.15	3.88	2.82	2.29	3.04
Phymaspermum parvifolium		7.00		7.40	7.20
Plinthus karooicus	1.30	1.73	2.19	1.54	1.69
Pteronia glauca	2.74	3.47	2.43	3.28	2.98
Pterothrix spinescens	4.79	5.16	4.33	4.82	4.78
Rosenia humilis	2.36	2.33	1.80	1.98	2.12
Salsola calluna	1.57	1.34	1.38	1.55	1.46
Walafrida geniculata	1.59	1.48	1.48	1.77	1.58
Mean	2.60	2.87	2.24	2.51	2.64

Ash	Apr/May	Jul/Aug	Oct/Nov	Jan/Feb	Mean
Aristida congesta	12.30	20.27	12.45	0.00	11.26
Aristida diffusa	11.70	9.53	9.74	9.85	10.21
Digitaria eriantha	11.35	9.93	10.04	10.45	10.44
Eragrostis lehmanniana	8.66	6.95	7.66	8.52	7.95
Heteropogon contortus	11.99	10.36	11.34	10.88	11.14
Sporobolus fimbriatus		11.40		9.60	10.50
Stipagrostis ciliata	6.46	9.02	7.83	9.24	8.14
Stipagrostis obtusa	24.86	11.78	9.05	0.00	11.42
Themeda triandra	13.26	10.50	11.53	12.60	11.97
Chrysocoma ciliata	8.72	4.61	6.07	9.88	7.32
Eriocephalus ericoides	6.79	5.40	5.64	5.78	5.90
Eriocephalus spinescens	10.23	6.51	5.64	5.40	6.95
Helichrysum lucilioides	6.30	4.00	4.72	5.06	5.02
Pentzia incana	8.96	7.80	8.90	7.27	8.23
Phymaspermum parvifolium		16.00		20.00	18.00
Plinthus karooicus	13.34	12.47	11.60	9.87	11.82
Pteronia glauca	9.88	6.86	7.38	6.65	7.69
Pterothrix spinescens	7.74	9.26	11.65	5.53	8.55
Rosenia humilis	12.48	8.85	9.10	11.45	10.47
Salsola calluna	16.64	11.99	11.40	14.93	13.74
Walafrida geniculata	5.61	6.16	4.86	5.02	5.41
Mean	10.91	9.51	8.77	8.48	9.63

TABLE 15 Climatological variables recorded at Grootfontein during the 1990/91, 1991/92 and 1992/93 seasons

1989/90	rain	max T	min T	mean T	sun	wind	evaporation
July	1.3	16.2	-0.9	11.925	8.8	206.0	4.1
August	5.4	20.7	2.8	16.225	9.3	251.6	5.9
September	8.0	21.7	3.1	17.050	9.1	219.0	6.6
October	30.2	23.2	5.2	18.700	9.2	212.5	7.4
November	94.9	25.0	9.8	21.200	8.6	197.2	7.2
December	42.0	30.2	11.6	25.550	11.2	185.9	8.7
January	37.8	31.7	12.5	26.900	11.1	199.3	9.5
February	17.8	28.3	10.8	23.925	9.3	168.2	7.4
March	64.9	26.2	9.9	22.125	8.7	154.3	5.7
April	16.2	22.8	7.6	19.000	8.0	171.7	4.4
May	1.9	20.3	2.7	15.900	8.7	183.2	4.6
June	24.1	15.8	-0.9	11.625	7.7	186.8	4.1
	344.5						
1990/91							
July	0.8	16.9	-0.7	12.500	8.5	209.7	4.4
August	12.2	18.8	2.0	14.600	8.5	216.6	5.2
September	0.3	23.5	3.6	18.525	9.4	185.3	6.5
October	1.4	25.1	5.0	20.075	10.1	210.0	8.0
November	14.9	28.4	7.7	23.225	11.3	248.4	10.2
December	42.4	29.6	11.5	25.075	10.1	184.4	9.3
January	57.2	30.5	13.1	26.150	9.4	201.1	8.9
February	141.8	29.3	13.1	25.250	9.5	162.6	7.6
March	51.3	26.4	10.8	22.500	8.3	153.1	5.8
April	2.2	26.4	8.3	21.875	9.2	182.5	6.4
May	11.3	21.4	3.8	17.000	9.2	201.6	5.1
June	32.8	15.1	0.1	11.350	7.3	168.0	2.5
	368.6						
1991/92							
July	0.3	17.1	-0.4	12.725	9.1	213.9	4.2
August	0.0	18.0	0.3	13.575	9.1	203.2	4.9
September	14.5	22.1	4.6	17.725	8.9	234.6	6.4
October	136.0	23.5	9.4	19.975	7.6	190.3	5.5
November	33.0	27.1	10.4	22.925	9.7	183.3	7.3
December	86.7	28.9	12.1	24.700	9.1	169.8	7.1
January	2.2	31.4	12.0	26.550	11.8	182.4	9.2
February	47.6	30.9	13.7	26.600	9.9	195.8	8.7
March	60.0	27.8	10.1	23.375	9.1	161.8	6.3
April	3.7	24.8	8.1	20.625	8.8	188.5	5.4
May	0.3	21.6	3.6	17.100	8.9	210.9	4.9
June	20.2	17.0	0.6	12.900	8.0	232.4	3.6
	404.5						
1992/93							
July	3.0	17.6	0.2	13.250	8.6	217.0	4.2
August	15.5	16.8	1.5	12.975	7.3	184.9	3.6
September	0.9	24.3	3.8	19.175	8.9	191.7	6.6
October	29.4	24.0	6.0	19.500	9.7	223.3	7.8
November	32.9	27.3	9.0	22.725	10.7	208.9	8.7
December	0.1	31.8	11.4	26.700	11.3	215.6	10.9
January	13.9	32.2	13.7	27.575	11.1	192.0	10.1
February	17.6	28.8	11.9	24.575	9.1	180.6	7.4
March	25.0	28.4	11.8	24.250	9.2	166.2	6.4
April	23.6	22.5	7.4	18.725	6.8	214.6	4.8
May	6.3	20.2	3.3	15.975	8.7	195.3	3.7
June	8.3	17.6	0.9	13.425	7.9	20.70	3.7
	176.5						

Grootfontein, 1990 to 1993, canopy spread cover : mass regressions
Karoo bushes
(x=area cm^2)(y=mass kg)

Chrysocoma ciliata 90	1013	61.74	Regression Output:			
	223	9.26	Constant			-7.73418
	878	51.02	Std Err of Y Est			10.68857
	348.5	11.76	R Squared			0.719164
Eriocephalus ericoides 92	647.5	34.16	No. of Observations			62
	815.5	34.24	Degrees of Freedom			60
	734.5	34.18				
	531	28.6	X Coefficient(s)	0.074874		
Eriocephalus ericoides 90	1064.5	73.34	Std Err of Coef.	0.006040		
	740	49.54	x	y		
	878	51.02	1064.5	93.18	max	
	914	41.94	193	9.26	min	
Eriocephalus spinescens 91	619.5	41.2	224.7258	19.84146	std	
	525	30.28	523.2741	31.44580	mean	
	482	26.66	50	-3.99048		
Helichrysum lucilioides 92	296.5	16.56	100	-0.24678		
	208	13.7	150	3.49692		
	193	10.38	200	7.24062		
	213.5	11.12	250	10.98432		
Pentzia incana 91	453	18.04	300	14.72802		
	391	13.78	350	18.47172		
	335.5	16.18	400	22.21542		
	379.5	10.7	450	25.95912		
Pentzia incana 92	320	13.92	500	29.70282		
	316.5	13.6	550	33.44652		
	267	11.28	600	37.19022		
	303.5	11.58	650	40.93392		
Pentzia incana 90	447.5	17.72	700	44.67762		
	446.5	16.7	750	48.42132		
	496.5	13.82	800	52.16502		
	375.5	13.42	850	55.90872		
Phymaspermum parvifolium 91	253	13.44	900	59.65242		
	355	19.28	950	63.39612		
	335	17.64	1000	67.13982		
	253	13.44	1050	70.88352		
Phymaspermum parvifolium 92	296.5	22.18	1100	74.62722		
	358.5	19.38				
	362.5	26.26				
	228	13.74				
Plinthus karooicus 92	276.5	18.92				
	447	28.36				
	290.5	18.94				
	346	21.38				
Pteronia glauca 91	792	56.5				
	573.5	33.96				
	822	55.92				
	597.5	37.28				
Pterothrix spinescens 91	791	68.24				
	713.5	93.18				
	596.5	61.6				
Rosenia humilis 91	664	46.54				
	581.5	37.06				
	636	28.1				
	522	24.96				
Rosenia humilis 92	649	52.78				
	934.5	74.34				
	721.5	58.16				
	626	43.48				
Salsola calluna 90	761	69.62				
	484	18.32				
	682.5	31.8				
	636.5	23.4				

Grasses
(x=area cm²)(y=mass kg)

Aristida congesta 92	56	1.92	Regression Output:		
	46.875	3.18	Constant		1.430059
	39.125	5.5	Std Err of Y Est		10.23976
	30.875	4.42	R Squared		0.706913
Aristida congesta 90	124.5	19.22	No. of Observations		52
	64.375	4.56	Degrees of Freedom		50
	54	2.54			
	47.25	2.3	X Coefficient(s)	0.095869	
Aristida diffusa 90	645	70.48	Std Err of Coef.	0.008729	
	385	63.26	x	y	
	331.5	55.28	702	78.82	max
	638	35.86	30.875	1.92	min
Digitaria eriantha 90	652	54.54	162.6582	18.54705	std
	317.5	22.6	213.7908	21.92615	mean
	388.5	32.4	50	6.223509	
	214	14.56	100	11.01695	
Eragrostis lehmanniana 92	84.625	10.86	150	15.81040	
	70.125	8.74	200	20.60385	
	73.125	7.48	250	25.39730	
	55.875	7.96	300	30.19075	
Eragrostis lehmanniana 90	135.625	7.26	350	34.98420	
	79.875	6.68	400	39.77765	
	69.625	5.92	450	44.57110	
	88.375	3.24	500	49.36455	
Heteropogon contortus 91	207	4	550	54.15800	
	196.5	12.1	600	58.95145	
	181	5.32	650	63.74490	
	172.5	10.9	700	68.53835	
Heteropogon contortus 92	173	15.94	750	73.33180	
	182.5	11.54			
	164.5	14.36			
	188.5	12.76			
Sporobolus fimbriatus 91	381	37.58			
	320	27.88			
	356.5	26.7			
	219.5	23.3			
Stipagrostis ciliata 91	231.125	23.98			
	188	36.28			
	175.25	22.98			
	177.375	11.28			
Stipagrotis obtusa 91	115.625	6.96			
	135	27.68			
	113.25	10.58			
	93.75	14.08			
Themeda triandra 92	279.5	40.18			
	184.5	46.18			
	181	31.9			
	179	28.18			
Themeda triandra 90	702	78.82			
	365.5	31.18			
	286.5	42.54			
	275.5	34.22			

Grootfontein, 1990 to 1993, canopy spread cover : mass regressions

Karoo bushes (x=area cm²)(y=mass kg)	May area	May mass	Jul area	Jul mass	Nov area	Nov mass	Jan area	Jan mass
Chrysocoma ciliata 90	1013	61.74	223	9.26	878	51.02	348.5	11.76
Eriocephalus ericoides 92	647.5	34.16	815.5	34.24	734.5	34.18	531	28.6
Eriocephalus ericoides 90	1064.5	73.34	740	49.54	878	51.02	914	41.94
Eriocephalus spinescens 91	619.5	41.2	525	30.28	193	10.38	482	26.66
Helichrysum lucilioides 92	296.5	16.56	208	13.7	335.5	16.18	213.5	11.12
Pentzia incana 91	453	18.04	391	13.78	267	11.28	379.5	10.7
Pentzia incana 92	320	13.92	316.5	13.6	496.5	13.82	303.5	11.58
Pentzia incana 90	447.5	17.72	446.5	16.7	335	17.64	375.5	13.42
Phymaspermum parvifolium 91	253	13.44	355	19.28	362.5	26.26	253	13.44
Phymaspermum parvifolium 92	296.5	22.18	358.5	19.38	290.5	18.94	228	13.74
Plinthus karooicus 92	276.5	18.92	447	28.36	822	55.92	346	21.38
Pteronia glauca 91	792	56.5	573.5	33.96	636	28.1	597.5	37.28
Pterothrix spinescens spi 91	791	68.24	713.5	93.18	721.5	58.16	596.5	61.6
Rosenia humilis 91	664	46.54	581.5	37.06	682.5	31.8	522	24.96
Rosenia humilis 92	649	52.78	934.5	74.34			626	43.48
Salsola calluna 90	761	69.62	484	18.32			636.5	23.4

May

Regression Output:

Constant	-7.08159
Std Err of Y Est	8.654663
R Squared	0.858944
No. of Observations	16
Degrees of Freedom	14
X Coefficient(s)	0.078998
Std Err of Coef.	0.008555

Jul

Regression Output:

Constant	-13.7599
Std Err of Y Est	14.39217
R Squared	0.644435
No. of Observations	16
Degrees of Freedom	14
X Coefficient(s)	0.089379
Std Err of Coef.	0.017743

Nov

Regression Output:

Constant	-3.73857
Std Err of Y Est	8.125505
R Squared	0.794131
No. of Observations	14
Degrees of Freedom	12
X Coefficient(s)	0.062501
Std Err of Coef.	0.009186

Jan

Regression Output:

Constant	-2.90934
Std Err of Y Est	9.907687
R Squared	0.583016
No. of Observations	16
Degrees of Freedom	14
X Coefficient(s)	0.060058
Std Err of Coef.	0.013574

	May		Jul		Nov		Jan	
Grasses								
(x=area cm^2)(y=mass kg)	area	mass	area	mass	area	mass	area	mass
Aristida congesta 92	56	1.92	46.875	3.18	39.125	5.5	30.875	4.42
Aristida congesta 90	124.5	19.22	64.375	4.56	54	2.54	47.25	2.3
Aristida diffusa 90	645	70.48	385	63.26	331.5	55.28	638	35.86
Digitaria eriantha 90	652	54.54	317.5	22.6	388.5	32.4	214	14.56
Eragrostis lehmanniana 92	84.625	10.86	70.125	8.74	73.125	7.48	55.875	7.96
Eragrostis lehmanniana 90	135.625	7.26	79.875	6.68	69.625	5.92	88.375	3.24
Heteropogon contortus 91	207	4	196.5	12.1	181	5.32	172.5	10.9
Heteropogon contortus 92	173	15.94	182.5	11.54	164.5	14.36	188.5	12.76
Sporobolus fimbriatus 91	381	37.58	320	27.88	356.5	26.7	219.5	23.3
Stipagrostis ciliata 91	231.125	23.98	188	36.28	175.25	22.98	177.375	11.28
Stipagrostis obtusa 91	115.625	6.96	135	27.68	113.25	10.58	93.75	14.08
Themeda triandra 92	279.5	40.18	184.5	46.18	181	31.9	179	28.18
Themeda triandra 90	702	78.82	365.5	31.18	286.5	42.54	275.5	34.22

May

Regression Output:

Constant	-2.43852
Std Err of Y Est	8.257865
R Squared	0.906101
No. of Observations	13
Degrees of Freedom	11
X Coefficient(s)	0.106533
Std Err of Coef.	0.010340

Jul

Regression Output:

Constant	2.129131
Std Err of Y Est	13.28114
R Squared	0.502415
No. of Observations	13
Degrees of Freedom	11
X Coefficient(s)	0.108126
Std Err of Coef.	0.032444

Nov

Regression Output:

Constant	-0.52979
Std Err of Y Est	10.18965
R Squared	0.654643
No. of Observations	13
Degrees of Freedom	11
X Coefficient(s)	0.112013
Std Err of Coef.	0.024530

Jan

Regression Output:

Constant	4.997748
Std Err of Y Est	7.102944
R Squared	0.639616
No. of Observations	13
Degrees of Freedom	11
X Coefficient(s)	0.058008
Std Err of Coef.	0.013128

Appendix 4 An exposition of the canopy spread cover, mean forage production, chemical analyses and canopy spread cover on available forage mass regressions of the species studied in the Karoo Mountainous areas

TABLE 1 Mean canopy spread cover of the studied species
1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	140.88	88.25	199.13	112.50	135.19
Merxmuelera disticha	227.75	178.75	228.00	159.50	198.50
Pentzia globosa	565.50	515.00	273.50	389.50	435.88
Phymaspermum parvifolium	390.00	413.50	288.50	341.00	358.25
Themeda triandra	99.63	52.25	68.28	53.13	68.32
Walafrida saxatilis	664.00	433.00	495.00	452.50	511.13
Mean	374.96	280.13	258.74	251.36	284.54

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	242.00	273.00	266.00	156.50	234.38
Eragrostis curvula var conferta	274.50	293.00	235.00	206.50	252.25
Hyparrhenia hirta	275.00	321.50	298.00	231.50	281.50
Eriocephalus ericoides	753.50	640.50	723.50	342.00	614.88
Felicia fascicularis	120.25	90.00	45.88	99.38	88.88
Felicia filifolia	967.00	585.50	536.50	445.00	633.50
Nenax microphylla	358.50	350.50	344.00	279.00	333.00
Pentzia globosa	477.50	421.00	447.00	265.00	402.63
Mean	433.53	371.88	361.99	253.11	355.13

1992/93

Species	May	Aug	Oct	Jan	Mean
Digitaria eriantha	215.00	180.50	151.50	157.50	176.12
Eragrostis lehmanniana	73.25	46.00	50.00	39.25	52.12
Eriocephalus ericoides	595.00	574.50	604.50	514.00	572.00
Helichrysum dregeanum	68.37	64.37	56.12	88.37	69.31
Nenax microphylla	346.50	1100.00	289.50	214.00	487.50
Pentzia globosa	422.50	441.50	400.00	234.50	374.62
Phymaspermum parvifolium	439.00	406.50	445.50	315.50	401.62
Rosenia oppositifolia	700.50	909.50	461.50	539.50	652.75
Themeda triandra	212.00	247.50	186.50	123.00	192.25
Mean	341.35	441.15	293.90	247.29	330.92

TABLE 2 Mean aboveground available forage production of the studied species (grammes per grass tuft/karoo bush)

1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	78.12	68.50	52.70	38.22	59.39
Merxmuelera disticha	155.38	171.80	137.46	110.72	143.84
Pentzia globosa	35.34	21.98	17.64	18.94	23.48
Phymaspermum parvifolium	43.36	26.20	22.78	19.26	27.90
Themeda triandra	40.94	33.44	35.52	23.00	33.23
Walafrida saxatilis	15.56	7.50	7.62	7.50	9.55
Mean	61.45	54.90	36.27	36.27	49.56

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	26.36	18.98	18.68	15.32	19.84
Eragrostis curvula var conferta	25.30	19.70	15.00	20.50	20.13
Hyparrhenia hirta	87.90	56.52	54.64	27.32	56.60
Eriocephalus ericoides	42.32	37.04	38.90	20.06	34.58
Felicia fascicularis	7.64	5.20	2.10	6.88	5.46
Felicia filifolia	64.72	33.76	31.54	31.40	40.36
Nenax microphylla	30.30	26.94	24.50	20.72	25.62
Pentzia globosa	25.14	20.48	22.66	13.24	20.38
Mean	38.71	27.33	26.00	19.43	27.87

1992/93

	May	Aug	Oct	Jan	Mean
Digitaria eriantha	17.70	14.80	16.76	19.68	17.23
Eragrostis lehmanniana	4.64	2.06	5.80	6.76	4.81
Eriocephalus ericoides	36.76	33.64	35.76	31.74	34.48
Helichrysum dregeanum	3.80	1.86	2.38	5.36	3.35
Nenax microphylla	33.00	61.80	25.18	22.38	35.59
Pentzia globosa	16.92	19.96	20.16	12.64	17.42
Phymaspermum parvifolium	29.92	30.12	39.48	22.04	30.39
Rosenia oppositifolia	27.14	46.46	27.98	32.16	33.44
Themeda triandra	15.22	29.42	40.42	19.74	26.20
Mean	20.57	26.68	23.77	19.17	22.55

TABLE 3 Percentage TDN of the studied species
1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	45.68	38.96	48.64	47.42	45.17
Merxmuelera disticha	43.46	41.49	44.13	44.38	43.36
Pentzia globosa	49.42	45.64	49.37	45.86	47.57
Phymaspermum parvifolium	45.80	44.40	41.95	46.84	44.75
Themeda triandra	49.57	47.70	47.40	49.81	48.62
Walafrida saxatilis	53.79	52.61	56.71	56.64	54.94
Mean	47.95	45.13	48.03	48.49	47.70

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	48.78	48.55	46.38	45.38	47.27
Eragrostis curvula var conferta	48.09	49.17	50.70	47.55	48.88
Hyparrhenia hirta	43.59	43.83	45.34	47.25	45.00
Eriocephalus ericoides	42.36	37.70	44.50	46.55	42.78
Felicia fascicularis	42.07	42.52	51.95	47.95	46.12
Felicia filifolia	51.22	44.55	40.86	40.04	44.17
Nenax microphylla	39.88	39.18	39.13	33.07	37.82
Pentzia globosa	47.71	46.18	49.30	48.35	47.88
Mean	45.46	43.96	46.02	44.52	44.99

1992/93

Mean	May	Aug	Oct	Jan	Mean
Digitaria eriantha	52.00	50.82	54.44	50.92	52.05
Eragrostis lehmanniana	53.91	53.64	56.10	52.76	54.10
Eriocephalus ericoides	48.01	51.78	49.88	46.91	49.14
Helichrysum dregeanum	58.14	63.65	63.69	59.29	61.19
Nenax microphylla	42.66	41.76	46.46	42.88	43.44
Pentzia globosa	50.02	49.74	54.18	50.40	51.09
Phymaspermum parvifolium	46.37	45.95	47.42	45.12	46.21
Rosenia oppositifolia	50.93	44.73	60.68	54.59	52.73
Themeda triandra	52.76	54.37	52.20	52.62	52.99
Mean	50.53	50.72	53.89	50.61	51.44

TABLE 4 Percentage N of the studied species
1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	0.47	0.68	0.60	0.59	0.59
Merxmuelera disticha	0.46	0.40	0.41	0.44	0.43
Pentzia globosa	1.23	1.08	1.17	1.05	1.13
Phymaspermum parvifolium	1.00	0.36	0.80	1.34	0.88
Themeda triandra	0.42	0.36	0.39	0.52	0.42
Walafrida saxatilis	1.15	0.96	0.88	1.08	1.02
Mean	0.79	0.64	0.71	0.84	0.75

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	0.80	0.77	0.84	0.58	0.75
Eragrostis curvula var conferta	0.61	0.62	0.90	0.73	0.72
Hyparrhenia hirta	0.39	0.65	0.56	0.56	0.54
Eriocephalus ericoides	0.88	0.75	0.90	0.87	0.85
Felicia fascicularis	0.89	1.00	1.22	1.04	1.04
Felicia filifolia	1.15	0.81	0.80	0.72	0.87
Nenax microphylla	0.79	0.91	0.90	0.58	0.80
Pentzia globosa	1.14	1.14	1.25	1.00	1.13
Mean	0.83	0.83	0.92	0.76	0.84

1992/93

Species	May	Aug	Oct	Jan	Mean
Digitaria eriantha	0.54	0.60	0.72	0.62	0.62
Eragrostis lehmanniana	0.64	0.72	0.76	0.63	0.69
Eriocephalus ericoides	0.97	1.05	0.86	0.84	0.93
Helichrysum dregeanum	1.04	0.94	1.07	0.79	0.96
Nenax microphylla	0.75	0.79	0.85	0.75	0.79
Pentzia globosa	1.22	1.07	1.28	0.82	1.10
Phymaspermum parvifolium	0.93	0.76	0.69	0.86	0.81
Rosenia oppositifolia	0.75	0.75	1.06	0.86	0.85
Themeda triandra	0.41	0.43	0.30	0.47	0.40
Mean	0.81	0.79	0.84	0.74	0.79

TABLE 5 Percentage ADF of the studied species
1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	44.37	55.56	41.04	42.74	45.93
Merxmuelera disticha	47.50	49.80	46.07	45.99	47.34
Pentzia globosa	42.73	47.69	42.60	47.26	45.07
Phymaspermum parvifolium	47.16	45.17	51.86	46.80	47.75
Themeda triandra	38.29	40.39	41.14	38.78	39.65
Walafrida saxatilis	36.16	37.13	30.84	31.75	33.97
Mean	42.70	45.96	42.26	42.22	43.29

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	41.96	42.15	45.64	45.63	43.85
Eragrostis curvula var conferta	41.90	40.39	39.65	43.38	41.33
Hyparrhenia hirta	46.66	48.32	45.54	42.77	45.82
Eriocephalus ericoides	51.64	57.76	48.63	45.52	50.89
Felicia fascicularis	52.10	51.92	39.09	44.20	46.83
Felicia filifolia	39.85	48.14	53.44	54.21	48.91
Nenax microphylla	54.81	56.38	56.41	63.47	57.77
Pentzia globosa	44.90	47.13	42.97	43.46	44.62
Mean	46.73	49.02	46.42	47.83	47.50

1992/93

Species	May	Aug	Oct	Jan	Mean
Digitaria eriantha	43.66	45.78	41.07	45.76	44.07
Eragrostis lehmanniana	41.43	42.25	38.79	43.09	41.39
Eriocephalus ericoides	51.66	46.35	48.45	52.78	49.81
Helichrysum dregeanum	36.88	28.36	28.76	34.20	32.05
Nenax microphylla	58.67	60.20	53.48	58.35	57.68
Pentzia globosa	49.49	49.43	43.49	47.51	47.48
Phymaspermum parvifolium	53.94	53.85	51.33	55.51	53.66
Rosenia oppositifolia	46.41	55.60	33.19	41.47	44.17
Themeda triandra	41.56	39.34	41.28	42.25	41.11
Mean	47.08	46.80	42.20	46.77	45.71

TABLE 6 Percentage K of the studied species
1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	0.25	1.17	0.33	0.18	0.48
Merxmuelera disticha	0.21	0.20	0.18	0.17	0.19
Pentzia globosa	0.99	0.49	0.96	0.90	0.84
Phymaspermum parvifolium	1.00	0.20	1.19	1.32	0.93
Themeda triandra	0.29	0.26	0.29	0.29	0.28
Walafrida saxatilis	0.50	0.44	0.46	0.44	0.46
Mean	0.54	0.46	0.57	0.55	0.53

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	0.63	0.24	0.62	0.77	0.57
Eragrostis curvula var conferta	0.24	0.20	0.61	0.63	0.42
Hyparrhenia hirta	0.28	0.29	0.56	0.53	0.42
Eriocephalus ericoides	1.52	1.14	1.92	2.05	1.66
Felicia fascicularis	0.65	0.78	1.56	0.99	1.00
Felicia filifolia	1.01	0.76	1.27	0.86	0.98
Nenax microphylla	0.83	0.44	0.91	0.94	0.78
Pentzia globosa	1.11	0.91	1.26	1.22	1.13
Mean	0.78	0.60	1.09	1.00	0.87

1992/93

Mean	May	Aug	Oct	Jan	Mean
Digitaria eriantha	0.54	0.21	0.37	0.31	0.36
Eragrostis lehmanniana	0.36	0.15	0.28	0.16	0.24
Eriocephalus ericoides	1.55	1.59	1.58	0.94	1.42
Helichrysum dregeanum	1.11	0.68	0.78	0.88	0.86
Nenax microphylla	0.93	0.75	0.80	0.58	0.77
Pentzia globosa	0.85	0.44	0.63	0.76	0.67
Phymaspermum parvifolium	1.03	0.63	1.02	0.97	0.91
Rosenia oppositifolia	8.68	1.46	1.86	1.66	3.42
Themeda triandra	0.21	0.24	0.15	0.26	0.21
Mean	1.70	0.68	0.83	0.72	0.98

TABLE 7 Percentage Ca of the studied species

1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	0.22	0.52	0.18	0.19	0.28
Merxmuelera disticha	0.15	0.14	0.17	0.18	0.16
Pentzia globosa	0.98	0.67	0.63	0.79	0.77
Phymaspermum parvifolium	0.61	0.18	0.46	0.59	0.46
Themeda triandra	0.44	0.36	0.41	0.39	0.40
Walafrida saxatilis	0.54	0.53	0.45	0.65	0.54
Mean	0.49	0.40	0.38	0.47	0.44

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	0.46	0.45	0.46	0.42	0.45
Eragrostis curvula var conferta	0.25	0.23	0.22	0.31	0.25
Hyparrhenia hirta	0.28	0.33	0.44	0.46	0.38
Eriocephalus ericoides	0.77	0.67	0.56	0.65	0.66
Felicia fascicularis	0.74	0.80	0.94	0.75	0.81
Felicia filifolia	0.87	0.69	0.54	0.52	0.66
Nenax microphylla	1.32	1.27	1.18	0.92	1.17
Pentzia globosa	0.77	0.80	0.73	0.69	0.75
Mean	0.68	0.66	0.63	0.59	0.64

1992/93

Species	May	Aug	Oct	Jan	Mean
Digitaria eriantha	0.49	0.40	0.40	1.23	0.63
Eragrostis lehmanniana	0.27	0.18	0.23	0.18	0.21
Eriocephalus ericoides	0.78	0.72	0.81	0.60	0.73
Helichrysum dregeanum	0.76	0.62	0.75	0.63	0.69
Nenax microphylla	1.00	1.06	1.07	1.02	1.04
Pentzia globosa	0.71	0.61	0.71	0.72	0.69
Phymaspermum parvifolium	0.53	0.45	0.58	0.54	0.53
Rosenia oppositifolia	0.69	0.55	0.82	0.68	0.69
Themeda triandra	0.47	0.35	0.21	0.30	0.33
Mean	0.63	0.55	0.62	0.66	0.61

TABLE 8 Percentage Mg of the studied species
1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	0.09	0.11	0.07	0.06	0.08
Merxmuelera disticha	0.03	0.03	0.02	0.04	0.03
Pentzia globosa	0.28	0.18	0.29	0.22	0.24
Phymaspermum parvifolium	0.12	0.04	0.19	0.14	0.12
Themeda triandra	0.24	0.08	0.10	0.09	0.13
Walafrida saxatilis	0.13	0.14	0.11	0.21	0.15
Mean	0.15	0.10	0.13	0.13	0.13

