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RELATIONS BETWEEN ECOLOGICAL, SOCIOLOGICAL AND ECONOMIC FACTORS AFFECTING RANCHING IN THE NORTH WESTERN TRANSVAAL

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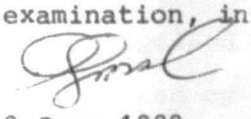
A thesis submitted to the Faculty of Science
University of the Witwatersrand, Johannesburg
in fulfilment of the requirements for the
degree of Doctor of Philosophy

Johannesburg 1988

DECLARATION

I declare that this thesis, unless otherwise stated, is my own unaided work. It has not been submitted before, for any degree or examination, in any other university.



9 June 1988

PREFACE

Several decades of research and extension relating to rangeland management for animal production have seemingly not halted or reversed the alleged deterioration of the rangeland resource. This study attempts to address the reasons underlying the problem by investigating pertinent ecological and socio - economic factors, as well as their interactions. The document is presented in 4 sections. Additional data and calculations are included in the form of appendices. In the interests of readability, relevant literature is reviewed within each section.

In the first section, the problem is stated and the objectives and approach to the study are described. A description of the study area is provided.

In the second section, rangeland composition, taken as representing the current "ecological status" of the 42 ranches surveyed, is discussed.

The third section describes sociological and economic factors measured during the study.

Finally, relations between the ecological, sociological and economic factors are discussed.

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ABSTRACT

This study examines the relations between certain ecological, sociological and economic factors which affect ranching in semi-arid savanna. The aim was to test a set of hypotheses (reflecting "current wisdom") in an attempt to identify possible reasons why several decades of research and extension into rangeland management had seemingly not halted or reversed the alleged deterioration of the rangeland resource :

H1 : limiting farm size results in veld deterioration,

H2 : poor management results in veld deterioration,

H3 : recommended management results in "good" veld and sound financial performance,

H4 : "poor" human characteristics result in poor veld management practice.

A relatively uniform area of savanna was selected. Forty two ranches within the area defined were surveyed. Planning and layout were described, herbaceous composition and woody

vegetation were quantified. Factors relating to each rancher's motivation, aspirations and management ability were scored. Indirect assessments of financial performance were made, due to the unwillingness of most ranchers to disclose details.

Data obtained were tested using Kendall rank correlation, factor analysis and multiple stepwise linear regression.

The results indicate that veld composition was poorly (r = 0,124) correlated with farm size, physical layout (r = 0,281), grazing management system (r = 0,159), and animal production system (r = 0,287). Veld composition was furthermore weakly correlated with rancher's age, years of experience, motivation or degree of contact with the extension officer ($r \leq 0,230$). It is suggested that driving forces largely beyond the control of the rancher (mainly rainfall) overrode management inputs in the majority of cases, and that recommended management did not necessarily result in good veld and sound financial performance.

In terms of sociological factors, three broad groups were identified. The first were capitally powerful "land barons"

whose lower order material needs were satisfied and were able to indulge in "conservation farming". The second comprised a group of "tryers but failures" - ecological and economic constraints hamstrung their efforts at "sound" range management. The final group were classical "laggards", but their aspirations were seemingly totally met by their current lifestyles.

That previous extension programmes in the area were successful is illustrated by the relatively high correlations between ranchers level of contact with the extension officer and physical planning ($r = 0,602$), knowledge of his veld ($r = 0,569$), and grazing management system ($r = 0,623$). The end result of "good veld" was however not achieved.

It is suggested that in dealing with humans and their dependence on "nature" (the rangeland resource) one is dealing with already complex components of a highly complex