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	0.26	0.14	0.13	0.16	0.17
Eragrostis curvula var conferta	0.07	0.09	0.07	0.11	0.09
Hyparrhenia hirta	0.11	0.10	0.17	0.11	0.12
Eriocephalus ericoides	0.17	0.14	0.18	0.17	0.17
Felicia fascicularis	0.15	0.16	0.23	0.14	0.17
Felicia filifolia	0.23	0.10	0.11	0.11	0.14
Nenax microphylla	0.20	0.19	0.17	0.18	0.19
Pentzia globosa	0.22	0.22	0.23	0.20	0.22
Mean	0.18	0.14	0.16	0.15	0.16

1992/93

Species	May	Aug	Oct	Jan	Mean
Digitaria eriantha	0.14	0.34	0.12	0.38	0.25
Eragrostis lehmanniana	0.07	0.06	0.07	0.06	0.07
Eriocephalus ericoides	0.15	0.18	0.17	0.13	0.16
Helichrysum dregeanum	0.16	0.19	0.20	0.20	0.19
Nenax microphylla	0.16	0.20	0.21	0.15	0.18
Pentzia globosa	0.20	0.20	0.20	0.19	0.20
Phymaspermum parvifolium	0.14	0.11	0.14	0.13	0.13
Rosenia oppositifolia	0.15	0.15	0.21	0.19	0.17
Themeda triandra	0.07	0.11	0.09	0.09	0.09
Mean	0.14	0.17	0.16	0.17	0.16

TABLE 9 Percentage Na of the studied species
1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	0.02	0.01	0.01	0.02	0.02
Merxmuelera disticha	0.06	0.03	0.02	0.01	0.03
Pentzia globosa	0.05	0.04	0.03	0.05	0.04
Phymaspermum parvifolium	0.03	0.03	0.08	0.07	0.05
Themeda triandra	0.02	0.03	0.02	0.02	0.02
Walafrida saxatilis	0.05	0.04	0.02	0.06	0.04
Mean	0.04	0.03	0.03	0.04	0.03

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	0.04	0.02	0.01	0.02	0.02
Eragrostis curvula var conferta	0.04	0.01	0.01	0.05	0.03
Hyparrhenia hirta	0.01	0.01	0.01	0.01	0.01
Eriocephalus ericoides	0.08	0.03	0.04	0.03	0.05
Felicia fascicularis	0.06	0.00	0.04	0.04	0.02
Felicia filifolia	0.03	0.03	0.01	0.02	0.02
Nenax microphylla	0.06	0.13	0.01	0.02	0.06
Pentzia globosa	0.07	0.02	0.01	0.02	0.03
Mean	0.05	0.03	0.02	0.03	0.03

1992/93

Species	May	Aug	Oct	Jan	Mean
Digitaria eriantha	0.02	0.02	0.02	0.48	0.14
Eragrostis lehmanniana	0.02	0.02	0.04	0.03	0.03
Eriocephalus ericoides	0.02	0.03	0.08	0.05	0.04
Helichrysum dregeanum	0.02	0.05	0.05	0.06	0.04
Nenax microphylla	0.02	0.04	0.04	0.04	0.04
Pentzia globosa	0.04	0.09	0.04	0.09	0.07
Phymaspermum parvifolium	0.05	0.07	0.02	0.03	0.04
Rosenia oppositifolia	0.01	0.02	0.03	0.07	0.03
Themeda triandra	0.01	0.02	0.00	0.02	0.01
Mean	0.02	0.04	0.04	0.10	0.05

TABLE 10Percentage P of the studied species
1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	0.08	0.17	0.07	0.06	0.10
Merxmuelera disticha	0.07	0.07	0.06	0.06	0.07
Pentzia globosa	0.24	0.13	0.14	0.17	0.17
Phymaspermum parvifolium	0.16	0.10	0.16	0.19	0.15
Themeda triandra	0.07	0.19	0.07	0.09	0.11
Walafrida saxatilis	0.17	0.12	0.10	0.16	0.14
Mean	0.13	0.13	0.10	0.12	0.12

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	0.16	0.08	0.15	0.14	0.13
Eragrostis curvula var conferta	0.08	0.05	0.13	0.15	0.10
Hyparrhenia hirta	0.07	0.12	0.10	0.13	0.11
Eriocephalus ericoides	0.13	0.10	0.17	0.16	0.14
Felicia fascicularis	0.14	0.10	0.21	0.16	0.15
Felicia filifolia	0.11	0.13	0.14	0.13	0.13
Nenax microphylla	0.09	0.12	0.11	0.09	0.10
Pentzia globosa	0.15	0.17	0.19	0.22	0.18
Mean	0.12	0.11	0.15	0.15	0.13

1992/93

	May	Aug	Oct	Jan	Mean
Digitaria eriantha	0.11	0.07	0.09	0.12	0.10
Eragrostis lehmanniana	0.10	0.08	0.09	0.06	0.08
Eriocephalus ericoides	0.14	0.17	0.18	0.13	0.15
Helichrysum dregeanum	0.17	0.12	0.11	0.16	0.14
Nenax microphylla	0.09	0.10	0.09	0.08	0.09
Pentzia globosa	0.13	0.11	0.12	0.13	0.12
Phymaspermum parvifolium	0.15	0.15	0.15	0.15	0.15
Rosenia oppositifolia	0.15	0.13	0.17	0.14	0.15
Themeda triandra	0.07	0.09	0.01	0.08	0.06
Mean	0.12	0.11	0.11	0.12	0.12

TABLE 11 The K/Ca+Mg ratio of the studied species
1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	0.18	1.86	1.32	0.72	1.18
Merxmuelera disticha	1.17	1.18	0.95	0.77	1.02
Pentzia globosa	0.79	0.58	1.04	0.89	0.82
Phymaspermum parvifolium	1.37	0.91	1.83	1.81	1.48
Themeda triandra	0.43	0.59	0.57	0.60	0.55
Walafrida saxatilis	0.75	0.66	0.82	0.51	0.68
Mean	0.88	0.96	1.09	0.88	0.95

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	0.88	0.41	1.05	1.33	0.92
Eragrostis curvula var conferta	0.75	0.63	2.10	1.50	1.24
Hyparrhenia hirta	0.72	0.67	0.92	0.93	0.81
Eriocephalus ericoides	1.62	1.41	2.59	2.50	2.03
Felicia fascicularis	0.73	0.81	1.33	1.11	1.00
Felicia filifolia	0.92	0.96	1.95	1.37	1.30
Nenax microphylla	0.55	0.30	0.67	0.85	0.59
Pentzia globosa	1.12	0.89	1.31	1.37	1.17
Mean	0.91	0.76	1.49	1.37	1.13

1992/93

Species	May	Aug	Oct	Jan	Mean
Digitaria eriantha	0.86	0.28	0.71	0.19	0.51
Eragrostis lehmanniana	1.06	0.63	0.93	0.67	0.82
Eriocephalus ericoides	1.67	1.77	1.61	1.29	1.58
Helichrysum dregeanum	1.21	0.84	0.82	1.06	0.98
Nenax microphylla	0.80	0.60	0.63	0.50	0.63
Pentzia globosa	0.93	0.54	0.69	0.84	0.75
Phymaspermum parvifolium	1.54	1.12	1.42	1.45	1.38
Rosenia oppositifolia	10.33	2.09	1.81	1.91	4.03
Themeda triandra	0.39	0.52	0.50	0.67	0.52
Mean	2.09	0.93	1.01	0.95	1.25

TABLE 12 The Ca/P ratio of the studied species
1990/91

Species	Apr	Jul	Nov	Jan	Mean
Aristida diffusa	2.75	3.06	2.57	3.17	2.89
Merxmuelera disticha	2.14	2.00	2.83	3.00	2.49
Pentzia globosa	4.08	5.15	4.50	4.65	4.60
Phymaspermum parvifolium	3.81	1.80	2.88	3.11	2.90
Themeda triandra	6.29	1.89	5.86	4.33	4.59
Walafrida saxatilis	3.18	4.42	4.50	4.06	4.04
Mean	3.71	3.05	3.86	3.72	3.58

1991/92

Species	May	Aug	Nov	Feb	Mean
Digitaria eriantha	2.88	5.63	3.07	3.00	3.64
Eragrostis curvula var conferta	3.13	4.60	1.69	2.07	2.87
Hyparrhenia hirta	4.00	2.75	4.40	3.54	3.67
Eriocephalus ericoides	5.92	6.70	3.29	4.06	4.99
Felicia fascicularis	5.29	8.00	4.48	4.69	5.61
Felicia filifolia	7.91	5.31	3.86	4.00	5.27
Nenax microphylla	14.67	10.58	10.73	10.22	11.55
Pentzia globosa	5.13	4.71	3.84	3.14	4.20
Mean	6.11	6.03	4.42	4.34	5.23

1992/93

	May	Aug	Oct	Jan	Mean
Digitaria eriantha	4.45	5.71	4.44	10.25	6.22
Eragrostis lehmanniana	2.70	2.25	2.56	3.00	2.63
Eriocephalus ericoides	5.57	4.24	4.50	4.62	4.73
Helichrysum dregeanum	4.47	5.17	6.82	3.94	5.10
Nenax microphylla	11.11	10.60	11.89	12.75	11.59
Pentzia globosa	5.46	5.55	5.92	5.54	5.62
Phymaspermum parvifolium	3.53	3.00	3.87	3.60	3.50
Rosenia oppositifolia	4.60	4.23	4.82	4.86	4.63
Themeda triandra	6.71	3.89	21.00	3.75	8.84
Mean	5.40	4.96	7.31	5.81	5.87

TABLE 13 Percentage ether extract and ash of the studied species, adapted from Botha, van Staden & Blom (1990), Botha & Nash (1990), Louw, Steenkamp & Steenkamp (1968a) and Louw, Steenkamp & Steenkamp (1968c)

Ether extract	Apr/May	Jul/Aug	Oct/Nov	Jan/Feb	Mean
Aristida diffusa	1.43	1.35	1.61	1.29	1.42
Digitaria eriantha	2.57	1.95	2.82	2.23	2.39
Eragrostis curvula var conferta	1.43	0.93	1.26	1.51	1.28
Eragrostis lehmanniana	1.89	1.55	1.56	1.59	1.65
Hyparrhenia hirta	1.90		2.70	2.30	
Merxmuelera disticha	1.50	3.12	1.54	1.56	1.93
Themeda triandra	1.80	2.25	2.15	1.83	2.01
Eriocephalus ericoides	4.87	5.03	2.85	2.30	3.76
Felicia fascicularis	1.80	4.66	1.67	4.32	3.11
Felicia filifolia	2.77	2.89	3.00	2.67	2.83
Helichrysum dregeanum		2.80		2.90	2.85
Nenax microphylla	3.09	2.96	3.12	2.24	2.85
Pentzia globosa	3.78	4.06	3.26	4.21	3.83
Phymaspermum parvifolium	1.88	2.21	1.44	1.45	1.74
Rosenia oppositifolia		8.10		11.00	9.55
Walafrida saxatilis	8.57	9.15	8.70	7.23	8.41
Mean	2.88	3.43	2.69	3.19	3.25

Ash	Apr/May	Jul/Aug	Oct/Nov	Jan/Feb	Mean
Aristida diffusa	11.70	9.53	9.74	9.85	10.21
Digitaria eriantha	11.35	9.93	10.04	10.45	10.44
Eragrostis curvula var conferta	8.67	6.82	7.42	6.71	7.41
Eragrostis lehmanniana	8.66	6.95	7.66	8.52	7.95
Hyparrhenia hirta		7.00		9.40	8.20
Merxmuelera disticha	8.04	8.37	8.28	8.55	8.31
Themeda triandra	13.26	10.50	11.53	12.60	11.97
Eriocephalus ericoides	6.79	5.40	5.64	5.78	5.90
Felicia fascicularis	8.16	6.02	9.35	8.17	7.92
Felicia filifolia	3.97	4.73	5.16	4.48	4.58
Helichrysum dregeanum		8.50		11.40	9.95
Nenax microphylla	13.48	6.83	7.54	6.19	8.51
Pentzia globosa	5.77	5.73	5.77	6.66	5.98
Phymaspermum parvifolium	5.23	4.62	9.31	4.73	5.97
Rosenia oppositifolia		6.20		9.10	7.65
Walafrida saxatilis	6.51	6.31	4.82	5.95	5.90
Mean	8.58	7.09	7.87	8.03	7.93

Carlton, 1990 to 1993, canopy spread cover : mass regressions
Karoo bushes
(x=area cm^2)(y=mass kg)

565.5	35.34	Regression Output:		
390	43.36	Constant		2.796392
664	15.56	Std Err of Y Est		7.849736
515	21.98	R Squared		0.682226
413.5	26.2	No. of Observations		56
433	7.5	Degrees of Freedom		54
273.5	17.64			
288.5	22.78	X Coefficient(s)	0.051022	
495	7.62	Std Err of Coef.	0.004738	
389.5	18.94			
341	19.26	50	5.347492	
452.5	7.5	100	7.898592	
753.5	42.32	150	10.44969	
120.25	7.64	200	13.00079	
967	64.72	250	15.55189	
358.5	30.3	300	18.10299	
477.5	25.14	350	20.65409	
640.5	37.04	400	23.20519	
90	5.2	450	25.75629	
585.5	33.76	500	28.30739	
350.5	26.94	550	30.85849	
421	20.48	600	33.40959	
723.5	38.9	650	35.96069	
45.875	2.1	700	38.51179	
536.5	31.54	750	41.06289	
344	24.5	800	43.61399	
447	22.66	850	46.16509	
342	20.26	900	48.71619	
99.375	6.88	950	51.26729	
445	31.4	1000	53.81839	
279	20.72	1050	56.36949	
265	13.24	1100	58.92059	
595	36.76			
68.375	3.8			
346.5	33			
422.5	16.92			
439	29.92			
700.5	27.14			
574.5	33.64			
64.375	1.86			
1100	61.8			
441.5	19.96			
406.5	30.12			
909.5	46.46			
604.5	35.76			
56.125	2.38			
289.5	25.18			
400	20.16			
445.5	39.48			
461.5	27.98			
514	31.74			
88.375	5.36			
214	22.38			
234.5	12.64			
315.5	22.04			
539.5	32.16			

Grasses

(x=area cm^2)(y=mass kg)

140.875	78.12	Regression Output:		
227.75	155.38	Constant		25.51144
99.625	40.94	Std Err of Y Est		41.96474
88.25	68.5	R Squared		0.037589
178.75	171.8	No. of Observations		36
52.25	33.44	Degrees of Freedom		34
119.125	52.7			
228	137.46	X Coefficient(s)	0.097178	
68.28125	35.52	Std Err of Coef.	0.084329	
79.375	38.92			
159.5	110.72	50	30.37034	
53.125	23	100	35.22924	
242	26.36	150	40.08814	
274.5	25.3	200	44.94704	
275	87.9	250	49.80594	
273	18.98	300	54.66484	
293	19.7	350	59.52374	
321.5	56.52			
266	18.68			
235	15			
298	54.64			
156.5	15.32			
206.5	20.5			
231.5	27.32			
215	17.7			
73.25	4.64			
212	15.22			
180.5	14.8			
46	2.06			
247.5	29.42			
151.5	16.76			
50	5.8			
186.5	40.42			
157.5	19.68			
39.25	6.76			
123	19.74			

Karoo bushes	Apr		Jul		Nov		Jan	
	area	mass	area	mass	area	mass	area	mass
Pentzia globosa 90	565.5	35.34	515	21.98	273.5	17.64	389.5	18.94
Phymaspermum parvifolium 90	390	43.36	413.5	26.2	288.5	22.78	341	19.26
Walafrida saxatilis 90	664	15.56	433	7.5	495	7.62	452.5	7.5
Eriocephalus ericoides 91	753.5	42.32	640.5	37.04	723.5	38.9	342	20.26
Felicia fascicularis 91	120.25	7.64	90	5.2	45.875	2.1	99.375	6.88
Felicia filifolia 91	967	64.72	585.5	33.76	536.5	31.54	445	31.4
Nenax microphylla 91	358.5	30.3	350.5	26.94	344	24.5	279	20.72
Pentzia globosa 91	477.5	25.14	421	20.48	447	22.66	265	13.24
Eriocephalus ericoides 92	595	36.76	574.5	33.64	604.5	35.76	514	31.74
Helichrysum dregeanum 92	68.375	3.8	64.375	1.86	56.125	2.38	88.375	5.36
Nenax microphylla 92	346.5	33	1100	61.8	289.5	25.18	214	22.38
Pentzia globosa 92	422.5	16.92	441.5	19.96	400	20.16	234.5	12.64
Phymaspermum parvifolium 92	439	29.92	406.5	30.12	445.5	39.48	315.5	22.04
Rosenia oppositifolia 92	700.5	27.14	909.5	46.46	461.5	27.98	539.5	32.16

Apr Regression Output:

Constant	5.949268
Std Err of Y Est	11.09387
R Squared	0.540225
No. of Observations	14
Degrees of Freedom	12
X Coefficient(s)	0.047848
Std Err of Coef.	0.012742

Jul Regression Output:

Constant	-0.51762
Std Err of Y Est	6.353675
R Squared	0.857253
No. of Observations	14
Degrees of Freedom	12
X Coefficient(s)	0.054739
Std Err of Coef.	0.006448

Nov Regression Output:

Constant	3.463647
Std Err of Y Est	7.969159
R Squared	0.604450
No. of Observations	14
Degrees of Freedom	12
X Coefficient(s)	0.049933
Std Err of Coef.	0.011660

Jan Regression Output:

Constant	3.838983
Std Err of Y Est	6.511999
R Squared	0.516831
No. of Observations	14
Degrees of Freedom	12
X Coefficient(s)	0.046639
Std Err of Coef.	0.013017

Grasses	Apr		Jul		Nov		Jan	
	area	mass	area	mass	area	mass	area	mass
Aristida diffusa 90	140.875	78.12	88.25	68.5	119.125	52.7	79.375	38.92
Merxmuelera disticha 90	227.75	155.38	178.75	171.8	228	137.46	159.5	110.72
Themeda triandra 90	99.625	40.94	52.25	33.44	68.28125	35.52	53.125	23
Digitaria eriantha 91	242	26.36	273	18.98	266	18.68	156.5	15.32
Eragrostis curvula 91	274.5	25.3	293	19.7	235	15	206.5	20.5
Hyparrhenia hirta 91	275	87.9	321.5	56.52	298	54.64	231.5	27.32
Digitaria eriantha 92	215	17.7	180.5	14.8	151.5	16.76	157.5	19.68
Eragrostis lehmanniana 92	73.25	4.64	46	2.06	50	5.8	39.25	6.76
Themeda triandra 92	212	15.22	247.5	29.42	186.5	40.42	123	19.74

Apr	Regression Output:
Constant	18.57406
Std Err of Y Est	50.36515
R Squared	0.060167
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.161587
Std Err of Coef.	0.241379

Jul	Regression Output:
Constant	45.85694
Std Err of Y Est	55.03347
R Squared	0.000009
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.001491
Std Err of Coef.	0.185220

Nov	Regression Output:
Constant	18.16317
Std Err of Y Est	40.66667
R Squared	0.084978
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.133244
Std Err of Coef.	0.165257

Jan	Regression Output:
Constant	20.14333
Std Err of Y Est	32.62067
R Squared	0.031772
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.083456
Std Err of Coef.	0.174130

Appendix 5 An exposition of the canopy spread cover, mean forage production, chemical analyses, botanical surveys and canopy spread cover on available forage mass regressions of the species studied in the Arid Karoo.

TABLE 1 The mean canopy spread cover of the studied species (cm²)

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B[1])	682.5	605.0	628.5	610.0	631.5
Fingerhuthia africana (G[2])	72.9	81.3	94.0	61.9	77.5
Monechma incanum (B)	937.0	943.0	974.5	2414.0	1317.1
Pentzia spinescens (B)	337.5	40.2	457.5	461.0	324.1
Pentzia spinescens (G)	1628.5	1407.5	1127.5	1235.5	1349.8
Plinthus cryptocarpus (G)	124.5	763.5	869.0	299.5	514.1
Pterothrix spinescens (G)	775.5	950.0	729.0	1259.5	928.5
Salsola tuberculata (B)	743.0	690.0	599.0	801.5	708.4
Stipagrostis ciliata (G)	59.9	253.1	253.6	305.0	217.9
Stipagrostis obtusa (B)	54.1	119.3	117.5	113.3	101.1
Stipagrostis obtusa (G)	35.5	150.6	135.4	93.4	103.7
Mean	495.5	545.8	544.1	695.9	570.3

[1] B = Karoo bush veld on stony shaleveld
[2] G = Bushman grassveld on red sandy soils

1991/92

Species	May	Aug	Nov	Feb	Mean
Aristida diffusa	311.5	377.5	276.0	227.0	298.0
Eragrostis lehmanniana	83.6	311.5	122.9	70.9	147.2
Eriocephalus ericoidesG	1316.0	1242.0	1236.0	1343.5	1284.4
Eriocephalus ericoidesB	843.5	913.5	597.5	603.5	739.5
Eriocephalus spinescens	881.5	768.5	666.0	805.0	780.3
Felicia macrorrhyza	131.8	164.0	135.3	105.5	134.2
Osteospermum spinescens	1376.5	1041.0	2238.0	2171.5	1706.8
Pentzia spinescens	543.0	590.0	745.0	634.0	628.0
Plinthus karooicus	239.3	247.4	126.1	143.9	189.2
Pteronia adenocarpa	721.5	1121.5	672.0	502.5	754.4
Pteronia glomerata	924.5	1081.5	1230.5	622.0	964.6
Rosenia humilis	964.0	840.0	924.0	530.0	814.5
Mean	694.7	724.9	747.4	646.6	703.4

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	370.00	488.50	576.00	407.00	460.37
Eragrostis lehmanniana	442.00	377.00	342.50	301.50	365.75
Eriocephalus ericoides	290.50	555.50	626.50	403.50	469.00
Helichrysum lucilioides	318.00	305.50	216.50	454.00	323.50
Pentzia spinescens	725.00	451.00	422.00	713.00	577.75
Plinthus cryptocarpus	155.25	91.12	71.75	111.00	107.28
Pteronia adenocarpa	420.00	522.00	600.50	389.00	482.87
Pterothrix spinescens	827.00	696.00	741.00	1136.00	850.00
Rosenia humilis	672.50	854.50	670.00	591.84	697.21
Stipagrostis ciliata	936.00	862.50	997.00	1274.00	1017.37
Stipagrostis obtusa	102.37	55.75	33.12	38.37	57.41
Zygophyllum lichtensteinianum	451.50	562.00	403.00	535.00	487.87
Mean	475.84	485.11	474.99	529.52	491.37

TABLE 2 The mean abovegroung available forage production of the studied species (g per grass tuft/karoo bush)

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B)	106.78	98.14	95.14	83.70	95.94
Fingerhuthia africana (G)	14.52	22.32	10.88	20.30	17.01
Monechma incanum (B)	90.88	70.52	57.98	96.56	78.99
Pentzia spinescens (B)	18.16	25.06	28.12	28.84	25.05
Pentzia spinescens (G)	109.68	109.84	69.50	99.23	97.06
Plinthus cryptocarpus (G)	11.20	18.58	16.10	11.98	14.47
Pterothrix spinescens (G)	101.34	97.98	121.50	152.12	118.24
Salsola tuberculata (B)	176.74	135.56	106.30	140.58	139.80
Stipagrostis ciliata (G)	42.54	48.38	70.38	102.12	65.86
Stipagrostis obtusa (B)	16.28	28.20	22.60	43.04	27.53
Stipagrostis obtusa (G)	5.04	35.74	28.60	40.82	27.55
Mean	63.01	62.76	57.01	74.48	64.32

1991/92

Spesie	May	Aug	Nov	Feb	Mean
Aristida diffusa	46.24	29.77	36.58	30.02	35.65
Eragrostis lehmanniana	12.84	4.70	7.60	13.24	9.60
Eriocephalus ericoides G	82.60	53.24	114.16	124.28	93.57
Eriocephalus ericoides B	42.02	133.06	30.52	43.16	62.19
Eriocephalus spinescens	58.88	61.12	46.64	70.92	59.39
Felicia macrorrhyza	11.58	12.46	16.30	11.40	12.94
Osteospermum spinescens	78.02	87.48	136.46	123.14	106.28
Pentzia spinescens	24.92	23.04	44.00	44.26	34.06
Plinthus karooicus	19.22	15.88	7.24	13.32	13.92
Pteronia adenocarpa	56.24	91.14	56.60	45.86	62.46
Pteronia glomerata	92.82	103.48	122.82	61.84	95.24
Rosenia humilis	115.52	118.82	89.34	84.02	101.93
Mean	53.41	61.18	59.02	55.46	57.27

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	62.48	68.20	88.42	59.80	69.72
Eragrostis lehmanniana	11.42	15.10	20.78	20.52	16.96
Eriocephalus ericoides	16.76	32.44	40.34	25.92	28.87
Helichrysum lucilioides	20.84	16.76	14.00	34.70	21.58
Pentzia spinescens	32.90	27.06	21.98	35.72	29.41
Plinthus cryptocarpus	10.78	6.46	7.42	17.28	10.48
Pteronia adenocarpa	43.26	47.36	51.88	28.12	42.66
Pterothrix spinescens	117.42	104.84	59.58	262.12	135.99
Rosenia humilis	65.04	107.40	61.46	79.62	78.38
Stipagrostis ciliata	82.28	148.86	191.52	100.78	130.86
Stipagrostis obtusa	35.58	12.52	14.72	20.86	20.92
Zygophyllum lichtensteinianum	25.14	32.14	29.10	30.58	29.24
Mean	43.66	51.59	50.10	59.67	51.26

TABLE 3 Percentage N of the studied species

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B)	0.82	0.72	0.75	0.64	0.73
Fingerhuthia africana (G)	0.82	0.66	0.71	0.71	0.73
Monechma incanum (B)	1.66	1.32	1.27	1.52	1.44
Pentzia spinescens (B)	1.18	1.22	1.07	1.02	1.12
Pentzia spinescens (G)	1.03	0.94	0.79	0.78	0.89
Plinthus cryptocarpus (G)	1.02	1.06	0.88	1.12	1.02
Pterothrix spinescens (G)	0.79	0.81	0.68	0.81	0.77
Salsola tuberculata (B)	1.49	1.32	1.58	1.19	1.40
Stipagrostis ciliata (G)	0.51	0.65	0.59	0.52	0.57
Stipagrostis obtusa (B)	0.62	0.78	0.66	0.68	0.69
Stipagrostis obtusa (G)	0.68	0.68	0.56	0.49	0.60
Mean	0.97	0.92	0.87	0.86	0.91

1991/92

Species	May	Aug	Nov	Feb	Mean
Aristida diffusa	0.53	0.49	0.50	0.49	0.50
Eragrostis lehmanniana	1.21	0.60	0.98	0.66	0.86
Eriocephalus ericoides G	1.15	0.83	0.84	0.80	0.91
Eriocephalus ericoides B	1.03	0.66	0.71	0.91	0.83
Eriocephalus spinescens	0.96	1.01	1.14	1.03	1.04
Felicia macrorrhyza	1.13	1.17	0.95	0.94	1.05
Osteospermum spinescens	0.98	0.93	0.92	0.74	0.89
Pentzia spinescens	1.07	0.90	1.21	1.05	1.06
Plinthus karooicus	1.14	1.17	1.14	1.31	1.19
Pteronia adenocarpa	1.27	1.14	1.10	0.91	1.11
Pteronia glomerata	1.17	1.05	0.99	1.26	1.12
Rosenia humilis	0.95	1.06	1.05	0.82	0.97
Mean	1.05	0.92	0.96	0.91	0.96

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.85	0.79	0.72	1.00	0.84
Eragrostis lehmanniana	0.57	0.82	0.57	0.73	0.67
Eriocephalus ericoides	1.04	0.95	1.14	0.71	0.96
Helichrysum lucilioides	0.73	0.86	0.71	0.70	0.75
Pentzia spinescens	1.25	0.90	0.92	1.00	1.02
Plinthus cryptocarpus	1.36	1.32	1.00	1.10	1.20
Pteronia adenocarpa	1.49	1.30	0.87	1.05	1.18
Pterothrix spinescens	0.72	0.91	0.70	0.60	0.73
Rosenia humilis	1.14	1.09	0.89	1.06	1.04
Stipagrostis ciliata	0.69	0.60	0.51	0.48	0.57
Stipagrostis obtusa	0.57	0.72	0.49	0.56	0.58
Zygophyllum lichtensteinianum	1.72	1.11	1.14	1.31	1.32
Mean	1.01	0.95	0.80	0.86	0.91

TABLE 4 Percentage ADF of the studied species

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B)	51.34	39.56	38.26	43.27	43.11
Fingerhuthia africana (G)	32.09	40.38	42.42	31.59	36.62
Monechma incanum (B)	43.07	44.56	49.42	46.06	45.78
Pentzia spinescens (B)	47.09	42.88	45.03	47.62	45.66
Pentzia spinescens (G)	47.31	48.68	58.35	51.15	51.37
Plinthus cryptocarpus (G)	34.99	39.93	47.80	39.90	40.66
Pterothrix spinescens (G)	42.16	47.16	69.16	45.41	50.97
Salsola tuberculata (B)	26.33	31.54	25.37	26.00	27.31
Stipagrostis ciliata (G)	41.27	42.81	42.90	42.85	42.46
Stipagrostis obtusa (B)	36.38	43.21	41.97	41.76	40.83
Stipagrostis obtusa (G)	38.87	44.76	36.95	40.35	40.23
Mean	40.08	42.32	45.24	41.45	42.27

1991/92

Species	May	Aug	Nov	Feb	Mean
Aristida diffusa	41.33	44.83	45.33	44.46	43.99
Eragrostis lehmanniana	34.91	42.84	43.58	41.09	40.61
Eriocephalus ericoides G	41.92	46.82	50.87	49.72	47.33
Eriocephalus ericoides B	42.05	53.78	56.97	53.97	51.69
Eriocephalus spinescens	52.36	51.37	54.34	55.52	53.40
Felicia macrorrhyza	29.85	30.70	32.64	39.32	33.13
Osteospermum spinescens	55.20	56.57	59.52	45.90	54.30
Pentzia spinescens	47.12	51.93	55.03	55.42	52.38
Plinthus karooicus	35.70	45.49	53.55	44.96	44.93
Pteronia adenocarpa	33.99	30.24	43.88	40.78	37.22
Pteronia glomerata	41.38	41.22	47.60	41.38	42.90
Rosenia humilis	46.02	44.35	50.24	54.97	48.90
Mean	41.82	45.01	49.46	47.29	45.90

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	42.11	35.46	49.31	41.59	42.12
Eragrostis lehmanniana	45.04	39.96	39.00	37.54	40.38
Eriocephalus ericoides	57.72	50.83	43.18	40.45	48.05
Helichrysum lucilioides	58.17	55.19	60.07	55.19	57.16
Pentzia spinescens	56.69	59.52	55.26	49.47	55.23
Plinthus cryptocarpus	34.49	30.45	35.54	29.03	32.38
Pteronia adenocarpa	44.35	34.47	38.26	38.45	38.88
Pterothrix spinescens	43.39	38.77	48.97	48.53	44.91
Rosenia humilis	53.13	49.93	46.34	45.07	48.62
Stipagrostis ciliata	28.69	36.28	42.79	41.28	37.26
Stipagrostis obtusa	34.16	40.25	28.79	30.50	33.42
Zygophyllum lichtensteinianum	42.35	43.18	57.61	42.94	46.52
Mean	45.02	42.86	45.43	41.67	43.74

TABLE 5 Percentage TDN of the studied species

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B)	42.38	50.15	51.16	47.27	47.74
Fingerhuthia africana (G)	55.66	49.35	48.14	55.61	52.19
Monechma incanum (B)	50.00	48.35	44.89	47.70	47.73
Pentzia spinescens (B)	46.30	49.29	47.45	45.54	47.14
Pentzia spinescens (G)	45.78	44.58	37.44	42.37	42.54
Plinthus cryptocarpus (G)	54.25	50.95	45.33	51.12	50.41
Pterothrix spinescens (G)	48.61	45.23	29.57	46.44	42.46
Salsola tuberculata (B)	61.25	57.33	62.08	60.87	60.38
Stipagrostis ciliata (G)	48.04	47.63	47.31	47.00	47.49
Stipagrostis obtusa (B)	51.94	47.85	48.25	48.48	49.13
Stipagrostis obtusa (G)	50.47	46.41	51.27	48.56	49.18
Mean	50.42	48.83	46.63	49.18	48.76

1991/92

Species	May	Aug	Nov	Feb	Mean
Aristida diffusa	48.10	45.47	45.18	45.73	46.12
Eragrostis lehmanniana	54.77	47.39	60.71	48.86	52.93
Eriocephalus ericoides G	49.79	45.53	42.77	43.43	45.38
Eriocephalus ericoides B	49.41	40.04	38.10	40.84	42.10
Eriocephalus spinescens	42.10	42.92	41.20	40.11	41.58
Felicia macrorrhyza	58.08	57.58	55.68	51.04	55.59
Osteospermum spinescens	40.20	39.11	37.04	45.85	40.55
Pentzia spinescens	46.01	42.22	40.89	40.23	42.34
Plinthus karooicus	54.06	47.38	41.75	48.05	47.81
Pteronia adenocarpa	55.54	57.83	48.32	49.95	52.91
Pteronia glomerata	50.21	50.03	45.47	50.52	49.03
Rosenia humilis	46.45	47.90	43.81	39.87	44.51
Mean	49.56	46.95	45.08	45.36	46.74

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	54.13	58.44	48.88	54.87	54.08
Eragrostis lehmanniana	51.20	55.50	55.28	56.85	54.71
Eriocephalus ericoides	44.09	48.52	54.11	54.82	50.38
Helichrysum lucilioides	42.94	45.34	41.59	44.85	43.68
Pentzia spinescens	45.22	42.53	45.45	49.56	45.69
Plinthus cryptocarpus	60.39	63.05	58.95	63.57	61.49
Pteronia adenocarpa	53.96	60.30	56.78	57.11	57.04
Pterothrix spinescens	52.87	56.55	49.04	48.97	51.86
Rosenia humilis	47.40	49.45	51.39	52.66	50.23
Stipagrostis ciliata	62.69	57.23	52.45	53.33	56.42
Stipagrostis obtusa	58.54	54.99	61.80	60.97	59.07
Zygophyllum lichtensteinianum	55.65	54.05	44.38	54.61	52.17
Mean	52.42	53.83	51.68	54.35	53.07

TABLE 6 Percentage K of the studied species

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B)	1.24	1.50	0.89	1.03	1.17
Fingerhuthia africana (G)	0.50	0.24	0.25	0.39	0.35
Monechma incanum (B)	1.10	1.00	0.90	1.09	1.02
Pentzia spinescens (B)	0.78	0.92	0.77	0.94	0.85
Pentzia spinescens (G)	0.50	0.47	0.54	0.50	0.50
Plinthus cryptocarpus (G)	1.37	1.47	1.13	1.45	1.36
Pterothrix spinescens (G)	0.26	0.48	0.36	0.37	0.37
Salsola tuberculata (B)	0.97	1.19	1.38	1.17	1.18
Stipagrostis ciliata (G)	0.18	0.15	0.20	0.25	0.20
Stipagrostis obtusa (B)	0.24	0.22	0.22	0.27	0.24
Stipagrostis obtusa (G)	0.28	0.19	0.24	0.19	0.23
Mean	0.67	0.71	0.63	0.70	0.68

1991/92

Species	May	Aug	Nov	Feb	Mean
Aristida diffusa	0.21	0.19	0.08	0.21	0.17
Eragrostis lehmanniana	0.86	0.18	0.12	0.63	0.45
Eriocephalus ericoides G	1.39	0.83	0.37	0.48	0.77
Eriocephalus ericoides B	1.29	0.40	0.60	0.79	0.77
Eriocephalus spinescens	1.72	0.83	0.67	0.15	0.84
Felicia macrorrhyza	0.69	0.65	0.33	0.37	0.51
Osteospermum spinescens	1.14	0.65	0.48	0.65	0.73
Pentzia spinescens	0.93	0.68	0.32	0.66	0.65
Plinthus karooicus	2.70	1.44	0.70	1.71	1.64
Pteronia adenocarpa	1.28	0.97	0.42	0.73	0.85
Pteronia glomerata	1.04	0.56	0.45	1.06	0.78
Rosenia humilis	1.22	1.19	0.51	0.92	0.96
Mean	1.21	0.71	0.42	0.70	0.76

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	1.10	0.85	0.94	0.71	0.90
Eragrostis lehmanniana	0.33	0.19	0.13	0.28	0.23
Eriocephalus ericoides	1.13	0.65	0.95	0.84	0.89
Helichrysum lucilioides	0.34	0.31	0.32	0.19	0.29
Pentzia spinescens	0.90	0.53	0.47	0.49	0.60
Plinthus cryptocarpus	1.36	1.17	1.09	1.09	1.18
Pteronia adenocarpa	1.02	0.84	0.90	0.49	0.81
Pterothrix spinescens	0.26	0.21	0.19	0.19	0.21
Rosenia humilis	1.11	1.15	1.36	0.19	0.95
Stipagrostis ciliata	0.20	0.14	0.13	0.14	0.15
Stipagrostis obtusa	0.19	0.21	0.16	0.18	0.18
Zygophyllum lichtensteinianum	0.88	0.60	0.69	0.80	0.74
Mean	0.73	0.57	0.61	0.47	0.60

TABLE 7 Percentage Ca of the studied species

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B)	1.48	1.43	1.41	1.32	1.41
Fingerhuthia africana (G)	0.31	0.42	0.29	0.41	0.36
Monechma incanum (B)	1.80	1.36	1.31	1.50	1.49
Pentzia spinescens (B)	0.82	1.08	0.77	0.82	0.87
Pentzia spinescens (G)	0.89	0.70	0.64	0.74	0.74
Plinthus cryptocarpus (G)	1.94	1.79	1.06	1.60	1.60
Pterothrix spinescens (G)	0.56	0.79	0.53	0.53	0.60
Salsola tuberculata (B)	2.11	2.90	2.60	2.00	2.40
Stipagrostis ciliata (G)	0.31	0.40	0.35	0.24	0.33
Stipagrostis obtusa (B)	0.34	0.32	0.33	0.21	0.30
Stipagrostis obtusa (G)	0.51	0.32	0.31	0.22	0.34
Mean	1.01	1.05	0.87	0.87	0.95

1991/92

Species	May	Aug	Nov	Feb	Mean
Aristida diffusa	0.22	0.20	0.17	0.17	0.19
Eragrostis lehmanniana	0.43	0.26	0.25	0.28	0.31
Eriocephalus ericoides G	0.80	0.73	0.57	0.74	0.71
Eriocephalus ericoides B	0.92	0.60	0.61	0.74	0.72
Eriocephalus spinescens	0.65	0.64	0.66	0.09	0.51
Felicia macrorrhyza	0.60	2.12	2.45	1.78	1.74
Osteospermum spinescens	0.95	0.97	1.21	0.58	0.93
Pentzia spinescens	0.69	0.67	0.65	0.68	0.67
Plinthus karooicus	1.75	1.21	1.04	1.36	1.34
Pteronia adenocarpa	1.31	1.32	1.33	1.39	1.34
Pteronia glomerata	0.70	0.63	0.55	0.76	0.66
Rosenia humilis	0.75	0.76	0.65	0.76	0.73
Mean	0.81	0.84	0.85	0.78	0.82

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	2.00	1.75	1.82	0.87	1.61
Eragrostis lehmanniana	0.23	0.25	0.29	0.33	0.28
Eriocephalus ericoides	0.90	0.71	0.78	1.51	0.97
Helichrysum lucilioides	0.62	0.57	0.42	0.46	0.52
Pentzia spinescens	0.90	0.63	0.67	0.62	0.71
Plinthus cryptocarpus	2.28	2.03	2.11	1.91	2.08
Pteronia adenocarpa	1.37	1.41	1.37	1.05	1.30
Pterothrix spinescens	0.62	0.64	0.50	0.55	0.58
Rosenia humilis	0.87	0.68	0.70	0.74	0.75
Stipagrostis ciliata	0.33	0.30	0.26	0.33	0.30
Stipagrostis obtusa	0.34	0.37	0.32	0.32	0.34
Zygophyllum lichtensteinianum	1.02	0.68	0.68	0.92	0.83
Mean	0.96	0.83	0.83	0.80	0.85

TABLE 8 Percentage Mg of the studied species

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B)	0.69	0.91	1.00	0.79	0.85
Fingerhuthia africana (G)	0.12	0.10	0.06	0.12	0.10
Monechma incanum (B)	0.30	0.59	0.24	0.28	0.35
Pentzia spinescens (B)	0.17	0.21	0.20	0.14	0.18
Pentzia spinescens (G)	0.21	0.16	0.18	0.14	0.17
Plinthus cryptocarpus (G)	0.63	0.73	0.53	0.65	0.64
Pterothrix spinescens (G)	0.20	0.22	0.19	0.17	0.20
Salsola tuberculata (B)	0.48	0.41	0.55	0.43	0.47
Stipagrostis ciliata (G)	0.10	0.11	0.11	0.10	0.11
Stipagrostis obtusa (B)	0.13	0.09	0.08	0.05	0.09
Stipagrostis obtusa (G)	0.16	0.13	0.11	0.09	0.12
Mean	0.29	0.33	0.30	0.27	0.30

1991/92

Species	May	Aug	Nov	Feb	Mean
Aristida diffusa	0.07	0.06	0.06	0.05	0.06
Eragrostis lehmanniana	0.15	0.10	0.10	0.09	0.11
Eriocephalus ericoides G	0.27	0.14	0.29	0.25	0.24
Eriocephalus ericoides B	0.19	0.19	0.17	0.14	0.17
Eriocephalus spinescens	0.20	0.19	0.21	0.02	0.16
Felicia macrorrhyza	0.26	0.29	0.29	0.17	0.25
Osteospermum spinescens	0.21	0.24	0.29	0.13	0.22
Pentzia spinescens	0.18	0.16	0.18	0.15	0.17
Plinthus karooicus	0.79	0.53	0.65	0.70	0.67
Pteronia adenocarpa	0.27	0.26	0.37	0.31	0.30
Pteronia glomerata	0.20	0.20	0.19	0.20	0.20
Rosenia humilis	0.22	0.25	0.21	0.21	0.22
Mean	0.25	0.22	0.25	0.20	0.23

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	1.19	0.93	1.17	0.18	0.87
Eragrostis lehmanniana	0.07	0.09	0.08	0.13	0.09
Eriocephalus ericoides	0.16	0.17	0.18	0.94	0.36
Helichrysum lucilioides	0.13	0.15	0.10	0.09	0.12
Pentzia spinescens	0.22	0.14	0.15	0.16	0.17
Plinthus cryptocarpus	0.80	0.74	0.80	1.07	0.85
Pteronia adenocarpa	0.29	0.31	0.28	0.31	0.30
Pterothrix spinescens	0.20	0.23	0.18	0.17	0.20
Rosenia humilis	0.25	0.24	0.20	0.22	0.23
Stipagrostis ciliata	0.13	0.11	0.09	0.09	0.10
Stipagrostis obtusa	0.11	0.13	0.12	0.12	0.12
Zygophyllum lichtensteinianum	0.22	0.16	0.19	0.19	0.19
Mean	0.31	0.28	0.29	0.31	0.30

TABLE 9 Percentage Na of the studied species

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B)	0.42	0.36	0.52	4.00	1.33
Fingerhuthia africana (G)	0.05	0.02	0.04	0.01	0.03
Monechma incanum (B)	0.05	0.03	0.04	0.05	0.04
Pentzia spinescens (B)	0.48	0.50	0.39	0.30	0.42
Pentzia spinescens (G)	0.50	0.49	0.51	0.45	0.49
Plinthus cryptocarpus (G)	0.05	0.06	0.06	0.01	0.05
Pterothrix spinescens (G)	0.04	0.06	0.13	0.02	0.06
Salsola tuberculata (B)	0.60	0.48	0.70	6.50	2.07
Stipagrostis ciliata (G)	0.01	0.03	0.03	0.03	0.02
Stipagrostis obtusa (B)	0.05	0.05	0.05	0.01	0.04
Stipagrostis obtusa (G)	0.03	0.01	0.06	0.01	0.03
Mean	0.21	0.19	0.23	1.04	0.42

1991/92

Species	May	Aug	Nov	Feb	Mean
Aristida diffusa	0.01	0.02	0.00	0.01	0.01
Eragrostis lehmanniana	0.01	0.04	0.04	0.02	0.03
Eriocephalus ericoides G	0.31	0.37	0.81	0.58	0.52
Eriocephalus ericoides B	0.60	0.47	0.52	0.47	0.52
Eriocephalus spinescens	0.16	0.26	0.17	0.01	0.15
Felicia macrorrhyza	0.10	0.14	0.08	0.05	0.09
Osteospermum spinescens	0.05	0.07	0.04	0.01	0.04
Pentzia spinescens	0.24	0.26	0.28	0.24	0.26
Plinthus karooicus	0.04	0.10	0.05	0.03	0.06
Pteronia adenocarpa	0.50	0.50	0.74	0.73	0.62
Pteronia glomerata	0.06	0.30	0.61	0.64	0.40
Rosenia humilis	0.10	0.13	0.10	0.04	0.09
Mean	0.18	0.22	0.29	0.24	0.23

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.51	0.48	0.44	0.72	0.54
Eragrostis lehmanniana	0.01	0.02	0.01	0.01	0.01
Eriocephalus ericoides	0.06	0.53	0.52	0.37	0.37
Helichrysum lucilioides	0.01	0.08	0.07	0.04	0.05
Pentzia spinescens	0.77	0.14	0.19	0.19	0.32
Plinthus cryptocarpus	0.04	0.06	0.07	0.02	0.05
Pteronia adenocarpa	0.52	0.73	0.82	0.43	0.63
Pterothrix spinescens	0.03	0.03	0.01	0.02	0.02
Rosenia humilis	0.29	0.07	0.05	0.10	0.13
Stipagrostis ciliata	0.02	0.02	0.03	0.02	0.02
Stipagrostis obtusa	0.01	0.02	0.02	0.02	0.02
Zygophyllum lichtensteinianum	0.60	0.44	0.51	0.53	0.52
Mean	0.24	0.22	0.23	0.21	0.22

TABLE 10Percentage P of the studied species

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B)	0.13	0.13	0.12	0.07	0.11
Fingerhuthia africana (G)	0.12	0.08	0.07	0.08	0.09
Monechma incanum (B)	0.11	0.11	0.06	0.09	0.09
Pentzia spinescens (B)	0.17	0.11	0.08	0.08	0.11
Pentzia spinescens (G)	0.12	0.11	0.06	0.09	0.10
Plinthus cryptocarpus (G)	0.11	0.12	0.06	8.00	2.07
Pterothrix spinescens (G)	0.08	0.09	0.06	0.07	0.08
Salsola tuberculata (B)	0.09	0.08	0.08	0.05	0.08
Stipagrostis ciliata (G)	0.07	0.09	0.06	0.06	0.07
Stipagrostis obtusa (B)	0.07	0.07	0.04	0.06	0.06
Stipagrostis obtusa (G)	0.10	0.09	0.05	0.06	0.08
Mean	0.11	0.10	0.07	0.79	0.27

1991/92

Species	May	Aug	Nov	Feb	Mean
Aristida diffusa	0.07	0.04	0.04	0.05	0.05
Eragrostis lehmanniana	0.13	0.04	0.05	0.07	0.07
Eriocephalus ericoides G	0.17	0.12	0.06	0.07	0.11
Eriocephalus ericoides B	0.20	0.12	0.14	0.10	0.14
Eriocephalus spinescens	0.13	0.09	0.11	0.01	0.09
Felicia macrorrhyza	0.13	0.11	0.08	0.06	0.10
Osteospermum spinescens	0.10	0.08	0.07	0.05	0.08
Pentzia spinescens	0.12	0.08	0.18	0.09	0.12
Plinthus karooicus	0.09	0.08	0.65	0.07	0.25
Pteronia adenocarpa	0.13	0.08	0.37	0.09	0.17
Pteronia glomerata	0.15	0.10	0.09	0.11	0.11
Rosenia humilis	0.16	0.13	0.21	0.12	0.16
Mean	0.14	0.09	0.17	0.07	0.12

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.12	0.10	0.10	0.11	0.11
Eragrostis lehmanniana	0.07	0.06	0.06	0.07	0.07
Eriocephalus ericoides	0.17	0.15	0.12	0.07	0.13
Helichrysum lucilioides	0.09	0.09	0.04	0.07	0.07
Pentzia spinescens	0.15	0.08	0.07	0.09	0.10
Plinthus cryptocarpus	0.12	0.11	0.09	0.09	0.10
Pteronia adenocarpa	0.12	0.13	0.10	0.09	0.11
Pterothrix spinescens	0.07	0.09	0.06	0.06	0.07
Rosenia humilis	0.15	0.15	0.10	0.13	0.13
Stipagrostis ciliata	0.08	0.06	0.08	0.06	0.07
Stipagrostis obtusa	0.08	0.06	0.06	0.07	0.07
Zygophyllum lichtensteinianum	0.13	0.08	0.05	0.16	0.11
Mean	0.11	0.10	0.08	0.09	0.09

TABLE 11The K/Ca+Mg ratio of the studied species

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B)	0.57	0.64	0.37	0.49	0.52
Fingerhuthia africana (G)	1.16	0.46	0.71	0.74	0.77
Monechma incanum (B)	0.52	0.51	0.58	0.61	0.56
Pentzia spinescens (B)	0.79	0.71	0.79	0.98	0.82
Pentzia spinescens (G)	0.45	0.55	0.66	0.57	0.56
Plinthus cryptocarpus (G)	0.53	0.58	0.71	0.64	0.62
Pterothrix spinescens (G)	0.34	0.48	0.50	0.53	0.46
Salsola tuberculata (B)	0.37	0.36	0.44	0.48	0.41
Stipagrostis ciliata (G)	0.44	0.29	0.43	0.74	0.48
Stipagrostis obtusa (B)	0.51	0.54	0.54	1.04	0.66
Stipagrostis obtusa (G)	0.42	0.42	0.57	0.61	0.51
Mean	0.56	0.50	0.57	0.67	0.58

1991/92

Species	May	Aug	Nov	Feb	Mean
Aristida diffusa	0.72	0.73	0.35	0.95	0.69
Eragrostis lehmanniana	1.48	0.50	0.34	1.70	1.01
Eriocephalus ericoides G	1.30	0.95	0.43	0.48	0.79
Eriocephalus ericoides B	1.16	0.51	0.77	0.90	0.83
Eriocephalus spinescens	2.02	1.00	0.77	1.36	1.29
Felicia macrorrhyza	0.80	0.27	0.12	0.19	0.35
Osteospermum spinescens	0.98	0.54	0.32	0.92	0.69
Pentzia spinescens	1.07	0.82	0.39	0.80	0.77
Plinthus karooicus	1.06	0.83	0.41	0.83	0.78
Pteronia adenocarpa	0.81	0.61	0.25	0.43	0.53
Pteronia glomerata	1.16	0.67	0.61	1.10	0.89
Rosenia humilis	1.26	1.18	0.59	0.95	0.99
Mean	1.15	0.72	0.45	0.88	0.80

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.34	0.32	0.31	0.68	0.41
Eragrostis lehmanniana	1.10	0.56	0.35	0.61	0.65
Eriocephalus ericoides	1.07	0.74	0.99	0.34	0.78
Helichrysum lucilioides	0.45	0.43	0.62	0.35	0.46
Pentzia spinescens	0.80	0.69	0.57	0.63	0.67
Plinthus cryptocarpus	0.44	0.42	0.37	0.37	0.40
Pteronia adenocarpa	0.61	0.49	0.55	0.36	0.50
Pterothrix spinescens	0.32	0.24	0.28	0.26	0.28
Rosenia humilis	0.99	1.25	1.51	0.20	0.99
Stipagrostis ciliata	0.43	0.34	0.37	0.33	0.37
Stipagrostis obtusa	0.42	0.42	0.36	0.41	0.40
Zygophyllum lichtensteinianum	0.71	0.71	0.79	0.72	0.73
Mean	0.64	0.55	0.59	0.44	0.56

TABLE 12The Ca/P ratio of the studied species

1990/91

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox (B)	11.38	11.00	11.75	18.86	13.25
Fingerhuthia africana (G)	2.58	5.25	4.14	5.13	4.28
Monechma incanum (B)	16.36	12.36	21.83	16.67	16.81
Pentzia spinescens (B)	4.82	9.82	9.63	10.25	8.63
Pentzia spinescens (G)	7.42	6.36	10.67	8.22	8.17
Plinthus cryptocarpus (G)	17.64	14.92	17.67	0.20	12.60
Pterothrix spinescens (G)	7.00	8.78	8.83	7.57	8.05
Salsola tuberculata (B)	23.44	36.25	32.50	40.00	33.05
Stipagrostis ciliata (G)	4.43	4.44	5.83	4.00	4.68
Stipagrostis obtusa (B)	4.86	4.57	8.25	3.50	5.29
Stipagrostis obtusa (G)	5.10	3.56	6.20	3.67	4.63
Mean	9.55	10.66	12.48	10.73	10.86

1991/92

Species	May	Aug	Nov	Feb	Mean
Aristida diffusa	3.14	5.00	4.25	3.40	3.95
Eragrostis lehmanniana	3.31	6.50	5.00	4.00	4.70
Eriocephalus ericoides G	4.71	6.08	9.50	10.57	7.72
Eriocephalus ericoides B	4.60	5.00	4.36	7.40	5.34
Eriocephalus spinescens	5.00	7.11	6.00	9.00	6.78
Felicia macrorrhyza	4.62	19.36	30.63	29.67	21.07
Osteospermum spinescens	9.50	12.13	17.29	11.60	12.63
Pentzia spinescens	5.75	8.38	3.61	7.56	6.32
Plinthus karooicus	9.21	15.13	1.60	19.43	11.34
Pteronia adenocarpa	10.08	16.50	3.59	15.44	11.40
Pteronia glomerata	4.67	6.30	6.11	6.91	6.00
Rosenia humilis	4.69	5.85	3.10	6.33	4.99
Mean	5.77	9.44	7.92	10.94	8.52

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	16.67	17.50	18.20	7.91	15.07
Eragrostis lehmanniana	3.29	4.17	4.83	4.71	4.25
Eriocephalus ericoides	5.29	4.73	6.50	21.57	9.52
Helichrysum lucilioides	6.89	6.33	10.50	6.57	7.57
Pentzia spinescens	6.00	7.87	9.57	6.89	7.58
Plinthus cryptocarpus	19.00	18.45	23.44	21.22	20.53
Pteronia adenocarpa	11.42	10.85	13.70	11.67	11.91
Pterothrix spinescens	8.86	7.11	8.33	9.17	8.37
Rosenia humilis	5.80	4.53	7.00	5.69	5.76
Stipagrostis ciliata	4.12	5.00	3.25	5.50	4.47
Stipagrostis obtusa	4.25	6.17	5.33	4.57	5.08
Zygophyllum lichtensteinianum	7.85	8.50	13.60	5.75	8.92
Mean	8.50	8.64	10.67	8.98	9.20

TABLE 13 Percentage ether extract and ash of the studied species, adapted from Botha, Becker & van der Merwe (1990), Louw, Steenkamp & Steenkamp (1968c) and Steenkamp & Hayward (1979)

Ether extract	Apr/May	Jul/Aug	Oct/Nov	Jan/Feb	Mean
Aristida diffusa	1.43	1.35	1.61	1.29	1.42
Eragrostis lehmanniana	1.89	1.55	1.56	1.59	1.65
Fingerhuthia africana	1.44	2.02	1.39	2.11	1.74
Stipagrostis ciliata	1.24	1.63	0.96	1.51	1.33
Stipagrostis obtusa B	1.63	2.01	0.56	1.47	1.42
Stipagrostis obtusa G	1.27	2.42	1.75	1.61	1.76
Eberlanzia ferox	2.27	3.03	2.93	3.23	2.87
Eriocephalus ericoides B	2.64	2.15	2.56	1.98	2.33
Eriocephalus ericoides G		3.30		6.60	4.95
Eriocephalus spinescens	2.31	2.20	1.55	2.03	2.02
Felicia macrorrhyza					
Helichrysum lucilioides	1.72	1.66	1.75	1.73	1.72
Monechma incanum	1.80	1.63	1.38	1.37	1.54
Osteospermum spinescens					
Pentzia spinescens B	2.86	2.65	2.35	2.63	2.62
Pentzia spinescens G		2.90		4.60	3.75
Plinthus cryptocarpus	1.45	1.78	2.62	1.93	1.95
Plinthus karooicus	1.30	1.73	2.19	1.54	1.69
Pteronia adenocarpa				4.00	4.00
Pteronia glomerata		4.70		6.40	5.55
Pterothrix spinescens	4.79	5.16	4.33	4.82	4.78
Rosenia humilis	2.36	2.33	1.80	1.98	2.12
Salsola tuberculata	1.43	1.70	1.34	1.48	1.49
Zygophyllum lichtensteinianum					
Mean	1.99	2.40	1.92	2.66	2.51

Ash	Apr/May	Jul/Aug	Oct/Nov	Jan/Feb	Mean
Aristida diffusa	11.70	9.53	9.74	9.85	10.21
Eragrostis lehmanniana	8.66	6.95	7.66	8.52	7.95
Fingerhuthia africana	9.22	10.13	8.49	7.13	8.74
Stipagrostis ciliata	6.46	9.02	7.83	9.24	8.14
Stipagrostis obtusa B	24.86	11.78	9.05	0.00	11.42
Stipagrostis obtusa G	11.68	14.98	9.53	12.36	12.14
Eberlanzia ferox	7.00	7.50	7.19	7.62	7.33
Eriocephalus ericoides B	6.29	6.30	6.78	4.39	5.94
Eriocephalus ericoides G		4.70		7.60	6.15
Eriocephalus spinescens	8.20	7.78	6.27	4.07	6.58
Felicia macrorrhyza					
Helichrysum lucilioides	6.30	4.00	4.72	5.06	5.02
Monechma incanum	8.53	7.23	7.87	6.71	7.58
Osteospermum spinescens					
Pentzia spinescens B	8.43	6.38	8.18	5.57	7.14
Pentzia spinescens G		5.70		7.60	6.65
Plinthus cryptocarpus	11.79	10.33	14.07	11.34	11.88
Plinthus karooicus	13.34	12.47	11.60	9.87	11.82
Pteronia adenocarpa				8.20	8.20
Pteronia glomerata		5.80		8.20	7.00
Pterothrix spinescens	7.74	9.26	11.65	5.53	8.54
Rosenia humilis	12.48	8.85	9.10	11.45	10.47
Salsola tuberculata	13.03	16.55	17.31	18.47	16.34
Zygophyllum lichtensteinianum					
Mean	10.34	8.76	9.24	8.04	8.82

TABLE 14Carnarvon Experimental farm, surveys employing the linepoint and descending point method. October 1991, Grazing Index values and Ecological Index Values are used in the computations. Bushmangrassveld, Red sand, 500 points

Species	Hits	Mean	Sp value	Sp weight	Sp value	Sp weight
Aptosimum spinescens	2	0.4	3	1.2	1	0.4
Chrysocoma ciliata	2	0.4	4.57	1.828	1	0.4
Eragrostis lehmanniana	18	3.6	4	14.4	4	14.4
Eriocephalus aspalathoides	2	0.4	4	1.6	1	0.4
Eriocephalus ericoides	2	0.4	4.57	1.828	1	0.4
Heliophila minuta	7	1.4	2	2.8	1	1.4
Lycium sp	2	0.4	4.86	1.944	1	0.4
Pentzia annua	2	0.4	2	0.8	1	0.4
Pentzia spinescens	42	8.4	5.4	45.36	4	33.6
Phymaspermum aciculare	1	0.2	6	1.2	7	1.4
Plinthus cryptocarpus	5	1	7	7	7	7
Protasparagus suaveolens	1	0.2	2.57	0.514	1	0.2
Pterothrix spinescens	4	0.8	3.14	2.512	1	0.8
Stipagrostis ciliata	45	9	7	63	10	90
Stipagrostis obtusa	74	14.8	6	88.8	10	148
Sutherlandia frutescens	1	0.2	7	1.4	7	1.4
Tetragonia arbuscula	1	0.2	7	1.4	7	1.4
Total	211	42.2		237.586		302
Grazing capacity ha/LSU				2.735851		2.152317

TABLE 15Carnarvon Experimental farm, surveys employing the linepoint and descending point method. October 1991, Grazing Index values and Ecological Index Values are used in the computations. Shaleveld, 1000 points

Species	Hits	Mean	Sp value	Sp weight	Sp value	Sp weight
Aptosimum marlothii	1	0.1	4	0.4	1	0.1
Aristida congesta	2	0.2	1.43	0.286	1	0.2
Eberlanzia ferox	22	2.2	4.29	9.438	4	8.8
Eriocephalus ericoides	42	4.2	4.57	19.194	4	16.8
Fingerhuthia africana	18	1.8	5.14	9.252	10	18
Helichrysum lucilioides	4	0.4	5.43	2.172	4	1.6
Hermannia cuneifolia	16	1.6	4.86	7.776	7	11.2
Hermannia grandiflora	1	0.1	6	0.6	7	0.7
Monechma incanum	40	4	7	28	7	28
Pentzia spinescens	118	11.8	5.4	63.72	4	47.2
Plinthus karooicus	6	0.6	6.86	4.116	7	4.2
Pteronia adenocarpa	1	0.1	6	0.6	7	0.7
Pteronia glauca	5	0.5	4	2	1	0.5
Pteronia glomerata	1	0.1	5	0.5	7	0.7
Pteronia sordida	10	1	6	6	7	7
Rosenia glandulosa	8	0.8	4	3.2	4	3.2
Rosenia humilis	1	0.1	6	0.6	7	0.7
Salsola calluna	3	0.3	6	1.8	7	2.1
Salsola tuberculata	22	2.2	7	15.4	7	15.4
Stipagrostis obtusa	8	0.8	6	4.8	10	8
Zygophyllum lichtensteinianum	5	0.5	5.71	2.855	7	3.5
Total				182.709		178.6
Grazing capacity ha/LSU				3.557569		3.639417

Carnarvon, 1990 to 1993, canopy spread cover : mass regressions
Karoo bushes
(x=area cm^2)(y=mass kg)

682.5	106.78	Regression Output:		
937	90.88	Constant		10.76721
337.5	18.16	Std Err of Y Est		33.61027
1628.5	109.68	R Squared		0.455831
124.5	11.2	No. of Observations		104
775.5	101.34	Degrees of Freedom		102
743	176.74			
605	98.14	X Coefficient(s)	0.076823	
943	70.52	Std Err of Coef.	0.008311	
402	25.06			
1407.5	109.84	50	14.60836	
763.5	18.85	100	18.44951	
950	97.98	150	22.29066	
690	135.56	200	26.13181	
628.5	95.14	250	29.97296	
974.5	57.98	300	33.81411	
457.5	28.12	350	37.65526	
1127.5	69.5	400	41.49641	
869	16.1	450	45.33756	
729	121.5	500	49.17871	
599	106.3	550	53.01986	
610	83.7	600	56.86101	
956	96.56	650	60.70216	
461	28.84	700	64.54331	
1235.5	99.32	750	68.38446	
577	11.98	800	72.22561	
1259.5	152.12	850	76.06676	
801.5	140.58	900	79.90791	
1316	82.6	950	83.74906	
843.5	46.02	1000	87.59021	
881.5	58.88	1050	91.43136	
131.75	11.58	1100	95.27251	
1376.5	78.02	1150	99.11366	
543	24.92	1200	102.9548	
239.25	19.22	1250	106.7959	
721.5	56.24	1300	110.6371	
924.5	92.82	1350	114.4782	
864	115.52	1400	118.3194	
1242	43.24	1450	122.1605	
913.5	133.06	1500	126.0017	
768.5	61.12	1550	129.8428	
164	12.46	1600	133.6840	
1041	87.48	1650	137.5251	
590	23.04	1700	141.3663	
247.375	15.88	1750	145.2074	
1121.5	91.14	1800	149.0486	
1081.5	103.48	1850	152.8897	
840	118.22	1900	156.7309	
1236	114.16	1950	160.5720	
597.5	30.52	2000	164.4132	
666	46.64	2050	168.2543	
135.25	16.3	2100	172.0955	
2238	136.46	2150	175.9366	
745	44	2200	179.7778	
126.125	7.24	2250	183.6189	
672	56.6			
1230.5	122.82			
924	89.34			
1343.5	124.28			
603.5	43.16			
805	70.92			
105.5	11.4			
2171.5	123.14			
634	44.26			
143.875	13.32			
502.5	45.86			

622	61.84
530	84.02
370	62.48
290.5	16.76
318	20.84
725	32.9
155.25	10.78
490	43.26
827	117.42
672.5	65.04
451.5	25.14
488.5	68.2
555.5	32.44
305.5	16.76
451	27.06
91.125	6.46
522	47.36
696	104.84
854.5	107.4
562	32.14
576	88.42
626.5	40.34
216.5	14
422	21.98
71.75	7.42
600.5	51.88
741	89.58
670	61.46
403	29.1
407	59.8
403.5	25.92
454	34.7
713	35.72
111	17.28
389	28.12
1136	262.12
591.8367	79.62
535	30.58

Grasses

(x=area cm²)(y=mass kg)

72.875	14.52	Regression Output:		
59.875	42.54	Constant		11.59308
54.125	16.28	Std Err of Y Est		26.70420
35.5	5.04	R Squared		0.579605
81.25	22.32	No. of Observations		36
253.125	48.38	Degrees of Freedom		34
119.25	28.2			
150.625	35.74	X Coefficient(s)	0.103764	
94	10.88	Std Err of Coef.	0.015155	
253.625	70.38			
117.5	22.6	50	16.78128	
135.375	28.6	100	21.96948	
61.875	20.3	150	27.15768	
305	102.12	200	32.34588	
113.25	43.04	250	37.53408	
93.375	40.82	300	42.72228	
311.5	46.24	350	47.91048	
83.625	12.84	400	53.09868	
377.5	29.72	450	58.28688	
311.5	4.7	500	63.47508	
276	36.58	550	68.66328	
122.875	7.6	600	73.85148	
227	30.02	650	79.03968	
70.875	13.24	700	84.22788	
442	11.42	750	89.41608	
936	82.28	800	94.60428	
102.375	35.58	850	99.79248	
377	15.1	900	104.9806	
862.5	148.86	950	110.1688	
55.75	12.52	1000	115.3570	
342.5	20.78	1050	120.5452	
997	191.52	1100	125.7334	
33.125	14.72	1150	130.9216	
301.5	20.52	1200	136.1098	
1274	100.78	1250	141.2980	
38.375	20.86	1300	146.4862	

Karoo bushes	Apr		Jul		Oct		Jan	
	area	mass	area	mass	area	mass	area	mass
Eberlanzia ferox 90	682.5	106.78	605	98.14	628.5	95.14	610	83.7
Monechma incanum 90	937	90.88	943	70.52	974.5	57.98	956	96.56
Pentzia spinescens B90	337.5	18.16	402	25.06	457.5	28.12	461	28.84
Pentzia spinescens G90	1628.5	109.68	1407.5	109.84	1127.5	69.5	1235.5	99.32
Plinthus cryptocarpus 90	124.5	11.2	763.5	18.85	869	16.1	577	11.98
Pterothrix spinescens 90	775.5	101.34	950	97.98	729	121.5	1259.5	152.12
Salsola tuberculata 90	743	176.74	690	135.56	599	106.3	801.5	140.58
Eriocephalus ericoides G91	1316	82.6	1242	43.24	1236	114.16	1343.5	124.28
Eriocephalus ericoides B91	843.5	46.02	913.5	133.06	597.5	30.52	603.5	43.16
Eriocephalus spinescens 91	881.5	58.88	768.5	61.12	666	46.64	805	70.92
Felicia macrorrhyza 91	131.75	11.58	164	12.46	135.25	16.3	105.5	11.4
Osteospermum spinescens 91	1376.5	78.02	1041	87.48	2238	136.46	2171.5	123.14
Pentzia spinescens 91	543	24.92	590	23.04	745	44	634	44.26
Plinthus karooicus 91	239.25	19.22	247.375	15.88	126.125	7.24	143.875	13.32
Pteronia adenocarpa 91	721.5	56.24	1121.5	91.14	672	56.6	502.5	45.86
Pteronia glomerata 91	924.5	92.82	1081.5	103.48	1230.5	122.82	622	61.84
Rosenia humilis 91	864	115.52	840	118.22	924	89.34	530	84.02
Eberlanzia ferox 92	370	62.48	488.5	68.2	576	88.42	407	59.8
Eriocephalus ericoides 92	290.5	16.76	555.5	32.44	626.5	40.34	403.5	25.92
Helichrysum lucilioides 92	318	20.84	305.5	16.76	216.5	14	454	34.7
Pentzia spinescens 92	725	32.9	451	27.06	422	21.98	713	35.72
Plinthus cryptocarpus 92	155.25	10.78	91.125	6.46	71.75	7.42	111	17.28
Pteronia adenocarpa 92	490	43.26	522	47.36	600.5	51.88	389	28.12
Pterothrix spinescens 92	827	117.42	696	104.84	741	89.58	1136	262.12
Rosenia humilis 92	672.5	65.04	854.5	107.4	670	61.46	591.8367	79.62
Zygophyllum lichtensteinianum 92	451.5	25.14	562	32.14	403	29.1	535	30.58

Apr	Regression Output:
Constant	12.21898
Std Err of Y Est	33.33283
R Squared	0.430945
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	0.073548
Std Err of Coef.	0.017251

Jul	Regression Output:
Constant	7.041630
Std Err of Y Est	32.18643
R Squared	0.428782
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	0.082236
Std Err of Coef.	0.019375

Oct	Regression Output:
Constant	13.91992
Std Err of Y Est	27.64727
R Squared	0.532155
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	0.065689
Std Err of Coef.	0.012572

Jan	Regression Output:
Constant	8.941441
Std Err of Y Est	42.22005
R Squared	0.470132
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	0.087098
Std Err of Coef.	0.018874

Grasses	Apr		Jul		Oct		Jan	
	area	mass	area	mass	area	mass	area	mass
Fingerhuthia africana 90	72.875	14.52	81.25	22.32	94	10.88	61.875	20.3
Stipagrostis ciliata 90	59.875	42.54	253.125	48.38	253.625	70.38	305	102.12
Stipagrostis obtusa B90	54.125	16.28	119.25	28.2	117.5	22.6	113.25	43.04
Stipagrostis obtusa G90	35.5	5.04	150.625	35.74	135.375	28.6	93.375	40.82
Aristida diffusa 91	311.5	46.24	377.5	29.72	276	36.58	227	30.02
Eragrostis lehmanniana 91	83.625	12.84	311.5	4.7	122.875	7.6	70.875	13.24
Eragrostis lehmanniana 92	442	11.42	377	15.1	342.5	20.78	301.5	20.52
Stipagrostis ciliata 92	936	82.28	862.5	148.86	997	191.52	1274	100.78
Stipagrostis obtusa 92	102.375	35.58	55.75	12.52	33.125	14.72	38.375	20.86

Apr Regression Output:	
Constant	15.30129
Std Err of Y Est	17.68276
R Squared	0.550995
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.061504
Std Err of Coef.	0.020984

Jul Regression Output:	
Constant	-3.06583
Std Err of Y Est	26.39132
R Squared	0.676998
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.144150
Std Err of Coef.	0.037633

Oct Regression Output:	
Constant	-4.71037
Std Err of Y Est	20.13589
R Squared	0.894960
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.188049
Std Err of Coef.	0.024349

Jan Regression Output:	
Constant	26.07987
Std Err of Y Est	25.62558
R Squared	0.511039
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.063165
Std Err of Coef.	0.023352

Appendix 6 An exposition of the canopy spread cover, mean forage production, chemical analyses, botanical surveys and canopy spread cover on available forage mass regressions of the species studied in the Great Karoo.

TABLE 1 Mean canopy spread cover of the studies species, cm^2

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	569.50	406.50	416.00	305.00	302.00	399.80
Eriocephalus spinescens	700.50	914.50	629.00	787.00	653.00	736.80
Pentzia spinescens	669.00	614.50	612.00	416.00	445.00	551.30
Rosenia humilis	970.50	1019.50	702.50	929.00	757.00	875.70
Salsola tuberculata	294.50	224.00	186.00	259.00	260.00	244.70
Zygophyllum microphyllum	914.00	790.50	619.00	609.50	742.50	735.10
Fingerhuthia africana		242.00	104.13	118.25	132.88	149.32
Stipagrostis obtusa	110.63	132.13	114.13	73.88	103.88	106.93
Mean	604.09	542.95	422.85	437.20	424.53	474.96

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	105.13	114.75	88.75	76.13	96.19
Felicia fascicularis	63.38	50.88	44.00	52.75	52.75
Galenia secunda	299.00	906.50	881.50	709.50	699.13
Nenax microphylla	210.50	96.13	102.63	126.00	133.82
Osteospermum microphyllum	85.13	107.13	99.00	93.25	96.13
Pentzia spinescens	595.50	449.50	380.50	474.00	474.88
Pteronia staehelinoides	628.50	651.50	753.50	467.00	625.13
Salsola rabieana	285.50	327.00	330.00	335.00	319.38
Walafrida geniculata	578.00	549.50	506.00	374.00	501.88
Mean	316.74	361.43	353.99	300.85	333.25

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	328.50	282.00	303.00	253.00	291.62
Eriocephalus spinescens	638.00	689.00	654.00	530.50	627.87
Felicia fascicularis	53.75	69.00	53.37	51.37	56.87
Fingerhuthia africana	101.50	182.00	108.00	135.50	131.75
Helichrysum lucilioides	157.37	229.00	119.37	99.12	151.22
Hermannia desertorum	149.12	169.12	139.50	135.50	148.31
Nenax microphylla	168.12	119.50	125.62	77.75	122.75
Pentzia spinescens	360.00	324.00	345.50	265.00	323.62
Rosenia humilis	741.00	595.00	649.50	375.00	590.12
Salsola rabieana	389.50	359.50	320.00	427.00	374.00
Stipagrostis obtusa	88.25	39.25	142.00	85.50	113.75
Mean	288.65	287.03	269.08	221.39	266.54

TABLE 2 Mean available aboveground forage production of the studied species (g/grasstuft, karoo bush)

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	77.26	44.98	46.00	44.82	34.72	49.56
Eriocephalus spinescens	53.54	61.26	63.00	64.16	52.92	58.98
Pentzia spinescens	53.22	59.94	60.28	41.12	46.50	52.21
Rosenia humilis	131.78	112.84	104.32	115.18	90.38	110.90
Salsola tuberculata	23.86	27.76	26.16	37.02	32.88	29.54
Zygophyllum microphyllum	87.78	85.14	86.10	74.16	84.69	83.57
Fingerhuthia africana		55.76	14.28	21.50	32.90	31.11
Stipagrostis obtusa	13.68	12.42	11.82	9.84	19.46	13.44
Mean	63.02	57.51	51.50	50.98	49.31	53.66

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	19.82	21.66	15.92	15.20	18.15
Felicia fascicularis	4.76	4.02	2.80	4.80	4.10
Galenia secunda	18.72	16.58	14.36	10.08	14.93
Nenax microphylla	25.30	8.72	6.96	11.24	13.06
Osteospermum microphyllum	21.58	23.72	21.82	25.52	23.16
Pentzia spinescens	42.06	33.46	25.96	34.62	34.03
Pteronia staehelinoides	37.96	46.54	50.38	30.16	41.26
Salsola rabieana	11.18	16.60	14.22	17.40	14.85
Walafrida geniculata	30.56	36.04	30.86	18.36	28.96
Mean	23.55	23.04	20.36	18.60	21.39

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	43.80	31.64	37.88	37.74	37.77
Eriocephalus spinescens	49.70	44.20	43.20	47.86	46.24
Felicia fascicularis	3.64	8.06	4.84	4.44	5.25
Fingerhuthia africana	21.46	21.66	25.68	38.76	26.89
Helichrysum lucilioides	13.78	19.46	8.72	10.20	13.04
Hermannia desertorum	9.42	13.76	9.82	36.00	17.25
Nenax microphylla	18.00	11.78	12.02	9.12	12.73
Pentzia spinescens	25.62	21.88	27.00	29.04	25.89
Rosenia humilis	87.78	56.68	75.66	49.48	67.40
Salsola rabieana	14.26	26.66	23.60	43.76	27.07
Stipagrostis obtusa	18.84	19.86	20.00	20.10	19.70
Mean	27.85	25.06	26.22	29.68	27.20

TABLE 3 Percentage N of the studied species

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.89	0.84	0.78	0.77	0.81	0.82
Eriocephalus spinescens	0.85	1.06	0.84	0.92	0.78	0.89
Pentzia spinescens	1.17	1.37	0.78	0.80	0.85	0.99
Rosenia humilis	0.99	1.13	0.83	0.90	0.73	0.92
Salsola tuberculata	1.72	1.33	1.64	1.38	1.37	1.49
Zygophyllum microphyllum	1.99	1.55	1.19	1.43	1.29	1.49
Fingerhuthia africana	*	0.42	0.56	0.43	0.61	0.51
Stipagrostis obtusa	0.74	0.71	0.82	0.85	0.70	0.76
Mean	1.19	1.05	0.93	0.93	0.89	0.98

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	0.87	0.85	0.66	0.79	0.79
Felicia fascicularis	0.82	0.81	1.17	0.78	0.90
Galenia secunda	0.64	0.85	1.20	0.56	0.81
Nenax microphylla	0.65	0.76	0.73	0.57	0.68
Osteospermum microphyllum	0.67	0.88	0.46	0.88	0.72
Pentzia spinescens	0.88	0.91	0.78	0.81	0.85
Pteronia staehelinoides	0.77	0.80	0.58	0.94	0.77
Salsola rabieana	0.90	0.57	1.19	1.06	0.93
Walafrida geniculata	0.64	0.99	0.64	0.60	0.72
Mean	0.76	0.82	0.82	0.78	0.80

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.96	1.12	0.71	0.77	0.89
Eriocephalus spinescens	0.86	0.76	0.68	0.75	0.76
Felicia fascicularis	1.08	0.96	0.85	0.83	0.93
Fingerhuthia africana	0.92	0.59	0.60	0.39	0.63
Helichrysum lucilioides	1.28	0.80	0.81	0.71	0.90
Hermannia desertorum	1.24	0.80	0.88	0.79	0.93
Nenax microphylla	0.91	0.52	0.45	0.48	0.59
Pentzia spinescens	0.58	0.98	0.77	0.85	0.80
Rosenia humilis	1.24	1.04	0.94	0.90	1.03
Salsola rabieana	1.35	1.22	1.25	1.23	1.26
Stipagrostis obtusa	0.68	0.67	0.66	0.55	0.64
Mean	1.01	0.86	0.78	0.75	0.85

TABLE 4 Percentage ADF of the studied species

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	28.79	46.28	56.07	51.59	50.27	46.60
Eriocephalus spinescens	33.98	44.65	51.25	53.21	50.25	46.67
Pentzia spinescens	33.17	34.35	50.88	55.30	51.44	45.03
Rosenia humilis	26.78	45.40	44.00	49.29	54.54	44.00
Salsola tuberculata	12.15	25.54	25.99	23.78	22.17	21.93
Zygophyllum microphyllum	13.95	29.63	39.51	32.55	36.15	30.36
Fingerhuthia africana	*	43.65	45.45	40.23	38.01	41.84
Stipagrostis obtusa	33.23	45.43	46.70	42.12	40.19	41.53
Mean	26.01	39.37	44.98	43.51	42.88	39.74

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	52.99	52.31	54.04	60.95	55.07
Felicia fascicularis	48.41	48.02	34.05	52.83	45.83
Galenia secunda	54.01	50.12	39.51	62.24	51.47
Nenax microphylla	56.46	53.35	49.06	61.60	55.12
Osteospermum microphyllum	50.55	44.06	46.27	46.58	46.87
Pentzia spinescens	57.70	54.10	50.12	66.37	57.07
Pteronia staehelinoides	50.39	51.01	49.99	50.81	50.55
Salsola rabieana	41.19	61.84	34.76	52.93	47.68
Walafrida geniculata	57.80	44.17	51.97	67.62	55.39
Mean	52.17	51.00	45.53	57.99	51.67

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	57.76	57.71	55.81	44.68	48.99
Eriocephalus spinescens	48.10	57.18	53.38	55.97	53.66
Felicia fascicularis	42.73	42.52	43.29	40.32	42.22
Fingerhuthia africana	44.07	43.58	40.58	40.12	42.09
Helichrysum lucilioides	48.23	43.63	46.78	44.85	45.87
Hermannia desertorum	48.29	56.24	51.29	52.60	52.11
Nenax microphylla	59.41	58.67	59.67	58.15	58.98
Pentzia spinescens	58.24	57.64	53.66	46.80	54.09
Rosenia humilis	44.78	47.17	47.79	40.62	45.09
Salsola rabieana	58.53	44.06	45.86	38.33	46.70
Stipagrostis obtusa	40.69	45.19	46.46	41.85	43.55
Mean	50.08	48.51	49.51	45.84	48.48

TABLE 5 Percentage TDN of the studied species

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	58.16	45.93	38.98	42.03	43.08	45.64
Eriocephalus spinescens	54.45	47.69	42.50	41.40	42.99	45.81
Pentzia spinescens	55.88	55.49	42.56	39.58	42.41	47.18
Rosenia humilis	59.83	47.35	47.47	44.04	39.85	47.71
Salsola tuberculata	71.43	61.49	61.75	62.81	63.90	64.27
Zygophyllum microphyllum	70.58	59.08	51.55	56.85	54.09	58.43
Fingerhuthia africana		45.87	45.41	48.29	50.77	47.58
Stipagrostis obtusa	54.59	46.06	45.58	48.84	49.64	48.94
Mean	60.70	51.12	46.97	47.98	48.34	50.70

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	41.40	41.80	39.92	35.64	39.69
Felicia fascicularis	44.40	44.63	55.27	41.21	46.38
Galenia secunda	39.86	43.32	51.57	33.82	42.14
Nenax microphylla	38.21	40.78	43.63	34.31	39.24
Osteospermum microphyllum	42.37	47.59	44.31	45.85	45.03
Pentzia spinescens	38.18	40.76	43.08	31.97	38.50
Pteronia staehelinoides	42.86	42.54	42.37	43.11	42.72
Salsola rabieana	49.63	34.14	54.83	41.98	45.15
Walafrida geniculata	37.25	47.84	41.27	30.30	39.16
Mean	41.57	42.60	46.25	37.58	42.00

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	43.87	57.76	44.46	52.16	49.56
Eriocephalus spinescens	50.12	43.70	46.00	44.48	46.08
Felicia fascicularis	54.29	54.15	53.34	55.28	54.26
Fingerhuthia africana	53.00	52.27	54.33	53.61	53.30
Helichrysum lucilioides	50.98	52.96	50.87	51.85	51.67
Hermannia desertorum	50.87	44.46	48.02	46.88	47.56
Nenax microphylla	42.63	41.79	40.77	41.95	41.78
Pentzia spinescens	42.34	44.00	46.11	50.97	45.85
Rosenia humilis	53.23	51.20	50.54	55.27	52.56
Salsola rabieana	44.16	53.68	52.52	57.56	51.98
Stipagrostis obtusa	54.56	51.49	50.59	53.27	52.48
Mean	49.09	49.77	48.87	51.21	49.74

TABLE 6 Percentage K of the studied species

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	1.08	1.24	1.17	1.42	1.36	1.25
Eriocephalus spinescens	1.15	1.50	1.00	1.58	1.01	1.25
Pentzia spinescens	0.98	1.31	1.27	0.89	0.82	1.05
Rosenia humilis	0.90	1.80	1.61	1.8	1.52	1.53
Salsola tuberculata	1.70	0.83	1.24	1.38	1.11	1.25
Zygophyllum microphyllum	0.85	0.88	0.92	0.95	0.69	0.86
Fingerhuthia africana		0.55	0.36	0.38	0.71	0.50
Stipagrostis obtusa	0.41	0.25	0.37	0.30	0.23	0.31
Mean	1.01	1.05	0.99	1.09	0.93	1.00

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	0.73	0.58	0.70	0.58	0.65
Felicia fascicularis	0.93	0.37	0.65	0.63	0.65
Galenia secunda	0.42	0.46	0.83	0.53	0.56
Nenax microphylla	0.51	0.32	0.59	0.57	0.50
Osteospermum microphyllum	1.00	0.27	0.27	0.48	0.51
Pentzia spinescens	0.54	0.48	0.76	0.69	0.62
Pteronia staehelinoides	0.92	0.80	0.85	1.17	0.94
Salsola rabieana	0.98	0.79	0.88	1.23	0.97
Walafrida geniculata	1.08	0.74	0.89	0.71	0.86
Mean	0.79	0.53	0.71	0.73	0.69

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	1.19	1.08	1.20	1.25	1.18
Eriocephalus spinescens	1.18	0.84	1.00	1.51	1.13
Felicia fascicularis	0.74	0.55	0.42	0.61	0.58
Fingerhuthia africana	0.93	0.48	0.41	0.30	0.53
Helichrysum lucilioides	0.68	0.43	0.45	0.42	0.49
Hermannia desertorum	0.75	0.44	0.37	0.38	0.48
Nenax microphylla	0.94	0.52	0.66	0.64	0.69
Pentzia spinescens	0.88	0.59	0.87	1.31	0.91
Rosenia humilis	0.81	1.28	1.70	2.72	1.63
Salsola rabieana	1.21	1.08	0.99	1.61	1.22
Stipagrostis obtusa	0.33	0.23	0.28	0.20	0.26
Mean	0.88	0.68	0.76	1.00	0.83

TABLE 7 Percentage Ca of the studied species

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	1.00	1.90	1.14	1.10	0.95	1.22
Eriocephalus spinescens	0.63	0.83	0.53	0.57	0.51	0.61
Pentzia spinescens	0.73	1.14	0.51	0.54	0.45	0.67
Rosenia humilis	0.70	0.87	0.69	0.60	0.59	0.69
Salsola tuberculata	2.80	2.45	2.45	3.10	3.00	2.76
Zygophyllum microphyllum	4.55	3.45	1.70	2.45	2.00	2.83
Fingerhuthia africana		0.36	0.74	0.30	0.27	0.42
Stipagrostis obtusa	0.43	0.29	0.30	0.28	0.23	0.31
Mean	1.55	1.41	1.01	1.12	1.00	1.19

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	0.69	0.84	0.62	0.54	0.67
Felicia fascicularis	0.75	0.66	0.75	0.81	0.74
Galenia secunda	0.54	1.01	0.83	0.47	0.71
Nenax microphylla	0.93	0.96	0.98	0.76	0.91
Osteospermum microphyllum	0.52	0.61	0.51	0.53	0.54
Pentzia spinescens	0.24	0.56	0.69	0.54	0.51
Pteronia staehelinoides	0.72	0.69	0.75	1.00	0.79
Salsola rabieana	1.08	1.08	1.30	1.29	1.19
Walafrida geniculata	0.58	0.43	0.52	0.39	0.48
Mean	0.67	0.76	0.77	0.70	0.73

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	1.44	1.31	1.25	1.25	1.31
Eriocephalus spinescens	0.60	0.56	0.45	0.51	0.53
Felicia fascicularis	0.83	0.74	0.66	0.73	0.74
Fingerhuthia africana	0.34	0.33	0.28	0.35	0.33
Helichrysum lucilioides	0.71	0.47	0.56	0.66	0.60
Hermannia desertorum	1.22	0.79	0.89	0.77	0.92
Nenax microphylla	0.55	0.70	0.61	0.65	0.63
Pentzia spinescens	0.94	0.52	0.48	0.53	0.62
Rosenia humilis	0.96	0.67	0.67	0.74	0.76
Salsola rabieana	0.86	0.85	0.62	1.11	0.86
Stipagrostis obtusa	0.29	0.23	0.22	0.21	0.24
Mean	0.79	0.65	0.61	0.68	0.68

TABLE 8 Percentage Mg of the studied species

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.57	1.00	0.54	0.61	0.48	0.64
Eriocephalus spinescens	0.18	0.20	0.15	0.15	0.13	0.16
Pentzia spinescens	0.22	0.26	0.12	0.15	0.15	0.18
Rosenia humilis	0.21	0.27	0.15	0.15	0.15	0.19
Salsola tuberculata	0.64	0.62	0.55	0.65	0.62	0.62
Zygophyllum microphyllum	0.31	0.30	0.22	0.31	0.15	0.26
Fingerhuthia africana		0.05	0.09	0.04	0.07	0.06
Stipagrostis obtusa	0.09	0.02	0.04	0.04	0.05	0.05
Mean	0.32	0.34	0.23	0.26	0.23	0.27

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	0.19	0.18	0.18	0.11	0.17
Felicia fascicularis	0.18	0.16	0.23	0.18	0.19
Galenia secunda	0.18	0.30	0.38	0.15	0.25
Nenax microphylla	0.19	0.22	0.25	0.18	0.21
Osteospermum microphyllum	0.16	0.18	0.15	0.19	0.17
Pentzia spinescens	0.17	0.16	0.19	0.13	0.16
Pteronia staehelinoides	0.20	0.20	0.19	0.27	0.22
Salsola rabieana	0.32	0.36	0.38	0.41	0.37
Walafrida geniculata	0.18	0.14	0.18	0.13	0.16
Mean	0.20	0.21	0.24	0.19	0.21

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.83	0.85	0.79	0.74	0.80
Eriocephalus spinescens	0.14	0.15	0.11	0.15	0.14
Felicia fascicularis	0.17	0.22	0.19	0.20	0.20
Fingerhuthia africana	0.08	0.07	0.05	0.04	0.06
Helichrysum lucilioides	0.19	0.15	0.19	0.19	0.18
Hermannia desertorum	0.29	0.19	0.22	0.17	0.22
Nenax microphylla	0.14	0.18	0.17	0.20	0.17
Pentzia spinescens	0.20	0.15	0.14	0.15	0.16
Rosenia humilis	0.19	0.17	0.14	0.19	0.17
Salsola rabieana	0.32	0.35	0.31	0.47	0.36
Stipagrostis obtusa	0.08	0.06	0.05	0.05	0.06
Mean	0.24	0.23	0.21	0.23	0.23

TABLE 9 Percentage Na of the studied species

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.70	1.10	0.65	0.50	0.40	0.67
Eriocephalus spinescens	0.39	0.51	0.25	0.37	0.22	0.35
Pentzia spinescens	0.31	0.44	0.25	0.27	0.22	0.30
Rosenia humilis	0.80	0.12	0.09	0.03	0.06	0.22
Salsola tuberculata	0.11	0.80	0.95	0.70	0.40	0.59
Zygophyllum microphyllum	0.70	0.60	0.40	0.55	0.31	0.51
Fingerhuthia africana		0.06	0.04	0.03	0.02	0.04
Stipagrostis obtusa	0.04	0.02	0.03	0.02	0.02	0.03
Mean	0.44	0.46	0.33	0.31	0.21	0.34

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	0.42	0.35	0.32	0.27	0.34
Felicia fascicularis	0.14	0.19	0.20	0.20	0.18
Galenia secunda	0.39	2.50	1.20	0.42	1.13
Nenax microphylla	0.15	0.75	0.19	0.15	0.31
Osteospermum microphyllum	0.18	0.22	0.12	0.26	0.20
Pentzia spinescens	0.23	0.28	0.19	0.17	0.22
Pteronia staehelinoides	0.29	0.25	0.23	0.49	0.32
Salsola rabieana	0.29	0.39	0.31	0.46	0.36
Walafrida geniculata	0.05	0.07	0.04	0.04	0.05
Mean	0.24	0.56	0.31	0.27	0.34

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	1.00	1.19	0.82	0.85	0.96
Eriocephalus spinescens	0.27	0.23	0.19	0.30	0.25
Felicia fascicularis	0.34	0.24	0.19	0.29	0.27
Fingerhuthia africana	0.04	0.02	0.02	0.04	0.03
Helichrysum lucilioides	0.45	0.21	0.37	0.20	0.31
Hermannia desertorum	0.27	0.09	0.16	0.12	0.16
Nenax microphylla	0.27	0.19	0.14	0.18	0.20
Pentzia spinescens	0.23	0.23	0.23	0.27	0.24
Rosenia humilis	0.03	0.08	0.04	0.03	0.04
Salsola rabieana	0.93	0.84	0.47	1.02	0.82
Stipagrostis obtusa	0.04	0.03	0.03	0.06	0.04
Mean	0.35	0.30	0.24	0.31	0.30

TABLE 10Percentage P of the studied species

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.13	0.10	0.06	0.09	0.06	0.09
Eriocephalus spinescens	0.16	0.16	0.13	0.14	0.10	0.14
Pentzia spinescens	0.23	0.29	0.10	0.13	0.11	0.17
Rosenia humilis	0.23	0.19	0.15	0.14	0.13	0.17
Salsola tuberculata	0.16	0.13	0.12	0.09	0.05	0.11
Zygophyllum microphyllum	0.22	0.12	0.10	0.11	0.06	0.12
Fingerhuthia africana		0.16	0.08	0.09	0.10	0.11
Stipagrostis obtusa	0.11	0.09	0.07	0.08	0.05	0.08
Mean	0.18	0.16	0.10	0.11	0.08	0.12

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	0.17	0.12	0.12	0.12	0.13
Felicia fascicularis	0.08	0.09	0.10	0.10	0.09
Galenia secunda	0.07	0.08	0.11	0.05	0.08
Nenax microphylla	0.08	0.06	0.07	0.04	0.06
Osteospermum microphyllum	0.07	0.08	0.08	0.06	0.07
Pentzia spinescens	0.13	0.10	0.13	0.09	0.11
Pteronia staehelinoides	0.10	0.07	0.07	0.10	0.09
Salsola rabieana	0.10	0.07	0.09	0.11	0.09
Walafrida geniculata	0.14	0.09	0.12	0.10	0.11
Mean	0.10	0.08	0.10	0.09	0.09

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.12	0.09	0.07	0.10	0.10
Eriocephalus spinescens	0.11	0.10	0.15	0.11	0.12
Felicia fascicularis	0.10	0.04	0.15	0.08	0.09
Fingerhuthia africana	0.12	0.12	0.15	0.10	0.12
Helichrysum lucilioides	0.12	0.07	0.05	0.09	0.08
Hermannia desertorum	0.12	0.10	0.07	0.07	0.09
Nenax microphylla	0.15	0.05	0.06	0.05	0.08
Pentzia spinescens	0.08	0.10	0.18	0.22	0.14
Rosenia humilis	0.20	0.15	0.12	0.13	0.15
Salsola rabieana	0.15	0.09	0.07	0.16	0.12
Stipagrostis obtusa	0.09	0.05	0.11	0.07	0.08
Mean	0.12	0.09	0.11	0.11	0.11

TABLE 11The K/Ca+Mg ratio of the studied species

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.69	0.43	0.70	0.83	0.95	0.72
Eriocephalus spinescens	1.42	1.46	1.47	2.19	1.58	1.62
Pentzia spinescens	1.03	0.94	2.02	1.29	1.37	1.33
Rosenia humilis	0.99	1.58	1.92	2.40	2.05	1.79
Salsola tuberculata	0.49	0.27	0.41	0.37	0.31	0.37
Zygophyllum microphyllum	0.17	0.23	0.48	0.34	0.32	0.31
Fingerhuthia africana		1.34	0.43	1.12	2.09	1.25
Stipagrostis obtusa	0.79	0.81	1.09	0.94	0.82	0.89
Mean	0.80	0.88	1.06	1.19	1.19	1.03

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	0.83	0.57	0.88	0.89	0.79
Felicia fascicularis	1.00	0.45	0.66	0.64	0.69
Galenia secunda	0.58	0.35	0.69	0.85	0.62
Nenax microphylla	0.46	0.27	0.48	0.61	0.45
Osteospermum microphyllum	1.47	0.34	0.41	0.67	0.72
Pentzia spinescens	1.32	0.67	0.86	1.03	0.97
Pteronia staehelinoides	1.00	0.90	0.90	0.92	0.93
Salsola rabieana	0.70	0.55	0.52	0.72	0.62
Walafrida geniculata	1.42	1.30	1.27	1.37	1.34
Mean	0.98	0.60	0.74	0.86	0.79

1992/93

	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	0.52	0.50	0.59	0.63	0.56
Eriocephalus spinescens	1.59	1.18	1.79	2.29	1.71
Felicia fascicularis	0.74	0.57	0.49	0.66	0.62
Fingerhuthia africana	2.21	1.20	1.24	0.77	1.36
Helichrysum lucilioides	0.76	0.69	0.60	0.49	0.64
Hermannia desertorum	0.50	0.45	0.33	0.40	0.42
Nenax microphylla	1.36	0.59	0.85	0.75	0.89
Pentzia spinescens	0.77	0.88	1.40	1.93	1.25
Rosenia humilis	0.70	1.52	2.10	2.92	1.81
Salsola rabieana	1.03	0.90	1.06	1.02	1.00
Stipagrostis obtusa	0.89	0.79	1.04	0.77	0.87
Mean	1.01	0.84	1.04	1.15	1.01

TABLE 12The Ca/P ratio of the studied species

1990/91

Species	Jan	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	7.69	19.00	19.00	12.22	15.83	14.75
Eriocephalus spinescens	3.94	5.19	4.08	4.07	5.10	4.47
Pentzia spinescens	3.17	3.93	5.10	4.15	4.09	4.09
Rosenia humilis	3.04	4.58	4.60	4.29	4.54	4.21
Salsola tuberculata	17.50	18.85	20.42	34.44	60.00	30.24
Zygophyllum microphyllum	20.68	28.75	17.00	22.27	33.33	24.41
Fingerhuthia africana		2.25	9.25	3.33	2.70	4.38
Stipagrostis obtusa	3.91	3.22	4.29	3.50	4.60	3.90
Mean	8.56	10.72	10.47	11.04	16.27	11.31

* missing data

1991/92

Species	Apr	Jul	Oct	Feb	Mean
Eriocephalus ericoides	4.06	7.00	5.17	4.50	5.18
Felicia fascicularis	9.38	7.33	7.50	8.10	8.08
Galenia secunda	7.71	12.63	7.55	9.40	9.32
Nenax microphylla	11.63	16.00	14.00	19.00	15.16
Osteospermum microphyllum	7.43	7.63	6.38	8.83	7.57
Pentzia spinescens	1.85	5.60	5.31	6.00	4.69
Pteronia staehelinoides	7.20	9.86	10.71	10.00	9.44
Salsola rabieana	10.80	15.43	14.44	11.73	13.10
Walafrida geniculata	4.14	4.78	4.33	3.90	4.29
Mean	7.13	9.58	8.38	9.05	8.54

1992/93

Species	Apr	Jul	Oct	Jan	Mean
Eberlanzia ferox	12.00	14.56	17.86	12.50	14.23
Eriocephalus spinescens	5.45	5.60	3.00	4.64	4.67
Felicia fascicularis	8.30	18.50	4.40	9.12	10.08
Fingerhuthia africana	2.83	2.75	1.87	3.50	2.74
Helichrysum lucilioides	5.92	6.71	11.20	7.33	7.79
Hermannia desertorum	10.17	7.90	12.71	11.00	10.45
Nenax microphylla	3.67	14.00	10.17	13.00	10.21
Pentzia spinescens	11.75	5.20	2.67	2.41	5.51
Rosenia humilis	4.80	4.47	5.58	5.69	5.14
Salsola rabieana	5.73	9.44	8.86	6.94	7.74
Stipagrostis obtusa	3.22	4.60	2.00	3.00	3.21
Mean	6.71	8.52	7.30	7.19	7.43

Table 13 Percentage ether extract and ash of the studied species, adapted from Botha, Becker & van der Merwe (1990), Botha, Erasmus & Theron (1990), Botha & Nash (1990), Botha, van Staden & Blom (1990) and Louw, Steenkamp & Steenkamp (1968a)

Ether extract	Apr/May	Jul/Aug	Oct/Nov	Jan/Feb	Mean
Fingerhuthia africana	1.44	2.02	1.39	2.11	1.74
Stipagrostis obtusa	1.63	2.01	0.56	1.47	1.42
Eberlanzia ferox	2.27	3.03	2.93	3.23	2.87
Eriocephalus ericoides	2.64	2.15	2.56	1.98	2.33
Eriocephalus spinescens	2.31	2.20	1.55	2.03	2.02
Felicia fascicularis	1.80	4.66	1.67	4.32	3.11
Galenia secunda	1.42	1.62	1.53	1.52	1.52
Helichrysum lucilioides	1.72	1.66	1.75	1.73	1.72
Hermannia desertorum	1.79	1.69	1.65	2.01	1.78
Nenax microphylla	3.09	2.96	3.12	2.24	2.85
Pentzia spinescens	2.86	2.65	2.35	2.63	2.62
Pteronia staehelinoides		43.00		38.70	40.85
Rosenia humilis	2.36	2.33	1.80	1.98	2.12
Salsola rabieana	1.16	1.36	1.14	1.30	1.24
Salsola tuberculata	1.43	1.70	1.34	1.48	1.49
Walafrida geniculata	1.59	1.48	1.48	1.77	1.58
Zygophyllum microphyllum	2.08	2.61	1.96	2.26	2.23
mean	1.97	4.65	1.80	4.28	3.18

Ash	Apr/May	Jul/Aug	Oct/Nov	Jan/Feb	Mean
Fingerhuthia africana	9.22	10.13	8.49	7.13	8.74
Stipagrostis obtusa	24.86	11.78	9.05	0.00	11.42
Eberlanzia ferox	7.00	7.50	7.19	7.62	7.33
Eriocephalus ericoides	6.28	6.30	6.78	4.39	5.94
Eriocephalus spinescens	8.20	7.78	6.27	4.07	6.58
Felicia fascicularis	8.16	6.02	9.35	8.17	7.92
Galenia secunda	6.53	8.04	7.87	4.28	6.68
Helichrysum lucilioides	6.30	4.00	4.72	5.06	5.02
Hermannia desertorum	6.61	7.27	6.12	6.21	6.55
Nenax microphylla	13.48	6.83	7.54	6.19	8.51
Pentzia spinescens	8.43	6.38	8.18	5.57	7.14
Pteronia staehelinoides		7.70		7.60	7.65
Rosenia humilis	7.89	6.87	6.47	5.97	6.80
Salsola rabieana	8.68	11.42	10.49	10.20	10.20
Salsola tuberculata	13.03	16.55	17.31	18.47	16.34
Walafrida geniculata	5.61	6.16	4.86	5.02	5.41
Zygophyllum microphyllum	9.62	9.36	9.14	9.17	9.32
mean	9.37	8.24	8.11	6.77	8.09

TABLE 14Rooikop, soft camps in the watercourses, quadrat survey, Oct. 1991. The grazing capacity differs by a half a ha per LSU.

Species	Hits	Mean	Sp value	Sp weight	Sp value	Sp weight
Anacampseros sp	1	0.11	1.1	0.12	1	0.11
Aptosimum spinescens	1	0.11	3	0.33	1	0.11
Aristida congesta	14	1.56	1.43	2.22	1	1.56
Crassula sp	0	0.00	1.1	0.00	1	0.00
Cynodon incompletus	7	0.78	5.24	4.08	4	3.11
Delosperma multiflora	10	1.11	6.19	6.88	7	7.78
Delosperma tuberosa	4	0.44	6.19	2.75	7	3.11
Drosanthemum lique	9	1.00	6.19	6.19	7	7.00
Eberlanzia ferox	124	13.78	1.9	26.18	1	13.78
Enneapogon desvauxii	139	15.44	1.43	22.09	1	15.44
Eriocephalus spinescens	2	0.22	4.76	1.06	4	0.89
Hermannia spinosa	0	0.00	4.5	0.00	4	0.00
Liliaceae sp	41	4.56	1	4.56	1	4.56
Lycium sp	26	2.89	2.86	8.26	1	2.89
Pentzia incana	30	3.33	5.71	19.03	4	13.33
Pentzia spinescens	108	12.00	5	60.00	4	48.00
Protasparagus suaveolens	13	1.44	1.9	2.74	1	1.44
Pteronia sordida	0	0.00	4.76	0.00	4	0.00
Rosenia humilis	111	12.33	1.9	23.43	1	12.33
Salsola rabieana	28	3.11	7.62	23.71	7	21.78
Salsola tuberculata	7	0.78	7.62	5.93	7	5.44
Senecio radicans	1	0.11	4.5	0.50	7	0.78
Thesium hystrix	5	0.56	1.43	0.79	1	0.56
Trichodiadema pomeridianum	2	0.22	7.14	1.59	7	1.56
Walafrida geniculata	65	7.22	7.62	55.03	7	50.56
Zygophyllum incrustatum	8	0.89	2.38	2.12	4	3.56
Zygophyllum microphyllum	18	2.00	4.76	9.52	4	8.00
Total				289.11		227.67
Grazing capacity ha/LSU				2.25		2.86

TABLE 15Rooikop, hard camps, quadrat surveys, Oct. 1991. The grazing capacity differs by a quarter of a ha per LSU.

Species	Hits	Mean	sp value	sp weight	sp value	sp weight
Aristida congesta	7	0.47	1.43	0.67	1	0.47
Aristida diffusa	97	6.47	5.24	33.89	7	45.27
Blepharis capensis	2	0.13	0.95	0.13	1	0.13
Bulbinella sp	1	0.07	1	0.07	1	0.07
Chrysocom ciliata	4	0.27	1.43	0.38	1	0.27
Crassula sp1	1	0.07	1.1	0.07	1	0.07
Crassula sp2	1	0.07	1.1	0.07	1	0.07
Delosperma multiflora	2	0.13	6.19	0.83	7	0.93
Drosanthemum lique	1	0.07	6.19	0.41	7	0.47
Eberlanzia ferox	210	14.00	1.9	26.60	1	14.00
Enneapogon desvauxii	53	3.53	1.43	5.05	1	3.53
Eriocephalus ericoides	53	3.53	5.24	18.51	4	14.13
Eriocephalus punctulatus	1	0.07	5.24	0.35	4	0.27
Eriocephalus spinescens	75	5.00	4.76	23.80	4	20.00
Euphorbia sp1	1	0.07	2	0.13	1	0.07
Euphorbia sp2	1	0.07	2	0.13	1	0.07
Felicia fascicularis	39	2.60	6.19	16.09	7	18.20
Galenia secunda	19	1.27	3.5	4.43	4	5.07
Huernia sp	1	0.07	3.5	0.23	7	0.47
Helichrysum lucilioides	4	0.27	3.81	1.02	4	1.07
Helichrysum sp	1	0.07	3	0.20	4	0.27
Hermannia desertorum	8	0.53	5.5	2.93	7	3.73
Kedrostis africana	1	0.07	4	0.27	7	0.47
Liliaceae sp1	6	0.40	1	0.40	1	0.40
Liliaceae sp2	1	0.07	1	0.07	1	0.07
Limeum aethiopicum	3	0.20	8.1	1.62	7	1.40
Lycium sp	9	0.60	2.86	1.72	1	0.60
Nenax microphylla	15	1.00	7.62	7.62	7	7.00
Oropetium capense	449	29.93	1.43	42.80	1	29.93
Osteospermum armatum	9	0.60	6.5	3.90	4	2.40
Osteospermum spinescens	3	0.20	6.5	1.30	4	0.80
Pentzia incana	1	0.07	5.71	0.38	4	0.27
Pentzia spinescens	25	1.67	5	8.33	4	6.67
Protasparagus suaveolens	3	0.20	1.9	0.38	1	0.20
Pteronia staehelinoides	34	2.27	4.76	10.79	4	9.07
Rhigozum obovatum	12	0.80	4.76	3.81	7	5.60
Ruschia grisea	15	1.00	6.19	6.19	7	7.00
Sarcocaulon patersonii	32	2.13	2	4.27	1	2.13
Selago triquetra	2	0.13	7.5	1.00	7	0.93
Senecio radicans	11	0.73	4.5	3.30	7	5.13
Senecio sp1	3	0.20	1.5	0.30	1	0.20
Tragus koelerioides	61	4.07	3.33	13.54	4	16.27
Trichodiadema pomeridianum	5	0.33	7.14	2.38	7	2.33
Tribulus terrestris	3	0.20	0.95	0.19	1	0.20
Urginea anomala	4	0.27	1	0.27	1	0.27
Zygophyllum microphyllum	4	0.27	4.76	1.27	4	1.07
Total				252.10		229.00
Grazing capacity ha/LSU				2.58		2.84

Beaufort-West, 1990 to 1993, canopy spread cover : mass regressions
Karoo bushes
(x=area cm^2)(y=mass kg)

569.5	77.26	Regression Output:		
700.5	53.54	Constant		3.721431
669	53.22	Std Err of Y Est		16.92521
970.5	131.78	R Squared		0.625898
294.5	23.86	No. of Observations		102
914	87.78	Degrees of Freedom		100
406.5	44.98			
914.5	61.26	X Coefficient(s)	0.082103	
614.5	59.94	Std Err of Coef.	0.006347	
1019.5	112.84			
224	27.76	50	7.826581	
790.5	85.14	100	11.93173	
416	46	150	16.03688	
629	63	200	20.14203	
612	60.28	250	24.24718	
702.5	104.32	300	28.35233	
186	26.16	350	32.45748	
619	86.1	400	36.56263	
305	44.82	450	40.66778	
787	64.16	500	44.77293	
416	41.12	550	48.87808	
929	115.18	600	52.98323	
259	37.02	650	57.08838	
609.5	74.16	700	61.19353	
302	32.72	750	65.29868	
653	52.92	800	69.40383	
445	46.5	850	73.50898	
757	90.38	900	77.61413	
260	32.88	950	81.71928	
742.5	84.68	1000	85.82443	
105.125	19.82	1050	89.92958	
63.375	4.76			
299	18.72			
210.5	25.3			
85.125	21.58			
595.5	42.06			
628.5	37.96			
285.5	11.18			
578	30.56			
114.75	21.66			
50.875	4.02			
906.5	16.58			
96.125	8.72			
107.125	23.72			
449.5	33.46			
651.5	46.54			
327	16.6			
549.5	36.04			
88.75	15.92			
44	2.8			
881.5	14.36			
102.625	6.96			
99	21.82			
380.5	25.96			
753.5	50.38			
330	14.22			
506	30.86			
76.125	15.2			
52.75	4.8			
709.5	10.08			
126	11.24			
93.25	25.52			
474	34.62			
476	30.16			
335	17.4			
374	18.36			

328.5	43.8
638	49.7
53.75	3.64
157.375	13.78
149.125	9.42
168.125	18
360	25.62
741	87.78
389.5	14.26
282	31.64
689	44.2
69	8.06
229	19.46
169.125	13.76
119.5	11.78
324	21.88
595	56.68
359.5	26.66
303	37.88
654	43.2
53.375	4.84
119.375	8.72
139.5	9.82
125.625	12.02
345.5	27
649.5	75.66
320	23.6
253	37.74
530.5	47.86
51.375	4.44
99.125	10.2
135.5	36
77.75	9.12
265	29.04
375	49.48
427	43.76

Grasses -

(x=area cm^2)(y=mass kg)

110.625	13.68	Regression Output:		
242	55.76	Constant		-3.71984
132.125	12.42	Std Err of Y Est		7.968949
104.125	14.28	R Squared		0.536108
114.125	11.82	No. of Observations		17
118.25	21.5	Degrees of Freedom		15
73.875	9.84			
132.875	32.9	X Coefficient(s)	0.208743	
103.875	19.46	Std Err of Coef.	0.050135	
101.5	21.46			
88.25	18.84	50	6.71731	
182	21.66	100	17.15446	
139.25	19.86	150	27.59161	
108	25.68	200	38.02876	
142	20	250	48.46591	
135.5	38.76	300	58.90306	
85.5	20.1			

Karoo bushes	Apr		Jul		Oct		Jan	
	area	mass	area	mass	area	mass	area	mass
Eberlanzia ferox 90							569.5	77.26
Eriocephalus spinescens 90							700.5	53.54
Pentzia spinescens 90							669	53.22
Rosenia humilis 90							970.5	131.78
Salsola tuberculata 90							294.5	23.86
Zygophyllum microphyllum 90							914	87.78
Eberlanzia ferox 90	406.5	44.98	416	46	305	44.82	302	32.72
Eriocephalus spinescens 90	914.5	61.26	629	63	787	64.16	653	52.92
Pentzia spinescens 90	614.5	59.94	612	60.28	416	41.12	445	46.5
Rosenia humilis 90	1019.5	112.84	702.5	104.32	929	115.18	757	90.38
Salsola tuberculata 90	224	27.76	186	26.16	259	37.02	260	32.88
Zygophyllum microphyllum 90	790.5	85.14	619	86.1	609.5	74.16	742.5	84.68
Eriocephalus ericoides 91	105.125	19.82	114.75	21.66	88.75	15.92	76.125	15.2
Felicia fascicularis 91	63.375	4.76	50.875	4.02	44	2.8	52.75	4.8
Galenia secunda 91	299	18.72	906.5	16.58	881.5	14.36	709.5	10.08
Nenax microphylla 91	210.5	25.3	96.125	8.72	102.625	6.96	126	11.24
Osteospermum microphyllum 91	85.125	21.58	107.125	23.72	99	21.82	93.25	25.52
Pentzia spinescens 91	595.5	42.06	449.5	33.46	380.5	25.96	474	34.62
Pteronia staehelinoides 91	628.5	37.96	651.5	46.54	753.5	50.38	476	30.16
Salsola rabieana 91	285.5	11.18	327	16.6	330	14.22	335	17.4
Walafrida geniculata 91	578	30.56	549.5	36.04	506	30.86	374	18.36
Eberlanzia ferox 92	328.5	43.8	282	31.64	303	37.88	253	37.74
Eriocephalus spinescens 92	638	49.7	689	44.2	654	43.2	530.5	47.86
Felicia fascicularis 92	53.75	3.64	69	8.06	53.375	4.84	51.375	4.44
Helichrysum lucilioides 92	157.375	13.78	229	19.46	119.375	8.72	99.125	10.2
Hermannia desertorum 92	149.125	9.42	169.125	13.76	139.5	9.82	135.5	36
Nenax microphylla 92	168.125	18	119.5	11.78	125.625	12.02	77.75	9.12
Pentzia spinescens 92	360	25.62	324	21.88	345.5	27	265	29.04
Rosenia humilis 92	741	87.78	595	56.68	649.5	75.66	375	49.48
Salsola rabieana 92	389.5	14.26	359.5	26.66	320	23.6	427	43.76

Apr Regression Output:		
Constant		0.135705
Std Err of Y Est		13.47157
R Squared		0.781868
No. of Observations		24
Degrees of Freedom		22
X Coefficient(s)	0.088379	
Std Err of Coef.	0.009952	

Jul Regression Output:		
Constant		7.826352
Std Err of Y Est		18.79536
R Squared		0.466486
No. of Observations		24
Degrees of Freedom		22
X Coefficient(s)	0.069107	
Std Err of Coef.	0.015756	

Oct Regression Output:		
Constant		4.992256
Std Err of Y Est		18.39633
R Squared		0.565390
No. of Observations		24
Degrees of Freedom		22
X Coefficient(s)	0.074192	
Std Err of Coef.	0.013868	

Jan Regression Output:		
Constant		2.862282
Std Err of Y Est		17.37275
R Squared		0.673269
No. of Observations		30
Degrees of Freedom		28
X Coefficient(s)	0.091467	
Std Err of Coef.	0.012041	

Grasses	Apr		Jul		Oct		Jan	
	area	mass	area	mass	area	mass	area	mass
Stipagrostis obtusa 90							110.625	13.68
Fingerhuthia africana 90	242	55.76	104.125	14.28	118.25	21.5	132.875	32.9
Stipagrostis obtusa 90	132.125	12.42	114.125	11.82	73.875	9.84	103.875	19.46
Fingerhuthia africana 92	101.5	21.46	182	21.66	108	25.68	135.5	38.76
Stipagrostis obtusa 92	88.25	18.84	139.25	19.86	142	20	85.5	20.1

Apr Regression Output:		
Constant		-8.39018
Std Err of Y Est		10.22424
R Squared		0.816110
No. of Observations		4
Degrees of Freedom		2
X Coefficient(s)	0.251901	
Std Err of Coef.	0.084551	

Jul Regression Output:		
Constant		1.118495
Std Err of Y Est		2.697367
R Squared		0.772950
No. of Observations		4
Degrees of Freedom		2
X Coefficient(s)	0.117045	
Std Err of Coef.	0.044856	

Oct Regression Output:		
Constant		2.231532
Std Err of Y Est		6.268557
R Squared		0.420079
No. of Observations		4
Degrees of Freedom		2
X Coefficient(s)	0.154014	
Std Err of Coef.	0.127957	

Jan Regression Output:		
Constant		-19.2653
Std Err of Y Est		7.535608
R Squared		0.608006
No. of Observations		5
Degrees of Freedom		3
X Coefficient(s)	0.389226	
Std Err of Coef.	0.180437	

Appendix 7 Statgraphics (Statistical Graphics Corporation 1991) printouts for parameter selection of parameters to include in the equations by which the objective grazing index value is to be estimated.

Selection: Forward	Maximum steps: 500	F-to-enter: 2.00
Control: Manual	Step: 5	F-to-remove: 2.00

R-squared: 0.65319	Adjusted: 0.62222	MSE: 1.90657	d.f.: 56

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Enter
2. GSTAT.PROD	-0.01569	3.3809	1. GSTAT.BED	0.0746	0.3074
3. GSTAT.N	-1.79676	12.9548	4. GSTAT.SUURV	0.1443	1.1697
5. GSTAT.TVV	0.11515	5.7535	6. GSTAT.K	0.0101	0.0056
10. GSTAT.ETER	-0.61420	31.3077	7. GSTAT.CA	0.1213	0.8208
11. GSTAT.AS	0.24400	6.0407	8. GSTAT.MG	0.0690	0.2631
			9. GSTAT.VERH1	0.1503	1.2711
			12. GSTAT.NA	0.1467	1.2101
			13. GSTAT.P	0.0739	0.3021

Model fitting results for: GSTAT.SUBJW

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	1.206094	2.047997	0.5889	0.5583
GSTAT.PROD	-0.015689	0.008532	-1.8387	0.0713
GSTAT.N	-1.796759	0.4992	-3.5993	0.0007
GSTAT.TVV	0.115153	0.048008	2.3986	0.0198
GSTAT.ETER	-0.614202	0.109771	-5.5953	0.0000
GSTAT.AS	0.244	0.099277	2.4578	0.0171

R-SQ. (ADJ.) = 0.6222 SE= 1.380786 MAE= 1.110191 DurbWat= 1.063
Previously: 0.0000 0.000000 0.000000 0.000
62 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

Analysis of Variance for the Full Regression

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	201.086	5	40.2173	21.0940	0.0000
Error	106.768	56	1.90657		
Total (Corr.)	307.854	61			

R-squared = 0.653187 Stnd. error of est. = 1.38079
R-squared (Adj. for d.f.) = 0.622221 Durbin-Watson statistic = 1.06297

Further ANOVA for Variables in the Order Fitted

Source	Sum of Squares	DF	Mean Sq.	F-Ratio	P-value
GSTAT.PROD	19.2581772	1	19.258177	10.10	0.0024
GSTAT.N	4.3604499	1	4.360450	2.29	0.1361
GSTAT.TVV	69.5916748	1	69.591675	36.50	0.0000
GSTAT.ETER	96.3589897	1	96.358990	50.54	0.0000
GSTAT.AS	11.5169681	1	11.516968	6.04	0.0171
Model	201.086260	5			

vall	sp	yrssn	cover	prod	N	ADF	TDN	K	Ca	Mg	Rat1	Ether	Ash	Na	P	Rat2
1	ccil1	1	1013	61.74	1.17	40.85	55.52	0.89	0.4	0.15	1.62	9.24	8.72	0.04	0.2	2
1	ccil1	2	223	9.26	0.59	40.52	54.1	1	0.28	0.1	2.63	9.25	4.61	0.04	0.15	1.87
1	ccil1	3	878	51.02	0.81	44.37	52.34	0.04	0.36	0.11	0.09	7.6	6.07	0.02	0.13	2.77
1	ccil1	4	348.5	11.76	0.95	42.82	53.73	0.59	0.38	0.1	0.43	8.19	9.88	0.05	0.13	2.92
2	eeri1	1	1064.5	73.34	0.92	50.02	48.95	1.9	0.48	0.25	2.6	4.87	6.79	0.03	0.18	2.67
2	eeri1	2	740	49.54	0.68	51.04	47.56	2.7	0.38	0.19	4.74	5.03	5.4	0.03	0.1	3.8
2	eeri1	3	878	51.02	0.72	47.72	49.87	1.48	0.44	0.19	2.35	2.85	5.64	0.07	0.11	4
2	eeri1	4	914	41.94	******	******	******	******	******	******	******	2.3	5.78	******	******	******
2	eeri3	1	647.5	34.16	0.75	61.11	41.21	1.75	0.47	0.27	2.36	4.87	6.79	0.02	0.15	3.13
2	eeri3	2	815.5	34.24	******	******	******	******	******	******	******	5.03	5.4	******	******	******
2	eeri3	3	734.5	34.18	******	******	******	******	******	******	******	2.85	5.64	******	******	******
2	eeri3	4	531	28.6	******	******	******	******	******	******	******	2.3	5.78	******	******	******
2.5	espi2	1	619.5	41.2	0.85	46.72	50.92	1.58	0.69	0.28	1.63	1.75	10.23	0.03	0.17	4.06
2.5	espi2	2	525	30.28	0.96	50.82	48.53	1.33	0.55	0.2	1.77	2.31	6.51	0.01	0.13	1.23
2.5	espi2	3	******	******	0.76	59.58	42.24	1.6	0.58	0.23	1.98	1.82	5.64	0.02	0.15	3.87
2.5	espi2	4	482	26.66	0.75	57.09	43.84	1.24	0.55	0.19	1.68	1.86	5.4	0.02	0.16	3.74
3	hluc3	1	292.5	16.56	1.46	44.78	53.48	0.87	0.91	0.29	0.73	******	******	0.06	0.11	8.27
3	hluc3	2	208	13.7	******	******	******	******	******	******	******	******	******	******	******	******
3	hluc3	3	193	10.38	******	******	******	******	******	******	******	******	******	******	******	******
3	hluc3	4	213.5	11.12	******	******	******	******	******	******	******	******	******	******	******	******
2	pinc1	1	447.5	17.72	0.91	50.32	48.73	1.17	0.68	0.28	1.22	3.15	8.96	0.1	0.2	3.4
2	pinc1	2	446.5	16.7	0.9	49.22	49.42	1.33	0.54	0.26	1.66	3.88	7.8	0.11	0.13	4.15
2	pinc1	3	496.5	13.82	1.01	42.65	53.99	0.88	0.47	0.3	0.85	2.82	8.9	0.07	0.14	3.36
2	pinc1	4	375.5	13.42	0.69	46.8	50.37	1.41	0.26	0.56	1.72	2.29	7.27	0.4	0.08	3.25
2	pinc2	1	453	18.04	1.03	44.39	52.9	0.91	0.66	0.34	0.91	3.15	8.96	0.27	0.17	3.88
2	pinc2	2	391	13.78	1.01	50.54	48.83	0.94	0.62	0.3	1.02	3.88	7.8	0.22	0.15	4.13
2	pinc2	3	335.5	16.18	0.88	53.92	46.29	1.4	0.56	0.27	1.69	2.82	8.9	0.14	0.18	3.11
2	pinc2	4	379.5	10.7	0.97	50.5	48.76	1.09	0.64	0.3	1.16	2.29	7.27	0.27	0.22	2.91
2	pinc3	1	320	13.92	0.83	56.64	44.38	0.95	0.46	0.22	1.4	3.15	8.96	0.13	0.19	2.42
2	pinc3	2	316.5	13.6	******	******	******	******	******	******	******	3.88	7.8	******	******	******
2	pinc3	3	267	11.28	******	******	******	******	******	******	******	2.82	8.9	******	******	******
2	pinc3	4	303.5	11.58	******	******	******	******	******	******	******	2.29	7.27	******	******	******
4.5	ppar2	1	235.5	21.8	1.04	40.43	55.51	1.78	0.81	0.25	1.68	******	******	0.47	0.15	5.4
4.5	ppar2	2	355	19.28	1.02	37.89	57.12	1.18	0.5	0.17	1.76	******	******	0.09	0.14	3.57
4.5	ppar2	3	335	17.64	0.89	51.32	48.02	1.72	0.52	0.18	2.46	******	******	0.03	0.2	2.6
4.5	ppar2	4	253	13.44	0.79	53.72	46.17	1.69	0.57	0.2	2.19	******	******	0.02	0.19	3
4.5	ppar3	1	296.5	22.18	0.66	57.48	43.17	1.48	0.49	0.21	2.11	******	******	0.07	0.14	3.5
4.5	ppar3	2	358.5	19.38	******	******	******	******	******	******	******	******	******	******	******	******
4.5	ppar3	3	362.5	26.26	******	******	******	******	******	******	******	******	******	******	******	******
4.5	ppar3	4	228	13.74	******	******	******	******	******	******	******	******	******	******	******	******
6	pkar3	1	276.5	18.92	0.93	48.32	50.09	1.33	0.92	0.37	1.03	******	13.34	0.02	0.22	4.18
6	pkar3	2	447	28.36	******	******	******	******	******	******	******	******	12.47	******	******	******
6	pkar3	3	290	18.94	******	******	******	******	******	******	******	******	11.6	******	******	******
6	pkar3	4	346	21.38	******	******	******	******	******	******	******	******	9.87	******	******	******
2	pgla2	1	792	56.5	1.03	51.6	48.19	1.3	0.52	0.21	1.78	3.47	9.88	0.03	0.16	3.25
2	pgla2	2	573.5	33.96	1.02	52.47	47.59	1.18	0.48	0.19	1.76	2.74	6.86	0.06	0.16	3
2	pgla2	3	822	55.92	1.27	55.06	46.43	1.49	0.49	0.24	2.04	2.43	7.38	0.01	0.23	2.13
2	pgla2	4	597.5	37.28	0.88	54.09	46.18	1.52	0.55	0.23	1.95	3.28	6.65	0.01	0.2	2.75
1.5	pspi2	1	791	68.24	0.88	44.41	52.51	1.56	0.35	0.38	2.14	5.16	7.74	0.05	0.07	5
1.5	pspi2	2	713.5	93.18	1.05	49.43	49.78	0.21	0.23	0.39	0.34	4.79	9.26	0.05	0.07	3.29
1.5	pspi2	3	******	******	0.68	50.16	48.14	0.46	0.41	0.26	0.69	4.33	11.65	0.02	0.11	3.73
1.5	pspi2	4	596.5	61.6	0.85	51.48	47.81	0.5	0.31	0.35	0.76	4.82	5.53	0.01	0.09	3.44
2.5	rhum2	1	664	46.54	1.01	39.29	60.76	1.78	0.67	0.3	1.84	4.15	12.48	0.03	0.18	3.72
2.5	rhum2	2	581.5	37.06	1.11	41.6	54.9	1.73	0.78	0.21	1.75	3.3	8.85	0.02	0.12	6.5
2.5	rhum2	3	636	28.1	1.09	48.14	50.58	1.69	0.76	0.25	1.67	3.35	9.1	0.02	0.18	4.2
2.5	rhum2	4	522	24.86	1.03	48.09	50.48	1.71	0.63	0.26	1.92	3.23	11.45	0.01	0.19	3.32
2.5	rhum3	1	649	52.78	0.77	53.75	46.09	1.43	0.68	0.29	1.47	4.15	12.48	0.01	0.12	5.67
2.5	rhum3	2	934.5	74.34	******	******	******	******	******	******	******	3.3	8.85	******	******	******
2.5	rhum3	3	721.5	58.16	******	******	******	******	******	******	******	3.35	9.1	******	******	******
2.5	rhum3	4	626	43.48	******	******	******	******	******	******	******	3.23	11.45	******	******	******
5.5	scal1	1	761	69.62	1.78	36.63	59.28	1.65	0.94	0.48	1.16	1.57	16.64	0.03	0.13	7.23
5.5	scal1	2	484	18.32	0.91	30.72	61.54	2.5	1.29	0.59	1.33	1.34	11.99	0.07	0.26	4.96
5.5	scal1	3	682.5	31.8	2.39	21.98	69.56	2.95	1.34	0.89	1.32	1.38	11.4	0.07	0.14	9357
5.5	scal1	4	636.5	32.4	2.88	21.26	70.47	2.9	1.5	0.84	1.24	1.55	14.93	0.09	0.17	8.82
4.5	wgen2	1	420.5	18.26	1.23	37.37	57.91	1.94	0.49	0.33	2	******	******	0.04	0.18	2.72
4.5	wgen2	2	425	12.24	1.04	54.09	46.58	1.19	0.36	0.24	1.98	******	******	0.02	0.13	2.77
4.5	wgen2	3	465.5	14.76	1.5	50.58	47.13	1.59	0.41	0.31	2.21	******	******	0.02	0.24	2.71
4.5	wgen2	4	296	10.98	0.84	52.52	47.1	1.26	0.33	0.25	2.17	******	******	0.01	0.15	2.2

2.5	acon1	1	124.5	19.22	0.58	41.29	53.55	0.2	0.12	0.06	1.11	******	******	0.03	0.09	1.33
2.5	acon1	2	64.4	4.56	0.4	43.2	51.42	0.23	0.08	0.06	1.64	******	******	0.01	0.07	1.14
2.5	acon1	3	54	2.54	0.51	39.02	54.73	0.14	0.16	0.09	0.56	******	******	0.01	0.14	1.14
2.5	acon1	4	47.3	2.3	0.67	40.88	54.17	0.22	0.19	0.07	0.85	******	******	0.01	0.06	3.17
2.5	acon3	1	56	1.92	1.08	43.57	53.55	0.32	0.15	0.13	1.14	******	******	0.01	0.14	1.07
2.5	acon3	2	46.9	3.18	******	******	******	******	******	******	******	******	******	******	******	******
2.5	acon3	3	39.1	5.5	******	******	******	******	******	******	******	******	******	******	******	******
2.5	acon3	4	30.9	4.42	******	******	******	******	******	******	******	******	******	******	******	******
5	adif1	1	645	70.48	0.58	41.96	53.12	0.29	0.15	0.06	1.38	1.43	11.7	0.02	0.08	1.88
5	adif1	2	385	63.26	0.45	40.11	53.72	0.28	0.08	0.07	1.87	1.35	9.53	0.01	0.04	2
5	adif1	3	331.5	55.28	0.43	38.11	54.92	0.18	0.15	0.05	0.8	1.61	9.74	0.01	0.04	3.75
5	adif1	4	638	35.86	******	******	******	******	******	******	******	1.29	9.85	******	******	******
8	deri1	1	652	54.54	0.71	40.98	54.78	0.5	0.33	0.18	0.98	2.57	11.35	0.02	0.12	2.75
8	deri1	2	317.5	22.6	0.69	43.17	54.92	0.41	0.29	0.16	0.91	1.95	9.93	0.03	0.07	4.14
8	deri1	3	388.5	32.4	0.65	41.28	57.33	0.37	0.39	0.17	0.66	2.82	10.04	0.01	0.09	4.33
8	deri1	4	214	14.56	0.95	43.56	60.15	0.45	0.33	0.16	0.92	2.23	10.45	0.07	0.14	2.36
4.5	eleh1	1	135.6	7.26	0.71	40.16	54.24	0.26	0.28	0.18	0.57	1.89	8.66	0.03	0.1	2.8
4.5	eleh1	2	79.9	6.68	0.7	39.84	52.77	0.42	0.21	0.07	1.5	1.55	6.95	0.03	0.08	2.63
4.5	eleh1	3	69.6	5.92	0.82	36.78	53.83	0.35	0.27	0.1	0.95	1.56	7.66	0.01	0.11	2.45
4.5	eleh1	4	88.4	3.24	1.45	34.54	53.25	0.52	0.37	0.17	0.96	1.59	8.52	0.05	0.13	2.85
4.5	eleh3	1	84.6	10.86	0.72	44.57	51.93	0.44	0.27	0.1	1.19	1.89	8.66	0.01	0.15	1.8
4.5	eleh3	2	70.1	8.74	******	******	******	******	******	******	******	1.55	6.95	******	******	******
4.5	eleh3	3	73.1	7.45	******	******	******	******	******	******	******	1.56	7.66	******	******	******
4.5	eleh3	4	55.9	7.96	******	******	******	******	******	******	******	1.59	8.52	******	******	******
4.5	hcon2	1	207.5	4	0.44	40.54	53.38	0.45	0.25	0.13	1.18	2.06	11.99	0.09	0.07	3.57
4.5	hcon2	2	196.5	12.1	0.48	44.67	50.89	0.4	0.25	0.1	1.14	2.24	10.36	0.03	0.06	4.17
4.5	hcon2	3	181	5.32	0.84	40.07	55.24	0.46	0.34	0.17	0.9	2	11.34	0.02	0.13	2.62
4.5	hcon2	4	172.5	10.9	0.58	40.49	54.08	0.61	0.44	0.11	1.1	1.76	10.88	0.01	0.16	2.75
4.5	hcon3	1	173	15.94	0.61	38.7	55.37	0.49	0.29	0.14	1.14	2.06	11.99	0.02	0.14	2.07
4.5	hcon3	2	182.5	11.54	******	******	******	******	******	******	******	2.24	10.36	******	******	******
4.5	hcon3	3	164.5	14.36	******	******	******	******	******	******	******	2	11.34	******	******	******
4.5	hcon3	4	188.5	12.76	******	******	******	******	******	******	******	1.76	10.88	******	******	******
6.5	sfim2	1	381	37.58	0.61	40.96	53.89	0.81	0.33	0.19	1.56	******	******	0.12	0.12	2.75
6.5	sfim2	2	320	27.88	0.57	41.86	53.14	0.31	0.29	0.09	0.82	******	******	0.02	0.09	3.22
6.5	sfim2	3	356.5	26.7	0.79	45.29	51.68	0.63	0.19	0.1	2.17	******	******	0.01	0.17	1.12
6.5	sfim2	4	219.5	23.3	0.86	38.99	56	1.47	0.3	0.15	3.27	******	******	0.01	0.24	1.25
3.5	scil2	1	231.1	23.98	0.35	46.9	48.68	0.24	0.47	0.35	0.29	1.63	9.02	0.03	0.01	47
3.5	scil2	2	188	36.28	0.51	45.85	50.27	0.15	0.12	0.3	0.36	1.98	6.46	0.01	0.03	4
3.5	scil2	3	175.3	22.98	0.65	48.3	49.24	0.26	0.22	0.43	0.4	1.53	7.83	0.01	0.09	2.44
3.5	scil2	4	177.4	13.28	0.5	49.73	47.68	0.33	0.36	0.25	0.54	1.72	9.24	0.01	0.12	3
3.5	sobt2	1	155.6	6.96	0.47	44.59	50.89	0.2	0.23	0.34	0.35	******	******	0.05	0.03	7.67
3.5	sobt2	2	135	27.68	0.35	32.09	58.36	0.1	0.14	0.7	0.12	******	******	0.01	0.03	4.67
3.5	sobt2	3	113.3	10.58	0.58	38.66	55.27	0.25	0.17	0.58	0.33	******	******	0.01	0.07	2.43
3.5	sobt2	4	93.8	14.08	0.41	44.03	50.76	0.16	0.18	0.47	0.25	******	******	0.02	0.06	3
10	ttri1	1	702	78.82	0.51	40.26	53.92	0.42	0.16	0.07	1.83	1.8	13.26	0.03	0.1	1.6
10	ttri1	2	365.5	31.18	0.55	38.08	55.52	0.47	0.12	0.04	2.94	2.25	10.5	0.06	0.09	1.33
10	ttri1	3	286.5	42.54	0.52	35.62	57	0.34	0.19	0.09	1.21	2.15	11.53	0.02	0.09	2.11
10	ttri1	4	275.5	34.22	0.77	39.64	55.31	0.42	0.2	0.09	1.45	1.83	12.6	0.02	0.11	1.72
10	ttri3	1	279.5	40.18	0.57	40.88	53.78	0.44	0.17	0.09	1.69	1.8	13.26	0.03	0.11	1.55
10	ttri3	2	184.5	46.18	******	******	******	******	******	******	******	2.25	10.5	******	******	******
10	ttri3	3	181	31.9	******	******	******	******	******	******	******	2.15	11.53	******	******	******
10	ttri3	4	179	28.18	******	******	******	******	******	******	******	1.83	12.6	******	******	******

Stepwise Selection for GSTAT2.WRD2

Selection: Forward	Maximum steps: 500		F-to-enter: 2.00
Control: Manual	Step: 8		F-to-remove: 2.00
R-squared: 0.81234	Adjusted: 0.78401	MSE: 1.5394	d.f.: 53

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Enter
2. GSTAT2.PROD	-0.02191	6.9805	1. GSTAT2.BED	0.0655	0.2238
4. GSTAT2.SUURV	0.15118	4.4197	3. GSTAT2.N	0.1638	1.4340
5. GSTAT2.TVV	0.40408	13.7231	7. GSTAT2.CA	0.0837	0.3665
6. GSTAT2.K	-2.45465	60.4975	8. GSTAT2.MG	0.1367	0.9907
9. GSTAT2.VERH1	1.32432	20.8342	13. GSTAT2.P	0.1373	0.9996
10. GSTAT2.ETER	-0.71075	49.5001			
11. GSTAT2.AS	0.21472	5.6464			
12. GSTAT2.NA	-6.26360	6.6912			

Model fitting results for: GSTAT2.WRD2

Independent variable	coefficient	std. error	t-value	sig.level
CONSTANT	-21.562679	8.494945	-2.5383	0.0141
GSTAT2.PROD	-0.021908	0.008292	-2.6421	0.0108
GSTAT2.SUURV	0.151178	0.07191	2.1023	0.0403
GSTAT2.TVV	0.404084	0.10908	3.7045	0.0005
GSTAT2.K	-2.454653	0.315589	-7.7780	0.0000
GSTAT2.VERH1	1.324318	0.290138	4.5644	0.0000
GSTAT2.ETER	-0.710749	0.101021	-7.0356	0.0000
GSTAT2.AS	0.214722	0.090363	2.3762	0.0211
GSTAT2.NA	-6.263597	2.421428	-2.5867	0.0125

R-SQ. (ADJ.) = 0.7840	SE= 1.240726	MAE= 0.826956	DurbWat= 1.454
Previously: 0.7885	1.227696	0.786927	1.549

62 observations fitted, forecast(s) computed for 0 missing val. of dep. var.

Further ANOVA for Variables in the Order Fitted

Source	Sum of Squares	DF	Mean Sq.	F-Ratio	P-value
GSTAT2.PROD	13.240703	1	13.24070	8.60	0.0050
GSTAT2.SUURV	95.948483	1	95.94848	62.33	0.0000
GSTAT2.TVV	0.251094	1	0.25109	0.16	0.6922
GSTAT2.K	87.699288	1	87.69929	56.97	0.0000
GSTAT2.VERH1	19.785032	1	19.78503	12.85	0.0007
GSTAT2.ETER	116.195597	1	116.19560	75.48	0.0000
GSTAT2.AS	9.753248	1	9.75325	6.34	0.0149
GSTAT2.NA	10.300445	1	10.30045	6.69	0.0125
Model	353.173892	8			

Correlation matrix for coefficient estimates

	CONSTANT	GSTAT2.PROD	GSTAT2.SUURV	GSTAT2.TVV
CONSTANT	1.0000	0.1250	-0.9748	-0.9779
GSTAT2.PROD	0.1250	1.0000	-0.1540	-0.0978
GSTAT2.SUURV	-0.9748	-0.1540	1.0000	0.9299
GSTAT2.TVV	-0.9779	-0.0978	0.9299	1.0000
GSTAT2.K	0.4097	0.0235	-0.3533	-0.4226
GSTAT2.VERH1	-0.2799	-0.1835	0.2034	0.2630
GSTAT2.ETER	0.1716	-0.2103	-0.2131	-0.2331
GSTAT2.AS	0.1218	-0.2294	-0.0948	-0.2932
GSTAT2.NA	0.0539	0.3001	-0.0991	-0.0659

	GSTAT2.K	GSTAT2.VERH1	GSTAT2.ETER	GSTAT2.AS
CONSTANT	0.4097	-0.2799	0.1716	0.1218
GSTAT2.PROD	0.0235	-0.1835	-0.2103	-0.2294
GSTAT2.SUURV	-0.3533	0.2034	-0.2131	-0.0948
GSTAT2.TVV	-0.4226	0.2630	-0.2331	-0.2932
GSTAT2.K	1.0000	-0.6271	0.0470	0.0146
GSTAT2.VERH1	-0.6271	1.0000	-0.0776	0.0887
GSTAT2.ETER	0.0470	-0.0776	1.0000	0.3883
GSTAT2.AS	0.0146	0.0887	0.3883	1.0000
GSTAT2.NA	-0.1883	0.0864	0.0036	0.0531

	GSTAT2.NA
CONSTANT	0.0539
GSTAT2.PROD	0.3001
GSTAT2.SUURV	-0.0991
GSTAT2.TVV	-0.0659
GSTAT2.K	-0.1883
GSTAT2.VERH1	0.0864
GSTAT2.ETER	0.0036
GSTAT2.AS	0.0531
GSTAT2.NA	1.0000

val2	sp	yrssn	cover	prod	N	ADF	TDN	K	Ca	Mg	Rat1	Ether	Ash	Na	P	Rat2
1	ccil1	1	1013.0	61.74	1.17	40.85	55.52	0.89	0.40	0.15	1.62	9.24	8.72	0.04	0.20	2.00
1	ccil1	2	223.0	9.26	0.59	40.52	54.10	1.00	0.28	0.10	2.63	9.25	4.61	0.04	0.15	1.87
1	ccil1	3	878.0	51.02	0.81	44.37	52.34	0.04	0.36	0.11	0.09	7.60	6.07	0.02	0.13	2.77
1	ccil1	4	348.5	11.76	0.95	42.82	53.73	0.59	0.38	0.10	0.43	8.19	9.88	0.05	0.13	2.92
2.5	eeri1	1	1064.5	73.34	0.92	50.02	48.95	1.90	0.48	0.25	2.60	4.87	6.79	0.03	0.18	2.67
2.5	eeri1	2	740.0	49.54	0.68	51.04	47.56	2.70	0.38	0.19	4.74	5.03	5.40	0.03	0.10	3.80
2.5	eeri1	3	878.0	51.02	0.72	47.72	49.87	1.48	0.44	0.19	2.35	2.85	5.64	0.07	0.11	4.00
2.5	eeri1	4	914.0	41.94	*****	*****	*****	*****	*****	*****	*****	2.30	5.78	*****	*****	*****
2.5	eeri3	1	647.5	34.16	0.75	61.11	41.21	1.75	0.47	0.27	2.36	4.87	6.79	0.02	0.15	3.13
2.5	eeri3	2	815.5	34.24	*****	*****	*****	*****	*****	*****	*****	5.03	5.40	*****	*****	*****
2.5	eeri3	3	734.5	34.18	*****	*****	*****	*****	*****	*****	*****	2.85	5.64	*****	*****	*****
2.5	eeri3	4	531.0	28.60	*****	*****	*****	*****	*****	*****	*****	2.30	5.78	*****	*****	*****
3.5	espi2	1	619.5	41.20	0.85	46.72	50.92	1.58	0.69	0.28	1.63	1.75	10.23	0.03	0.17	4.06
3.5	espi2	2	525.0	30.28	0.96	50.82	48.53	1.33	0.55	0.20	1.77	2.31	6.51	0.01	0.13	1.23
3.5	espi2	3	*****	*****	0.76	59.58	42.24	1.60	0.58	0.23	1.98	1.82	5.64	0.02	0.15	3.87
3.5	espi2	4	482.0	26.66	0.75	57.09	43.84	1.24	0.55	0.19	1.68	1.86	5.40	0.02	0.16	3.74
3	hluc3	1	292.5	16.56	1.46	44.78	53.48	0.87	0.91	0.29	0.73	*****	*****	0.06	0.11	8.27
3	hluc3	2	208.0	13.70	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
3	hluc3	3	193.0	10.38	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
3	hluc3	4	213.5	11.12	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
2.5	pinc1	1	447.5	17.72	0.91	50.32	48.73	1.17	0.68	0.28	1.22	3.15	8.96	0.10	0.20	3.40
2.5	pinc1	2	446.5	16.70	0.90	49.22	49.42	1.33	0.54	0.26	1.66	3.88	7.80	0.11	0.13	4.15
2.5	pinc1	3	496.5	13.82	1.01	42.65	53.99	0.88	0.47	0.30	0.85	2.82	8.90	0.07	0.14	3.36
2.5	pinc1	4	375.5	13.42	0.69	46.80	50.37	1.41	0.26	0.56	1.72	2.29	7.27	0.40	0.08	3.25
2.5	pinc2	1	453.0	18.04	1.03	44.39	52.90	0.91	0.66	0.34	0.91	3.15	8.96	0.27	0.17	3.88
2.5	pinc2	2	391.0	13.78	1.01	50.54	48.83	0.94	0.62	0.30	1.02	3.88	7.80	0.22	0.15	4.13
2.5	pinc2	3	335.5	16.18	0.88	53.92	46.29	1.40	0.56	0.27	1.69	2.82	8.90	0.14	0.18	3.11
2.5	pinc2	4	379.5	10.70	0.97	50.50	48.76	1.09	0.64	0.30	1.16	2.29	7.27	0.27	0.22	2.91
2.5	pinc3	1	320.0	13.92	0.83	56.64	44.38	0.95	0.46	0.22	1.40	3.15	8.96	0.13	0.19	2.42
2.5	pinc3	2	316.5	13.60	*****	*****	*****	*****	*****	*****	*****	3.88	7.80	*****	*****	*****
2.5	pinc3	3	267.0	11.28	*****	*****	*****	*****	*****	*****	*****	2.82	8.90	*****	*****	*****
2.5	pinc3	4	303.5	11.58	*****	*****	*****	*****	*****	*****	*****	2.29	7.27	*****	*****	*****
5	ppar2	1	235.5	21.80	1.04	40.43	55.51	1.78	0.81	0.25	1.68	*****	*****	0.47	0.15	5.40
5	ppar2	2	355.0	19.28	1.02	37.89	57.12	1.18	0.50	0.17	1.76	*****	*****	0.09	0.14	3.57
5	ppar2	3	335.0	17.64	0.89	51.32	48.02	1.72	0.52	0.18	2.46	*****	*****	0.03	0.20	2.60
5	ppar2	4	253.0	13.44	0.79	53.72	46.17	1.69	0.57	0.20	2.19	*****	*****	0.02	0.19	3.00
5	ppar3	1	296.5	22.18	0.66	57.48	43.17	1.48	0.49	0.21	2.11	*****	*****	0.07	0.14	3.50
5	ppar3	2	358.5	19.38	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
5	ppar3	3	362.5	26.26	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
5	ppar3	4	228.0	13.74	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
6.5	pkar3	1	276.5	18.92	0.93	48.32	50.09	1.33	0.92	0.37	1.03	*****	13.34	0.02	0.22	4.18
6.5	pkar3	2	447.0	28.36	*****	*****	*****	*****	*****	*****	*****	*****	12.47	*****	*****	*****
6.5	pkar3	3	290.0	18.94	*****	*****	*****	*****	*****	*****	*****	*****	11.60	*****	*****	*****
6.5	pkar3	4	346.0	21.38	*****	*****	*****	*****	*****	*****	*****	*****	9.87	*****	*****	*****
2.5	pgla2	1	792.0	56.50	1.03	51.60	48.19	1.30	0.52	0.21	1.78	3.47	9.88	0.03	0.16	3.25
2.5	pgla2	2	573.5	33.96	1.02	52.47	47.59	1.18	0.48	0.19	1.76	2.74	6.86	0.06	0.16	3.00
2.5	pgla2	3	822.0	55.92	1.27	55.06	46.43	1.49	0.49	0.24	2.04	2.43	7.38	0.01	0.23	2.13
2.5	pgla2	4	597.5	37.28	0.88	54.09	46.18	1.52	0.55	0.23	1.95	3.28	6.65	0.01	0.20	2.75
1.5	pspi2	1	791.0	68.24	0.88	44.41	52.51	1.56	0.35	0.38	2.14	5.16	7.74	0.05	0.07	5.00
1.5	pspi2	2	713.5	93.18	1.05	49.43	49.78	0.21	0.23	0.39	0.34	4.79	9.26	0.05	0.07	3.29
1.5	pspi2	3	*****	*****	0.68	50.16	48.14	0.46	0.41	0.26	0.69	4.33	11.65	0.02	0.11	3.73
1.5	pspi2	4	596.5	61.60	0.85	51.48	47.81	0.50	0.31	0.35	0.76	4.82	5.53	0.01	0.09	3.44
2.5	rhum2	1	664.0	46.54	1.01	39.29	60.76	1.78	0.67	0.30	1.84	4.15	12.48	0.03	0.18	3.72
2.5	rhum2	2	581.5	37.06	1.11	41.60	54.90	1.73	0.78	0.21	1.75	3.30	8.85	0.02	0.12	6.50
2.5	rhum2	3	636.0	28.10	1.09	48.14	50.58	1.69	0.76	0.25	1.67	3.35	9.10	0.02	0.18	4.20
2.5	rhum2	4	522.0	24.86	1.03	48.09	50.48	1.71	0.63	0.26	1.92	3.23	11.45	0.01	0.19	3.32
2.5	rhum3	1	649.0	52.78	0.77	53.75	46.09	1.43	0.68	0.29	1.47	4.15	12.48	0.01	0.12	5.67
2.5	rhum3	2	934.5	74.34	*****	*****	*****	*****	*****	*****	*****	3.30	8.85	*****	*****	*****
2.5	rhum3	3	721.5	58.16	*****	*****	*****	*****	*****	*****	*****	3.35	9.10	*****	*****	*****
2.5	rhum3	4	626.0	43.48	*****	*****	*****	*****	*****	*****	*****	3.23	11.45	*****	*****	*****
5.5	scal1	1	761.0	69.62	1.78	36.63	59.28	1.65	0.94	0.48	1.16	1.57	16.64	0.03	0.13	7.23
5.5	scal1	2	484.0	18.32	0.91	30.72	61.54	2.50	1.29	0.59	1.33	1.34	11.99	0.07	0.26	4.96
5.5	scal1	3	682.5	31.80	2.39	21.98	69.56	2.95	1.34	0.89	1.32	1.38	11.40	0.07	0.14	*****
5.5	scal1	4	636.5	32.40	2.88	21.26	70.47	2.90	1.50	0.84	1.24	1.55	14.93	0.09	0.17	8.82
6	wgen2	1	420.5	18.26	1.23	37.37	57.91	1.94	0.49	0.33	2.00	*****	*****	0.04	0.18	2.72
6	wgen2	2	425.0	12.24	1.04	54.09	46.58	1.19	0.36	0.24	1.98	*****	*****	0.02	0.13	2.77
6	wgen2	3	465.5	14.76	1.50	50.58	47.13	1.59	0.41	0.31	2.21	*****	*****	0.02	0.24	2.71
6	wgen2	4	296.0	10.98	0.84	52.52	47.10	1.26	0.33	0.25	2.17	*****	*****	0.01	0.15	2.20

2.5	acon1	1	124.5	19.22	0.58	41.29	53.55	0.20	0.12	0.06	1.11	*****	*****	0.03	0.09	1.33
2.5	acon1	2	64.4	4.56	0.40	43.20	51.42	0.23	0.08	0.06	1.64	*****	*****	0.01	0.07	1.14
2.5	acon1	3	54.0	2.54	0.51	39.02	54.73	0.14	0.16	0.09	0.56	*****	*****	0.01	0.14	1.14
2.5	acon1	4	47.3	2.30	0.67	40.88	54.17	0.22	0.19	0.07	0.85	*****	*****	0.01	0.06	3.17
2.5	acon3	1	56.0	1.92	1.08	43.57	53.55	0.32	0.15	0.13	1.14	*****	*****	0.01	0.14	1.07
2.5	acon3	2	46.9	3.18	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
2.5	acon3	3	39.1	5.50	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
2.5	acon3	4	30.9	4.42	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
5.5	adif1	1	645.0	70.48	0.58	41.96	53.12	0.29	0.15	0.06	1.38	1.43	11.70	0.02	0.08	1.88
5.5	adif1	2	385.0	63.26	0.45	40.11	53.72	0.28	0.08	0.07	1.87	1.35	9.53	0.01	0.04	2.00
5.5	adif1	3	331.5	55.28	0.43	38.11	54.92	0.18	0.15	0.05	0.80	1.61	9.74	0.01	0.04	3.75
5.5	adif1	4	638.0	35.86	*****	*****	*****	*****	*****	*****	*****	1.29	9.85	*****	*****	*****
10	deri1	1	652.0	54.54	0.71	40.98	54.78	0.50	0.33	0.18	0.98	2.57	11.35	0.02	0.12	2.75
10	deri1	2	317.5	22.60	0.69	43.17	54.92	0.41	0.29	0.16	0.91	1.95	9.93	0.03	0.07	4.14
10	deri1	3	388.5	32.40	0.65	41.28	57.33	0.37	0.39	0.17	0.66	2.82	10.04	0.01	0.09	4.33
10	deri1	4	214.0	14.56	0.95	43.56	60.15	0.45	0.33	0.16	0.92	2.23	10.45	0.07	0.14	2.36
6	eleh1	1	135.6	7.26	0.71	40.16	54.24	0.26	0.28	0.18	0.57	1.89	8.66	0.03	0.10	2.80
6	eleh1	2	79.9	6.68	0.70	39.84	52.77	0.42	0.21	0.07	1.50	1.55	6.95	0.03	0.08	2.63
6	eleh1	3	69.6	5.92	0.82	36.78	53.83	0.35	0.27	0.10	0.95	1.56	7.66	0.01	0.11	2.45
6	eleh1	4	88.4	3.24	1.45	34.54	53.25	0.52	0.37	0.17	0.96	1.59	8.52	0.05	0.13	2.85
6	eleh3	1	84.6	10.86	0.72	44.57	51.93	0.44	0.27	0.10	1.19	1.89	8.66	0.01	0.15	1.80
6	eleh3	2	70.1	8.74	*****	*****	*****	*****	*****	*****	*****	1.55	6.95	*****	*****	*****
6	eleh3	3	73.1	7.45	*****	*****	*****	*****	*****	*****	*****	1.56	7.66	*****	*****	*****
6	eleh3	4	55.9	7.96	*****	*****	*****	*****	*****	*****	*****	1.59	8.52	*****	*****	*****
7.5	hcon2	1	207.5	4.00	0.44	40.54	53.38	0.45	0.25	0.13	1.18	2.06	11.99	0.09	0.07	3.57
7.5	hcon2	2	196.5	12.10	0.48	44.67	50.89	0.40	0.25	0.10	1.14	2.24	10.36	0.03	0.06	4.17
7.5	hcon2	3	181.0	5.32	0.84	40.07	55.24	0.46	0.34	0.17	0.90	2.00	11.34	0.02	0.13	2.62
7.5	hcon2	4	172.5	10.90	0.58	40.49	54.08	0.61	0.44	0.11	1.10	1.76	10.88	0.01	0.16	2.75
7.5	hcon3	1	173.0	15.94	0.61	38.70	55.37	0.49	0.29	0.14	1.14	2.06	11.99	0.02	0.14	2.07
7.5	hcon3	2	182.5	11.54	*****	*****	*****	*****	*****	*****	*****	2.24	10.36	*****	*****	*****
7.5	hcon3	3	164.5	14.36	*****	*****	*****	*****	*****	*****	*****	2.00	11.34	*****	*****	*****
7.5	hcon3	4	188.5	12.76	*****	*****	*****	*****	*****	*****	*****	1.76	10.88	*****	*****	*****
9	sfim2	1	381.0	37.58	0.61	40.96	53.89	0.81	0.33	0.19	1.56	*****	*****	0.12	0.12	2.75
9	sfim2	2	320.0	27.88	0.57	41.86	53.14	0.31	0.29	0.09	0.82	*****	*****	0.02	0.09	3.22
9	sfim2	3	356.5	26.70	0.79	45.29	51.68	0.63	0.19	0.10	2.17	*****	*****	0.01	0.17	1.12
9	sfim2	4	219.5	23.30	0.86	38.99	56.00	1.47	0.30	0.15	3.27	*****	*****	0.01	0.24	1.25
5.5	scil2	1	231.1	23.98	0.35	46.90	48.68	0.24	0.47	0.35	0.29	1.63	9.02	0.03	0.01	47.00
5.5	scil2	2	188.0	36.28	0.51	45.85	50.27	0.15	0.12	0.30	0.36	1.98	6.46	0.01	0.03	4.00
5.5	scil2	3	175.3	22.98	0.65	48.30	49.24	0.26	0.22	0.43	0.40	1.53	7.83	0.01	0.09	2.44
5.5	scil2	4	177.4	13.28	0.50	49.73	47.68	0.33	0.36	0.25	0.54	1.72	9.24	0.01	0.12	3.00
3	sobt2	1	155.6	6.96	0.47	44.59	50.89	0.20	0.23	0.34	0.35	*****	*****	0.05	0.03	7.67
3	sobt2	2	135.0	27.68	0.35	32.09	58.36	0.10	0.14	0.70	0.12	*****	*****	0.01	0.03	4.67
3	sobt2	3	113.3	10.58	0.58	38.66	55.27	0.25	0.17	0.58	0.33	*****	*****	0.01	0.07	2.43
3	sobt2	4	93.8	14.08	0.41	44.03	50.76	0.16	0.18	0.47	0.25	*****	*****	0.02	0.06	3.00
8.5	ttri1	1	702.0	78.82	0.51	40.26	53.92	0.42	0.16	0.07	1.83	1.80	13.26	0.03	0.10	1.60
8.5	ttri1	2	365.5	31.18	0.55	38.08	55.52	0.47	0.12	0.04	2.94	2.25	10.50	0.06	0.09	1.33
8.5	ttri1	3	286.5	42.54	0.52	35.62	57.00	0.34	0.19	0.09	1.21	2.15	11.53	0.02	0.09	2.11
8.5	ttri1	4	275.5	34.22	0.77	39.64	55.31	0.42	0.20	0.09	1.45	1.83	12.60	0.02	0.11	1.72
8.5	ttri3	1	279.5	40.18	0.57	40.88	53.78	0.44	0.17	0.09	1.69	1.80	13.26	0.03	0.11	1.55
8.5	ttri3	2	184.5	46.18	*****	*****	*****	*****	*****	*****	*****	2.25	10.50	*****	*****	*****
8.5	ttri3	3	181.0	31.90	*****	*****	*****	*****	*****	*****	*****	2.15	11.53	*****	*****	*****
8.5	ttri3	4	179.0	28.18	*****	*****	*****	*****	*****	*****	*****	1.83	12.60	*****	*****	*****

Appendix 8 A plotplan of the Camp number 6 trial

Botanical surveys conducted in the Camp number 6 trial during 1991, recording primary canopy spread cover strikes, diameter of plants struck by the pin and the harvested mass of the plants under the pin (refer to Chapter 7, section 7.3.1 and Table 7.1, column 6).

Botanical surveys conducted in the Camp number 6 trial during 1991, with the veld condition scores calculated according to the original ecological index method of survey, the EIV's have, however, been replaced by the GIV's (refer to Chapter 7, Table 7.1, column 7).

The regression and d statistic results of the calculations of the grazing capacity employing the EIV, GIV and OIV on the Departmental Norm for the specific areas (refer to Table 2.2 in Chapter 2 and Table 7.2 in Chapter 7).

Site 1a

	total no. strikes	total mass	diameter/strike
Pentzia globosa	5	177	23 8 19 27 33
Phymaspermum parvifolium	7	469	13 38 22 22 25 18 30
Aristida congesta	31	17	1 1 2 3 6 5 3 4 3 4 3 3 4 4 3
	3	3	4 3 2 5 5 2 3 6 3 3 3 5 2
			6
Aristida diffusa	5	343	9 43 1 30 20
Enneapogon desvauxii	3	1	2 2 2
Osteospermum leptolobum	1	9	16
Tragus koelerioides	28	46	6 1 7 5 5 4 10 5 6 5 3 4 5 4 1
			3 1 2 1 4 7 2 5 5 2 16 3 3
Walafrida saxatilis	2	56	43 18
Helichrysum parviflorum	1	144	47
Tragus racemosus	4	5	5 6 3 5
Lotononis laxa	1	1	3
Eragrostis lehmanniana	8	9	10 13 6 3 6 3 4 2
Lycium sp	4	32	20 11 15 14
Aptosimum procumbens	2	9	8 5
Microchloa caffra	1	1	2
Geigeria ornativa	1	2	5
Indigofera alternans	7	8	4 4 4 10 10 6 11
Blepharis villosa	1	6	7
Rosenia humilis	1	40	20
Thesium hystrix	1	78	26
Lightfootia albens	1	675	66
Pentzia lanata	1	21	22
Hertia pallens	1	223	56
Pterothrix spinescens	3	384	40 6 50
Gazania krebsiana	1	1	1
	121	2757	

22.79 grammes/strike = 16.47 ha/LSU (refer to the calculations in Chapter 7, section 7.3.1).

Site 1a

Species	C	%C	GIV	Value
Aptosimum depressum	2.0	1.0	2.0	2.0
Aristida congesta	31.0	15.5	1.3	20.2
Aristida diffusa	5.0	2.5	5.1	12.7
Blepharis villosa	1.0	0.5	1.0	0.5
Enneapogon desvauxii	3.0	1.5	1.0	1.5
Eragrostis lehmanniana	8.0	4.0	5.4	21.6
Gazania krebsiana	1.0	0.5	1.6	0.8
Geigeria passerinoides	1.0	0.5	1.0	0.5
Helichrysum parviflorum	1.0	0.5	3.3	1.6
Hertia pallens	1.0	0.5	2.1	1.1
Indigofera alternans	7.0	3.5	1.9	6.6
Lightfootia albens	1.0	0.5	3.3	1.6
Lotononis laxa	1.0	0.5	3.3	1.6
Lycium sp.	4.0	2.0	3.0	6.0
Microchloa caffra	1.0	0.5	1.8	0.9
Osteospermum leptolobum	1.0	0.5	6.6	3.3
Pentzia globosa	5.0	2.5	4.8	12.0
Pentzia lanata	1.0	0.5	5.7	2.9
Phymaspermum parvifolium	7.0	3.5	6.2	21.7
Pterothrix spinescens	3.0	1.5	2.0	3.0
Rosenia humilis	1.0	0.5	3.5	1.7
Thesium hystrix	1.0	0.5	1.6	0.8
Tragus koelerioides	28.0	14.0	2.2	30.8
Tragus racemosus	4.0	2.0	1.3	2.6
Walafrida saxatilis	2.0	1.0	2.0	2.0
Total		60.5		160.2

29.0 ha/LSU

Site 1b

	total no. strikes	total mass	diameter/strike														
Helichrysum parviflorum	1	40	15														
Aristida congesta	27	15	3	7	1	2	1	1	1	1	1	1	2	1	4	1	1
			1	1	1	1	1	1	1	2	1	2	2	1			
Eragrostis lehmanniana	39	243	3	23	20	20	5	4	12	5	10	10	8	7	7	5	3
			2	2	5	6	5	7	9	10	4	6	6	3	5	5	6
			4	8	4	8	6	4	4	2	10						
Eragrostis obtusa	7	24	3	5	7	10	4	7	8								
Tragus koelerioides	14	44	7	5	6	5	5	2	5	5	3	5	4	5	3	2	
Aristida diffusa	24	1831	25	57	42	34	27	15	25	26	28	22	11	6	6	3	14
			23	8	25	32	18	6	1	2	10						
Eriocephalus spinescens	1	140	35														
Oxalis sp	1	1	1														
Enneapogon desvauxii	2	2	2	3													
Lycium sp	3	31	20	11	5												
Aptosimum procumbens	1	16	8														
Enneapogon scoparius	1	99	40														
Pterothrix spinescens	2	115	30	12													
Blepharis villosa	2	7	5	3													
Indigofera alternans	1	1	4														
	126	2609															

20.71 grammes/strike = 15.65 ha/LSU.

Site 1b

Species	C	%C	GIV	Value
Aptosimum depressum	1.0	0.5	2.0	1.0
Aristida congesta	27.0	13.5	1.3	17.6
Aristida diffusa	24.0	12.0	5.1	61.2
Blepharis villosa	2.0	1.0	1.0	1.0
Enneapogon desvauxii	2.0	1.0	1.0	1.0
Enneapogon scoparius	1.0	0.5	4.4	2.2
Eragrostis lehmanniana	39.0	19.5	5.4	105.3
Eragrostis obtusa	7.0	3.5	4.0	14.0
Eriocephalus spinescens	1.0	0.5	4.5	2.2
Helichrysum parviflorum	1.0	0.5	3.3	1.6
Indigofera alternans	1.0	0.5	1.9	0.9
Lycium sp	3.0	1.5	3.0	4.5
Oxalis depressa	1.0	0.5	0.8	0.4
Pterothrix spinescens	2.0	1.0	2.0	2.0
Tragus koelerioides	14.0	7.0	2.2	15.4
Total		63.0		230.4

20.1 ha/LSU

Site 2a

	total no. strikes	total mass	diameter/strike														
Eragrostis lehmanniana	18	21	3	3	3	2	1	2	2	2	2	3	6	4	4	5	2
			2	1	5												
Tragus koelerioides	25	52	2	3	3	6	2	2	5	2	2	3	12	3	2	1	3
			4	2	1	2	2	3	2	4	2	4					
Aristida congesta	40	29	3	10	3	2	1	3	5	1	1	1	1	4	2	1	2
			2	4	4	2	2	2	2	3	3	2	2	2	2	3	2
			2	2	1	9	2	5	7	1	1	1					
Blepharis villosa	5	12	9	10	4	4	10										
Lycium sp	12	161	1	15	4	2	23	22	14	1	17	17	17	4			
Stipagrostis obtusa	2	58	10	10													
Pterothrix spinescens	3	152	33	22	11												
Eragrostis obtusa	6	6	3	3	4	2	2	3									
Tragus racemosus	1	1	2														
Aptosimum procumbens	1	6	6														
Hertia pallens	2	32	20	1													
Rosenia humilis	1	40	31														
Nenax microphylla	1	32	15														
Salvia verbenaca	1	1	3														
Helichrysum dregeanum	2	2	4	4													
Indigofera alternans	7	3	5	2	4	2	1	3	2								
Phymaspermum parvifolium	3	80	19	13	3												
Enneapogon desvauxii	1	1	3														
	131	689															

5.26 grammes/strike = 44.41 ha/LSU.

Site 2a

Species	C	%C	GIV	Value
Aptosimum depressum	1.0	0.5	2.0	1.0
Aristida congesta	40.0	20.0	1.3	26.0
Blepharis villosa	5.0	2.5	1.0	2.5
Enneapogon desvauxii	1.0	0.5	1.0	0.5
Eragrostis lehmanniana	18.0	9.0	5.4	48.6
Eragrostis obtusa	6.0	3.0	4.0	12.0
Helichrysum dregeanum	1.0	0.5	6.3	3.1
Helichrysum parviflorum	1.0	0.5	3.3	1.6
Hertia pallens	2.0	1.0	2.1	2.1
Indigofera alternans	7.0	3.5	1.9	6.6
Lycium sp	12.0	6.0	3.0	18.0
Nenax microphylla	1.0	0.5	7.0	3.5
Phymaspermum parvifolium	3.0	1.5	6.2	9.3
Pterothrix spinescens	3.0	1.5	2.0	3.0
Rosenia humilis	1.0	0.5	3.5	1.7
Salvia clandestina	1.0	0.5	0.8	0.4
Stipagrostis obtusa	2.0	1.0	6.6	6.6
Tragus koelerioides	25.0	12.5	2.2	27.5
Tragus racemosus	1.0	0.5	1.3	0.7
Total		65.5		174.8

26.5 ha/LSU

Site 2b

	total no. strikes	total mass	diameter/strike														
Thesium hystrix	2	50	11	13													
Aristida congesta	23	15	1	1	1	1	1	2	1	1	1	1	2	1	1	7	1
			2	5	2	2	1	1	1	1							
Tragus koelerioides	24	28	2	2	2	2	2	6	2	2	2	2	5	3	1	4	4
			3	4	5	3	2	5	2	1	3						
Blepharis villosa	4	12	3	5	5	1											
Cynodon incompletus	1	1	1														
Walfrida saxatilis	8	78	11	22	12	7	4	5	18	4							
Indigofera alternans	6	1	5	1	7	3	1	1									
Phymaspermum parvifolium	15	750	23	29	27	32	6	3	2	22	26	22	38	25	36	1	4
Eragrostis lehmanniana	25	62	12	5	1	5	5	1	3	10	8	1	2	4	1	3	8
			7	2	1	8	1	1	1	3	5	5					
Rosenia humilis	2	392	45	25													
Chrysocoma ciliata	1	270	65														
Lycium sp	4	118	10	15	10	25											
Aptosimum procumbens	2	10	6	10													
Aristida diffusa	1	30	19														
	118	1817															

15.40 grammes/strike = 19.44 ha/LSU.

Site 2b

Species	C	%C	GIV	Value
Aptosimum depressum	2.0	1.0	2.0	2.0
Aristida congesta	23.0	11.5	1.3	15.0
Aristida diffusa	1.0	0.5	5.1	2.5
Blepharis villosa	4.0	2.0	1.0	2.0
Chrysocoma tenuifolia	1.0	0.5	1.5	0.8
Cynodon incompletus	1.0	0.5	4.1	2.0
Eragrostis lehmanniana	25.0	12.5	5.4	67.5
Indigofera alternans	6.0	3.0	1.9	5.7
Lycium sp	4.0	2.0	3.0	6.0
Phymaspermum parvifolium	15.0	7.5	6.2	46.5
Rosenia humilis	2.0	1.0	3.5	3.5
Thesium hystrix	2.0	1.0	1.6	1.6
Tragus koelerioides	24.0	12.0	2.2	26.4
Walafrida saxatilis	8.0	4.0	2.0	8.0
Total		59.0		189.5

24.5 ha/LSU

Site 3a

	total no. strikes	total mass	diameter/strike														
Eragrostis lehmanniana	40	117	3	4	3	10	1	5	3	5	2	5	2	2	2	2	5
			7	1	7	2	4	3	3	2	5	5	3	5	1	1	3
			2	3	4	3	3	2	3	3	10	3					
Aristida congesta	22	27	1	2	2	2	2	1	1	2	2	1	1	3	1	3	1
		1	1	1	1	3	2	1									
Phymaspermum parvifolium	8	362	21	37	29	23	3	27	22	20							
Lycium sp	3	17	15	5	3												
Aristida diffusa	3	512	14	70	28												
Pentzia lanata	1	3	6														
Lepidium divaricatum	1	1	1														
Geranium sp	1	1	2														
Pentzia globosa	1	15	11														
Walafrida saxatilis	4	180	11	31	24	29											
Pterothrix spinescens	4	386	24	13	42	39											
Indigofera alternans	27	19	5	4	4	4	8	2	7	1	5	3	3	7	3	1	3
			2	1	3	1	2	15	7	3	2	3	2	5			
Felicia muricata	1	2	3														
Aptosimum procumbens	1	9	5														
Blepharis villosa	2	2	3	3													
Tragus koelerioides	14	20	3	3	3	3	3	3	1	3	7	3	1	2	2	4	
Chrysocoma ciliata	2	57	22	4													
	135	1730															

12.81 grammes/strike = 20.24 ha/LSU.

Site 3a

Species	C	%C	GIV	Value
Aptosimum depressum	1.0	0.5	2.0	1.0
Aristida congesta	22.0	11.0	1.3	14.3
Aristida diffusa	3.0	1.5	5.1	7.6
Blepharis villosa	2.0	1.0	1.0	1.0
Chrysocoma tenuifolia	2.0	1.0	1.5	1.5
Eragrostis lehmanniana	40.0	20.0	5.4	108.0
Erodium moschatum	1.0	0.5	1.0	0.5
Felicia muricata	1.0	0.5	6.5	3.2
Indigofera alternans	27.0	13.5	1.9	25.6
Leyssera deverra	1.0	0.5	1.2	0.6
Lycium sp	3.0	1.5	3.0	4.5
Pentzia globosa	1.0	0.5	4.8	2.4
Pentzia lanata	1.0	0.5	5.7	2.9
Phymaspermum parvifolium	8.0	4.0	6.2	24.8
Pterothrix spinescens	4.0	2.0	2.0	4.0
Tragus koelerioides	14.0	7.0	2.2	15.4
Walafrida saxatilis	4.0	2.0	2.0	4.0
Total		67.5		221.4

21.0 ha/LSU

Site 3b

	total no. strikes	total mass	diameter/strike														
Eragrostis lehmanniana	36	82	1	1	2	2	5	3	2	2	1	1	1	3	3	3	4
			2	2	3	7	13	5	1	1	3	7	7	8	5	3	5
			6	3	3	2	2	2									
Aristida congesta	29	25	1	1	1	1	1	2	5	1	3	2	1	1	1	1	1
			5	1	3	2	1	2	1	6	6	1	1	8	1	1	
Hertia pallens	1	159	52														
Lycium sp	2	18	10	20													
Aristida diffusa	3	41	10	15	8												
Walafrida saxatilis	13	402	27	16	24	5	4	10	10	30	12	5	25	2	10		
Tragus racemosus	4	1	2	2	1	2											
Eriocephalus spinescens	4	2131	60	40	35	80											
Enneapogon desvauxii	1	1	1														
Tragus koelerioides	13	14	4	4	2	1	1	2	2	2	2	2	2	2	2		
Felicia muricata	1	1	2														
Eragrostis obtusa	4	6	2	5	2	3											
Pteronia glauca	1	318	45														
Melica decumbens	1	2	5														
Nenax microphylla	1	16	6														
Blepharis villosa	4	1	3	1	1	2											
Chrysocoma ciliata	1	4	26														
Indigofera alternans	2	1	3	1													
Osteospermum leptolobum	1	1	40														
Phymaspermum parvifolium	1	137	38														
Rosenia humilis	4	830	55	16	35	32											
	127	4191															

33.00 grammes/strike = 9.54 ha/LSU.

Site 3b

Species	C	%C	GIV	Value
Aristida congesta	29.0	14.5	1.3	18.9
Aristida diffusa	3.0	1.5	5.1	7.6
Blepharis villosa	4.0	2.0	1.0	2.0
Chrysocoma tenuifolia	1.0	0.5	1.5	0.8
Enneapogon desvauxii	1.0	0.5	1.0	0.5
Eragrostis lehmanniana	36.0	18.0	5.4	97.2
Eragrostis obtusa	4.0	2.0	4.0	8.0
Eriocephalus spinescens	4.0	2.0	4.5	9.0
Felicia muricata	1.0	0.5	6.5	3.2
Hertia pallens	1.0	0.5	2.1	1.1
Indigofera alternans	2.0	1.0	1.9	1.9
Lycium sp	2.0	1.0	3.0	3.0
Melica decumbens	1.0	0.5	4.7	2.4
Nenax microphylla	1.0	0.5	7.0	3.5
Osteospermum leptolobum	1.0	0.5	6.6	3.3
Phymaspermum parvifolium	1.0	0.5	6.2	3.1
Pteronia glomerata	1.0	0.5	3.9	1.9
Rosenia humilis	4.0	2.0	3.5	7.0
Tragus koelerioides	13.0	6.5	2.2	14.3
Tragus racemosus	4.0	2.0	1.3	2.6
Walafrida saxatilis	13.0	6.5	2.0	13.0
Total		63.5		204.2

22.7 ha/LSU

Site 3c

	total no. strikes	total mass	diameter/strike														
Eragrostis lehmanniana	44	273	13	10	5	7	15	16	3	4	8	4	4	2	5	9	15
			5	5	6	3	6	12	14	8	7	1	3	3	4	5	6
			3	5	11	11	8	11	4	5	4	3	9	6	12	3	
Aristida congesta	13	8	2	4	4	1	2	2	1	3	2	2	2	2	1		
Enneapogon desvauxii	1	4	3														
Tragus racemosus	1	2	1														
Nenax microphylla	1	106	29														
Aptosimum procumbens	1	6	2														
Geranium sp	1	2	1														
Indigofera alternans	11	1	1	1	4	1	1	1	1	3	2	1	1				
Eragrostis obtusa	4	4	2	7	4	4											
Phymaspermum parvifolium	2	74	18	20													
Eriocephalus spinescens	2	122	14	25													
Heteropogon contortus	1	16	8														
Digitaria eriantha	1	147	28														
Themeda triandra	1	146	30														
Walafrida saxatilis	1	2	7														
Rosenia humilis	1	166	37														
Sutera pinnatifida	1	1	2														
Aristida diffusa	3	230	19	34	20												
Tragus koelerioides	15	35	2	2	4	5	3	1	6	1	2	4	3	4	5	2	3
Blepharis capensis	6	5	4	7	3	4	6	3									
	111	1350															

12.16 grammes/strike = 28.33 ha/LSU.

Site 3c

Species	C	%C	GIV	Value
Aptosimum depressum	1.0	0.5	2.0	1.0
Aristida congesta	13.0	6.5	1.3	8.5
Aristida diffusa	3.0	1.5	5.1	7.6
Blepharis capensis	6.0	3.0	1.0	3.0
Digitaria eriantha	1.0	0.5	8.9	4.5
Enneapogon desvauxii	1.0	0.5	1.0	0.5
Eragrostis lehmanniana	44.0	22.0	5.4	118.8
Eragrostis obtusa	4.0	2.0	4.0	8.0
Eriocephalus spinescens	2.0	1.0	4.5	4.5
Erodium moschatum	1.0	0.5	1.0	0.5
Heteropogon contortus	1.0	0.5	7.2	3.6
Indigofera alternans	11.0	5.5	1.9	10.4
Nenax microphylla	1.0	0.5	7.0	3.5
Phymaspermum parvifolium	2.0	1.0	6.2	6.2
Rosenia humilis	1.0	0.5	3.5	1.7
Sutera pinnatifida	1.0	0.5	4.8	2.4
Themeda triandra	1.0	0.5	9.3	4.7
Tragus koelerioides	15.0	7.5	2.2	16.5
Tragus racemosus	1.0	0.5	1.3	0.7
Walafrida saxatilis	1.0	0.5	2.0	1.0
Total		55.5		207.6

22.4 ha/LSU

Site 4a

	total no. strikes	total mass	diameter/strike														
Eragrostis lehmanniana	25	91	8	5	4	5	2	2	3	4	3	3	4	2	33	2	5
			4	4	3	2	3	1	3	3	1	3					
Aristida congesta	25	17	2	2	2	3	1	1	1	1	1	1	1	2	1	1	1
			1	1	1	1	2	3	2	3	3	2					
Themeda triandra	2	47	10	18													
Pentzia globosa	4	298	28	5	10	22											
Tragus racemosus	3	1	2	2	1												
Cynodon incompletus	1	1	4														
Blepharis capensis	3	4	7	4	3												
Walafrida geniculata	2	35	23	5													
Plinthus karooicus	1	12	12														
Eragrostis bergiana	1	4	5														
Phymaspermum parvifolium	8	487	32	11	10	22	28	17	31	24							
Aristida diffusa	4	178	3	11	3	35											
Tragus koelerioides	14	22	3	5	5	3	1	2	3	2	2	2	3	1	3	1	
Indigofera alternans	19	4	1	1	2	4	2	1	1	1	2	2	3	3	3	3	1
			4	1	3	4											
Eragrostis obtusa	8	3	4	2	5	3	2	3	3	1							
Lycium sp	1	7	8														
Rosenia humilis	3	241	11	33	7												
Enneapogon desvauxii	3	3	3	2	3												
	127	1455															

11.46 grammes/strike = 22.52 ha/LSU.

Site 4a

Species	C	%C	GIV	Value
Aristida congesta	25.0	12.5	1.3	16.2
Aristida diffusa	4.0	2.0	5.1	10.2
Blepharis capensis	3.0	1.5	1.0	1.5
Cynodon incompletus	1.0	0.5	4.1	2.0
Enneapogon desvauxii	3.0	1.5	1.0	1.5
Eragrostis bergiana	1.0	0.5	2.8	1.4
Eragrostis lehmanniana	25.0	12.5	5.4	67.5
Eragrostis obtusa	8.0	4.0	4.0	16.0
Indigofera alternans	19.0	9.5	1.9	18.1
Lycium sp	1.0	0.5	3.0	1.5
Pentzia globosa	4.0	2.0	4.8	9.6
Phymaspermum parvifolium	8.0	4.0	6.2	24.8
Plinthus karooicus	1.0	0.5	6.4	3.2
Rosenia humilis	3.0	1.5	3.5	5.2
Themeda triandra	2.0	1.0	9.3	9.3
Tragus koelerioides	14.0	7.0	2.2	15.4
Tragus racemosus	3.0	1.5	1.3	2.0
Walafrida geniculata	2.0	1.0	7.0	7.0
Total		63.5		212.5

21.8 ha/LSU

Site 4b

	total no. strikes	total mass	diameter/strike														
Eragrostis lehmanniana	47	259	9	10	3	8	5	8	3	2	8	15	6	7	2	5	4
			2	2	2	12	5	4	3	14	12	10	7	11	4	5	1
			2	1	5	2	15	5	4	8	6	5	11	10	2	5	10
			3	7													
Aristida congesta	31	20	1	1	1	1	4	1	4	2	1	1	1	1	1	2	3
			1	1	2	3	1	2	7	1	1	4	1	1	2	1	1
			1														
Tragus koelerioides	17	29	3	4	3	2	9	1	3	3	3	1	5	3	2	2	2
			3	4													
Phymaspermum parvifolium	6	107	1	12	15	3	30	13									
Eriocephalus spinescens	1	199	27														
Walafrida saxatilis	1	50	24														
Thesium hystrix	1	8	8														
Aristida diffusa	8	149	13	11	1	5	12	15	8	27							
Enneapogon desvauxii	5	3	1	1	3	4	3										
Rosenia humilis	8	773	24	23	39	17	34	6	20	32							
	125	1597															

12.90 grammes/strike = 22.27 ha/LSU.

Site 4b

Species	C	%C	GIV	Value
Aristida congesta	31.0	15.5	1.3	20.2
Aristida diffusa	8.0	4.0	5.1	20.4
Enneapogon desvauxii	5.0	2.5	1.0	2.5
Eragrostis lehmanniana	47.0	23.5	5.4	126.9
Eriocephalus spinescens	1.0	0.5	4.5	2.2
Pentzia globosa	1.0	0.5	4.8	2.4
Phymaspermum parvifolium	6.0	3.0	6.2	18.6
Rosenia humilis	8.0	4.0	3.5	14.0
Thesium hystrix	1.0	0.5	1.6	0.8
Tragus koelerioides	17.0	8.5	2.2	18.7
Walafrida saxatilis	1.0	0.5	2.0	1.0
Total		63.0		227.7

20.4 ha/LSU

Site 5 upper

	total no. strikes	total mass	diameter/strike														
Aristida congesta	67	32	1	2	2	1	1	1	1	1	1	1	1	2	1	1	1
			1	1	1	1	1	1	1	1	4	2	1	1	1	1	1
			1	1	2	3	1	2	1	1	1	1	1	2	2	1	1
			1	1	1	1	1	2	2	1	1	1	1	1	1	1	1
			1	2	1	1	1	1	1								
Aristida diffusa	8	618	30	16	50	14	12	10	15	37							
Eragrostis lehmanniana	17	22	2	2	1	3	3	1	1	4	1	1	1	2	1	2	1
			3	1													
Helichrysum rutilans	1	4	5														
Erodium sp	1	1	1														
Eberlanzia ferox	3	476	29	29	33												
Eragrostis obtusa	1	1	3														
Enneapogon desvauxii	7	8	2	4	2	4	3	3	4								
Walafrida saxatilis	3	12	8	4	11												
Pentzia globosa	1	45	21														
Rosenia humilis	2	87	17	8													
Eriocephalus spinescens	1	242	46														
Phymaspermum parvifolium	1	17	20														
Tragus koelerioides	7	21	3	3	3	2	2	2	3								
Aptosimum procumbens	1	5	4														
	121	1591															

13.15 grammes/strike = 19.49 ha/LSU.

Site 5 upper

Species	C	%C	GIV	Value
Aptosimum depressum	1.0	0.5	2.0	1.0
Aristida congesta	67.0	33.5	1.3	43.6
Aristida diffusa	8.0	4.0	5.1	20.4
Eberlanzia ferox	3.0	1.5	2.7	4.1
Enneapogon desvauxii	7.0	3.5	1.0	3.5
Eragrostis lehmanniana	17.0	8.5	5.4	45.9
Eragrostis obtusa	1.0	0.5	4.0	2.0
Eriocephalus spinescens	1.0	0.5	4.5	2.2
Erodium moschatum	1.0	0.5	1.0	0.5
Helichrysum parviflorum	1.0	0.5	3.3	1.6
Pentzia globosa	1.0	0.5	4.8	2.4
Phymaspermum parvifolium	1.0	0.5	6.2	3.1
Rosenia humilis	2.0	1.0	3.5	3.5
Tragus koelerioides	7.0	3.5	2.2	7.7
Walafrida saxatilis	3.0	1.5	2.0	3.0
Total		60.5		144.5

32.1 ha/LSU

Site 5 lower

	total no. strikes	total mass	diameter/strike														
Aristida congesta	65	18	2	1	1	2	1	1	1	1	2	1	1	1	1	2	1
			1	2	1	1	1	1	1	1	1	1	2	1	1	1	1
			1	2	1	1	1	1	1	1	1	1	1	2	1	1	1
			1	1	1	1	1	2	1	1	2	2	1	2	1	1	3
			1	1	1	1	2										
Chloris virgata	6	6	1	1	1	1	1	1									
Blepharis capensis	1	7	4														
Tragus racemosus	4	1	1	1	2	1											
Pentzia globosa	3	56	1	23	7												
Enneapogon desvauxii	1	1	4														
Rosenia humiliscon	2	89	17	12													
Salsola calluna	1	30	13														
Pentzia incana	2	11	10	5													
Eragrostis curvula	4	90	30	26	3	2											
Eragrostis bicolor	1	2	2														
Lebeckia spinescens	1	1	2														
Felicia muricata	10	15	2	1	2	13	3	1	7	1	3	3					
Aptosimum procumbens	1	5	5														
Aristida diffusa	1	135	20														
Plinthus karooicus	1	130	25														
Phymaspermum parvifolium	5	197	28	17	5	19	22										
Tragus koelerioides	6	5	1	3	2	3	1	2									
Lycium sp	1	2	3														
Walafrida geniculata	4	11	14	1	7	2											
Eragrostis obtusa	5	5	3	3	5	2	2										
Eragrostis lehmanniana	3	4	2	2	2												
Cynodon incompletus	4	2	5	2	1	1											
	132	823															

6.23 grammes/strike = 32.12 ha/LSU.

Site 5 lower

Species	C	%C	GIV	Value
Aptosimum depressum	1.0	0.5	2.0	1.0
Aristida congesta	65.0	32.5	1.3	42.2
Aristida diffusa	1.0	0.5	5.1	2.5
Blepharis capensis	1.0	0.5	1.0	0.5
Chloris virgata	6.0	3.0	1.8	5.4
Cynodon incompletus	4.0	2.0	4.1	8.2
Enneapogon desvauxii	1.0	0.5	1.0	0.5
Eragrostis bicolor	1.0	0.5	6.0	3.0
Eragrostis curvula	4.0	2.0	6.7	13.4
Eragrostis lehmanniana	3.0	1.5	5.4	8.1
Eragrostis obtusa	5.0	2.5	4.0	10.0
Felicia muricata	10.0	5.0	6.5	32.5
Lessertia paucifolia	1.0	0.5	4.8	2.4
Lycium sp	1.0	0.5	3.0	1.5
Pentzia globosa	3.0	1.5	4.8	7.2
Pentzia incana	2.0	1.0	5.7	5.7
Phymaspermum parvifolium	5.0	2.5	6.2	15.5
Plinthus karooicus	1.0	0.5	6.4	3.2
Rosenia humilis conferta	2.0	1.0	3.2	3.2
Salsola calluna	1.0	0.5	7.2	3.6
Tragus koelerioides	6.0	3.0	2.2	6.6
Tragus racemosus	4.0	2.0	1.3	2.6
Walafrida geniculata	4.0	2.0	7.0	14.0
Total		66.0		192.9

24.1 ha/LSU

Regressions of EIV, GIV and OIV on the grazing capacity norm

NORM	EIV	GIV	OIV
39	7.2	10.2	15.7
10	5.2	6.6	7
20	12.4	13.9	27.7
16	13.3	13	17.5
32	23.8	22.8	45
26	22.8	16.4	28.5
26	11.5	11.7	30

EIV	Regression Output:	
Constant		8.497655
Std Err of Y Est		7.469377
R Squared		0.088364
No. of Observations		7
Degrees of Freedom		5
X Coefficient(s)	0.217256	
Std Err of Coef.	0.312076	

GIV	Regression Output:	
Constant		8.200448
Std Err of Y Est		5.085216
R Squared		0.176706
No. of Observations		7
Degrees of Freedom		5
X Coefficient(s)	0.220099	
Std Err of Coef.	0.212464	

OIV	Regression Output:	
Constant		10.18965
Std Err of Y Est		11.90432
R Squared		0.220868
No. of Observations		7
Degrees of Freedom		5
X Coefficient(s)	0.592144	
Std Err of Coef.	0.497372	

E.I.V.

Location: 1	Control	Model
Min	5.2000	10.0000
Max	23.8000	39.0000
Mean	13.7429	24.1429
Stdev	7.1414	9.7712
Slope		0.2173
Intercept		8.4977
MAE		10.4000
RMSE		14.0766
RMSEs		5.6470
RMSEu		15.3765
D-Index		0.4850
R^2		0.0884

G.I.V.

Location: 1	Control	Model
Min	6.6000	10.0000
Max	22.8000	39.0000
Mean	13.5143	24.1429
Stdev	5.1161	9.7712
Slope		0.2201
Intercept		8.2005
MAE		10.6286
RMSE		13.4616
RMSEs		4.3725
RMSEu		15.5936
D-Index		0.4251
R^2		0.1767

O.I.V.

Location: 1	Control	Model
Min	7.0000	10.0000
Max	45.0000	39.0000
Mean	24.4857	24.1429
Stdev	12.3114	9.7712
Slope		0.5921
Intercept		10.1897
MAE		7.8571
RMSE		10.7217
RMSEs		4.6532
RMSEu		8.3844
D-Index		0.7052
R^2		0.2209

Appendix 9 Species lists for the various areas where the studies were undertaken, as described in chapter 4.

Table 1 The following list of species are normally encountered when carrying out botanical surveys in the Eastern Mixed Karoo. They are listed in terms of their importance in the Eastern Mixed Karoo, with the values representing the total number of times that they were recorded in the surveys (adapted from Botha pers. comm.[14] and Du Toit 1992d, 1993b & 1994). The studied species are indicated by asterisks.

Species	Number
Eragrostis lehmanniana	11299 *
Aristida diffusa	7303 *
Cymbopogon plurinodis	5524
Eragrostis chloromelas	5162
Pentzia incana	4991 *
Sporobolus fimbriatus	4679 *
Aristida congesta	4490 *
Themeda triandra	4191 *
Eragrostis bicolor	3437
Phymaspermum parvifolium	2517 *
Digitaria eriantha	2341 *
Tragus koelerioides	2288
Pentzia globosa	2210
Chrysocoma ciliata	1998 *
Enneapogon desvauxii	1903
Lycium spp	1529
Eragrostis obtusa	1508
Panicum stapfianum	1432
Cynodon dactylon	1358
Eragrostis bergiana	1295
Cynodon incompletus	1226
Ephemeral spp	948
Heteropogon contortus	920 *
Eberlanzia ferox	731
Stipagrostis obtusa	642 *
Rosenia humilis	617 *
Eriocephalus spinescens	601 *
Eriocephalus ericoides	595 *
Protasparagus spp	473
Eragrostis curvula	464
Enneapogon scoparius	459
Salsola calluna	437 *
Walafrida saxatilis	414
Pentzia calcarea	389
Plinthus karooicus	380 *
Eragrostis plana	364
Cyperus spp	338
Sporobolus tenellus	329
Galenia procumbens	326
Rhigozum obovatum	307
Tragus racemosus	296
Felicia muricata	295
Stipagrostis uniplumis	270
Pterothrix spinescens	266 *
Salsola aphylla	263
Pteronia sordida	254
Pteronia glabrata	228
Aristida adscensionis	225
Microchloa caffra	216
Rhigozum trichotomum	215
Fingerhuthia africana	199
Thesium hystrix	185
Felicia muricata	183

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Gnidia polycephala	177
Melica decumbens	165
Chloris virgata	161
Galenia africana	161
Schismus barbatus	160
Walafrida geniculata	156 *
Zygophyllum incrustatum	142
Medicago spp	124
Aptosimum marlothii	122
Drosanthemum lique	117
Salvia verbenaca	113
Osteospermum spinescens	112
Galenia sarcophylla	106
Salsola rabieana	91
Nenax microphylla	85
Scirpus dioecus	78
Pentzia spinescens	72
Tetrachne dregei	69
Helichrysum pentzioides	69
Cenchrus ciliaris	63
Melolobium candicans	59
Osteospermum leptolobum	59
Zygophyllum microcarpum	58
Helichrysum dregeanum	55
Pennisetum sphacelatum	51
Helichrysum zeyheri	51
Blepharis capensis	43
Felicia fascicularis	43
Enneapogon scaber	41
Polygala pungens	41
Euryops anthemoides	36
Hertia pallens	36
Zygophyllum gilfillani	36
Oropetium capense	35
Lightfootia tenella	32
Psilocaulon absimile	29
Monechma spartioides	27
Sporobolus ludwigii	27
Pteronia glomerata	25
Berkheya spp	25
Rhus erosa	25
Pegolettia retrofracta	23
Oligomeris dipetala	22
Hyparrhenia hirta	21
Helichrysum lucilioides	20
Aspalathus acicularis	20
Salsola glabrescens	20
Pteronia tricephala	18
Felicia filifolia	17
Eragrostis virescens	16
Rosenia oppositifolia	15
Kochia salsoloides	15
Rhus lucida	15
Eragrostis gummiflua	15
Euryops asparagoides	14
Phaeoptilum spinosum	14
Setaria sphacelata	13
Anthericum spp	12
Aridaria noctiflora	12
Rhus undulata	11
Setaria flabellata	11
Brachymeris scoparia	11
Bromus catharticus	11
Thesium lineatum	11
Salsola tuberculata	9
Aptosimum spinescens	9
Diospyros lycioides	8
Melinis repens	8
Stachys rugosa	7

Microloma massonii	7
Hertia cluytiifolia	7
Trichodiadema pomeridianum	7
Delosperma tuberosum	6
Diospyros austro-africana	6
Hermannia linearifolia	6
Sutera halimifolia	5
Stipagrostis ciliata	5 *
Peliostomum leucorrhizum	5
Othonna retrorsa	5
Hermannia spinosa	5
Salvia stenophylla	5
Tetragonia arbuscula	5
Othonna spinescens	4
Hermannia pulchella	4
Indigofera alternans	4
Indigofera sessilifolia	4
Eriocephalus aspalathoides	3
Hypertelis salsoloides	3
Eleusine indica	3
Sutera pinnatifida	3
Euryops lateriflorus	3
Andropogon appendiculatus	3
Monechma incanum	3
Triraphis andropogonoides	3
Chrysocoma coma-aurea	2
Melianthus comosus	2
Aptosimum depressum	2
Mesembryanthemum spp	2
Atriplex vestita	2
Moraea polystachya	2
Helictotrichon turgidulum	2
Polygala leptophylla	2
Limeum aethiopicum	2
Salsola geminiflora	2
Aloe striata	2
Atriplex semibaccata	2
Hermania coccocarpa	2
Senecio longiflorus	2
Dianthus thunbergii	1
Pteronia scariosa	1
Brachiaria eruciformis	1
Pteronia viscosa	1
Eragrostis nindensis	1
Rosenia glandulosa	1
Lebeckia spinescens	1
Sericocoma avolans	1
Pteronia adenocarpa	1
Setaria verticillata	1
Eustachys paspaloides	1
Emex australis	1
Pentzia sphaerocephala	1
Sutera atropurpurea	1
Walafrida articulata	1

Table 2 Following is a list of species which are normally encountered when carrying out botanical surveys in the Karoo Mountainous Area. They are listed in terms of their importance in the Karoo Mountainous Area with the values representing the total number of times that they were recorded in the surveys (adapted from Botha pers. comm.[15]). The studied species are indicated by asterisks.

Species	Number
Merxmuellera disticha	27422 *
Eragrostis chloromelas	7278
Pentzia globosa	3917 *
Themeda triandra	2108 *
Aristida diffusa	1848 *
Eragrostis bicolor	1675
Eragrostis curvula	1641 *
Digitaria eriantha	1530 *
Walafrida saxatilis	1403 *
Tetrachne dregei	1224
Chrysocoma ciliata	982
Cymbopogon plurinodis	929
Elytropappus rhinocerotis	746
Eragrostis lehmanniana	714 *
Cynodon incompletus	708
Tragus koelerioides	658
Ephemeral spp	610
Rosenia oppositifolia	605 *
Cynodon dactylon	590
Karroochloa purpurea	510
Euryops lateriflorus	473
Panicum stapfianum	360
Eriocephalus ericoides	318 *
Schismus barbatus	301
Passerina montana	266
Cyperus spp	258
Lycium spp	256
Euryops oligoglossus	254
Helictotrichon turgidulum	228
Pterothrix spinescens	228
Bromus catharticus	186
Phalaris aquatica	185
Helichrysum hamulosum	180
Sporobolus fimbriatus	153
Felicia muricata	145
Eberlanzia ferox	122
Helichrysum psilolepis	120
Lightfootia tenella	117
Pentzia punctata	100
Eragrostis obtusa	99
Pentzia spinescens	99
Euryops floribundus	98
Melica decumbens	97
Felicia filifolia	96 *
Ehrharta calycina	91
Rosenia humilis	91
Hermannia spinosa	86
Walafrida geniculata	79
Helichrysum niveum	70
Helichrysum dregeanum	66 *
Fingerhuthia sesleriiformis	62
Helichrysum zeyheri	58
Pentzia incana	55
Anthospermum dregei	55
Protasparagus spp	54
Galenia sarcophylla	54

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Galenia procumbens	54
Festuca arundinacea	53
Passerina obtusifolia	52
Diospyros lycioides	51
Aristida congesta	50
Diospyros austro-africana	48
Scirpus spp	48
Koeleria capensis	44
Stachys rugosa	44
Eumorphia dregeana	43
Enneapogon desvauxii	41
Festuca scabra	41
Helichrysum dregeanum	41
Osteospermum sinuatum	40
Tragus racemosus	39
Euryops multifidus	38
Triraphis andropogonoides	38
Nenax microphylla	38 *
Melolobium candicans	38
Plinthus karooicus	36
Selago corymbosa	32
Salsola aphylla	32
Hermannia cuneifolia var	31
Eriocephalus africanus	30
Sporobolus tenellus	30
Heteropogon contortus	29
Phymaspermum parvifolium	29 *
Hermannia linearifolia	29
Osteospermum leptolobum	29
Lasiopogon spp	29
Triticum aestivum	28
Merxmuellera stricta	26
Medicago sativa	25
Pteronia sordida	24
Drosanthemum lique	24
Pennisetum sphacelatum	23
Oligomeris dipetala	22
Felicia fascicularis	22 *
Rhus erosa	20
Aspalathus acicularis	19
Andropogon appendiculatus	19
Echinochloa crus-galli	19
Eriocephalus spinescens	18
Avena fatua	18
Hyparrhenia hirta	18 *
Kochia salsoloides	18
Berkheya fruticosa	16
Salvia verbenaca	16
Passerina filiformis	15
Stipagrostis ciliata	15
Salsola calluna	14
Pteronia glabrata	14
Euphorbia decussata	14
Bromus pectinatus	14
Agrostis lachnantha	13
Eragrostis virescens	13
Selago albida	11
Delosperma tuberosum	10
Galenia fruticosa	8
Brachiaria eruciformis	8
Sutera halimifolia	7
Mesembryanthemum spp	7
Pentzia sphaerocephala	7
Lycium oxycarpum	7
Pentzia calcarea	7
Dianthus thunbergii	6
Stipagrostis obtusa	6
Eragrostis nindensis	5
Microchloa caffra	5

Osteospermum spinescens	5
Enneapogon scoparius	5
Eragrostis bergiana	5
Medicaco spp	5
Senecio longiflorus	5
Aridaria noctiflora	4
Sutera atropurpurea	4
Deverra burchellii	4
Helichrysum lucilioides	4
Fingerhuthia africana	4
Xanthium spinosum	4
Eriocephalus punctulatus	3
Hertia pallens	3
Limeum aethiopicum	3
Psilocaulon absimile	3
Hermannia coccocarpa	3
Helichrysum pentzioides	3
Enneapogon scaber	3
Zygophyllum microcarpum	3
Cirsium vulgare	2
Pelargonium abrotanifolia	2
Blepharis capensis	2
Protasparagus suaveolens	2
Helichrysum obtusifolia	2
Thesium lineatum	2
Indigofera alternans	2
Trichodiadema pomeridianum	2
Aptosimum procumbens	2
Nolletia ciliaris	2
Hertia cluytiifolia	2
Zygophyllum incrustatum	2
Dimorphotheca spp	1
Microloma massonii	1
Miscanthus capensis	1
Cineraria aspera	1
Pelargonium acetosum	1
Atriplex suberecta	1
Phymaspermum aciculare	1
Eragrostis gummiflua	1
Phymaspermum scoparium	1
Gnidia burchellii	1
Polygala leptophylla	1
Heliophila suavissima	1
Pteronia glomerata	1
Lotononis spp	1
Ruschia spp	1
Chloris virgata	1
Senecio radicans	1
Ehrharta melicoides	1
Senecio spp	1
Gnidia spp	1
Sutera pinnatifida	1
Melianthus comosus	1
Sutherlandia frutescens	1
Geigeria africana	1
Deverra aphylla	1
Hermannia multiflora	1
Tetragonia arbuscula	1
Thesium hystrix	1

Table 3 Following is a list of species which are normally encountered when carrying out botanical surveys in the Arid Karoo. They are listed in terms of their importance in the Arid Karoo with the values representing the total number of times that they were recorded in the surveys (adapted from Botha pers. comm.[16] and Du Toit 1992b). The studied species are indicated by asterisks.

Species	Number
Pentzia globosa	4062
Pentzia incana	4005
Stipagrostis obtusa	3778 *
Eriocephalus spinescens	2524 *
Eriocephalus ericoides	2518 *
Eberlanzia ferox	2145 *
Ennneapogon desvauxii	1363
Lycium spp	1105
Stipagrostis ciliata	807 *
Eragrostis bicolor	799
Pteronia sordida	717
Aristida congesta	712
Aristida diffusa	680 *
Rosenia humilis	614 *
Chrysocoma ciliata	606
Aristida adscensionis	587
Euryops multifidus	494
Eragrostis lehmanniana	448 *
Ephemeral spp	373
Rosenia oppositifolia	278
Felicia muricata	226
Plinthus karooicus	200 *
Salsola calluna	180
Eriocephalus aspalathoides	174
Pteronia glabrata	171
Thesium hystrix	133
Salsola geminiflora	120
Salsola tuberculata	117 *
Felicia filifolia	103
Eragrostis bergiana	100
Euryops lateriflorus	86
Walafrida geniculata	84
Kochia salsoloides	82
Zygophyllum gilfillani	82
Pentzia spinescens	77 *
Salsola aphylla	77
Protasparagus spp	75
Eragrostis obtusa	74
Osteospermum spinescens	73 *
Pterothrix spinescens	72 *
Pteronia glomerata	72 *
Aridaria noctiflora	72
Galenia sarcophylla	69
Tragus racemosus	61
Helichrysum pentzioides	47
Pteronia punctata	46
Medicago laciniata	44
Salsola rabieana	44
Galenia secunda	42
Drosanthemum lique	42
Pteronia viscosa	35
Chloris virgata	31
Pteronia adenocarpa	31 *
Aptosimum marlothii	29
Galenia procumbens	28
Aptosimum procumbens	25

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Helichrysum lucilioides	25 *
Hermannia spinosa	24
Lightfootia tenella	24
Zygophyllum microcarpum	24
Aptosimum indivisum	21
Hermannia desertorum	19
Stachys rugosa	19
Hermannia linearifolia	18
Polygala pungens	17
Enneapogon scaber	16
Selago albida	16
Limeum aethiopicum	14
Fingerhuthia africana	13 *
Sutera atropurpurea	12
Cladoraphis spinosa	12
Schismus barbatus	12
Polygala leptophylla	12
Gnidia polycephala	11
Cynodon incompletus	9
Lebeckia spinescens	9
Cynodon dactylon	8
Tragus koelerioides	8
Eragrostis obtusa	7
Psilocaulon absimile	7
Eragrostis nindensis	7
Stipagrostis uniplumis	7
Pentzia pinnatisecta	7
Mesembryanthemum spp	7
Pentzia punctata	7
Tetragonia arbuscula	7
Digitaria eriantha	6
Pteronia scariosa	6
Sporobolus fimbriatus	6
Melolobium candicans	5
Hermannia gracilis	5
Rosenia glandulosa	5
Zygophyllum incrustatum	4
Pteronia erythrochaeta	4
Euphorbia caterviflora	4
Nenax microphylla	4
Microloma massonii	4
Peliostomum leucorrhizum var leucorrhizum	4
Berkheya spp	3
Galenia africana	3
Pegolettia retrofracta	3
Stipagrostis namaquensis	3
Walafrida saxatilis	2
Aptosimum marlothii	2
Thesium lineatum	2
Hermannia cuneifolia var	2
Trichodiadema pomeridianum	2
Osteospermum sinuatum	2
Atriplex vestita	2
Dicoma capensis	2
Ruschia perfoliata	2
Lessertia pauciflora	2
Ruschia spp	2
Gnidia deserticola	1
Lessertia inflata	1
Lessertia spp	1
Eragrostis porosa	1
Monechma incanum	1 *
Helichrysum obtusifolia	1
Osteospermum leptolobum	1
Hirpicium alienatum	1
Atriplex nummularia	1
Eragrostis curvula	1
Sutera halimifolia	1
Helichrysum zeyheri	1

Eragrostis chloromelas	1
Indigofera alternans	1
Sutera pinnatifida	1
Sutherlandia frutescens	1

Table 4 Following is a list of species which are normally encountered when carrying out botanical surveys in the Great Karoo. They are listed in terms of their importance in the Great Karoo with the values representing the total number of times that they were recorded in the surveys (adapted from Botha pers. comm.[17] and Du Toit 1992c & 1995a). The studied species are indicated by asterisks.

Species	Number
Pentzia incana	9694
Eberlanzia ferox	4545 *
Pentzia spinescens	3966 *
Stipagrostis ciliata	3700
Lycium spp	1878
Aristida diffusa	1667
Rhigozum obovatum	1602
Ephemeral spp	1478
Aristida congesta	1458
Drosanthemum lique	1427
Stipagrostis obtusa	1396 *
Eriocephalus ericoides	1230 *
Eragrostis obtusa	1073
Eriocephalus spinescens	783 *
Rosenia humilis	773 *
Chrysocoma ciliata	578
Felicia muricata	500
Zygophyllum microcarpum	439
Protasparagus spp	436
Enneapogon desvauxii	419
Walafrida geniculata	393 *
Digitaria eriantha	373
Osteospermum sinuatum	363
Mesembryanthemum spp	308
Pteronia viscosa	293
Aridaria noctiflora	269
Hermannia desertorum	260 *
Garuleum bipinnatum	243
Eragrostis lehmanniana	204
Fingerhuthia africana	180 *
Phymaspermum parvifolium	177
Tragus racemosus	176
Enneapogon scaber	175
Cynodon incompletus	175
Digitaria argyrograpta	165
Felicia filifolia	161
Cynodon dactylon	160
Monechma spartioides	157
Asaemia minuta subsp minuta	153
Chloris virgata	135
Cenchrus ciliaris	132
Salsola calluna	129
Galenia fruticosa	125
Tragus koelerioides	124
Heteropogon contortus	122
Salsola rabieana	107 *
Galenia secunda	104
Limeum aethiopicum	102
Hermannia spinosa	99
Ruschia spp	90
Zygophyllum gilfillani	89
Galenia sarcophylla	89
Osteospermum sinuatum	89
Salsola aphylla	86
Rosenia oppositifolia	84
Pteronia glabrata	80

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Pteronia sordida	77
Zygophyllum incrustatum	73
Psilocaulon absimile	73
Aristida adscensionis	72
Schismus barbatus	66
Galenia procumbens	57
Atriplex lindleyi subsp inflata	57
Lebeckia spinescens	57
Grewia robusta	53
Pteronia adenocarpa	52
Pteronia glomerata	52
Galenia africana	42
Maytenus capitata	42
Sutera atropurpurea	39
Salsola tuberculata	39 *
Plinthus karooicus	39
Blepharis capensis	38
Helichrysum zeyheri	37
Helichrysum dregeanum	36
Thesium lineatum	36
Panicum stapfianum	34
Euphorbia stellispina	32
Trichodiadema pomeridianum	28
Rhus spp	27
Helichrysum lucilioides	27 *
Berkheya spinosa	26
Dicoma spinosa	26
Euphorbia spp	25
Indigofera sessilifolia	25
Eragrostis bicolor	24
Stipagrostis uniplumis	23
Hermannia gracilis	22
Aptosimum spinescens	22
Pegolettia retrofracta	21
Pentzia globosa	21
Tetragonia arbuscula	21
Osteospermum spinescens	20
Hypertelis salsoloides	19
Thesium hystrix	17
Hermannia linearifolia	16
Maytenus heterophylla	16
Aptosimum depressum	15
Delosperma spp	15
Carissa haematocarpa	15
Atriplex semibaccata	14
Hirpicium alienatum	14
Nenax microphylla	12 *
Rhus undulata	11
Sericocoma avolans	11
Rhus lucida	11
Euphorbia horrida	11
Hyparrhenia hirta	10
Othonna spinescens	10
Aptosimum marlothii	10
Gnidia deserticola	9
Euclea undulata	9
Selago albida	8
Senecio spp	8
Sutera halimifolia	8
Hermannia cuneifolia var	8
Pentzia pinnatisecta	7
Delosperma tuberosum	7
Pentzia sphaerocephala	7
Melolobium candicans	7
Indigofera porrecta	7
Eragrostis porosa	7
Medicago laciniata	6
Sutera pinnatifida	6
Boscia albitrunca	6

Eragrostis virescens	6
Kochia salsoloides	6
Osteospermum leptolobum	6
Acacia karroo	6
Hermannia pulchella	6
Sarcocaulon patersonii	5
Hermannia multiflora	5
Euryops anthemoides	5
Crassula muscosa var muscosa	5
Polygala pungens	5
Monechma spp	4
Hermannia paucifolia	4
Crassula spp	4
Stipagrostis anomala	4
Euphorbia mauritanica	4
Hermannia spp	4
Monechma incanum	4
Peliostomum leucorrhizum	4
Pteronia scariosa	4
Panicum maximum	3
Pelargonium acetosum	3
Aptosimum indivisum	3
Polygala leptophylla	3
Lampranthus ornatus	3
Osteospermum scariosum	3
Zygophyllum spp	3
Helichrysum hamulosum	2
Dianthus thunbergii	2
Gnidia spp	2
Setaria verticillata	2
Dodonaea angustifolia	2
Pteronia incana	2
Stipagrostis namaquensis	2
Euphorbia coerulescens	2
Asclepias burchellii	2
Euryops spp	1
Pterothrix spinescens	1
Sarcocaulon salmoniflorum	1
Felicia ovata	1
Eragrostis virescens	1
Gnidia stricta	1
Senecio longiflorus	1
Carissa macrocarpa	1
Enneapogon scoparius	1
Grewia occidentalis	1
Sporobolus tenellus	1
Atriplex vestita	1
Lotononis brachyloba	1
Atriplex nummularia	1
Cyperus spp	1
Asaemia minuta subsp minuta	1
Diospyros austro-africana	1
Helichrysum pentzioides	1
Ehrharta longiflora	1
Helichrysum spp	1
Rhus lancea	1
Indigofera spinescens	1
Pteronia tricephala	1
Monechma genistifolium subsp australe	1
Eriocephalus aspalathoides	1
Senecio acutifolius	1
Eustachys paspaloides	1
Aloe ferox	1
Microloma massonii	1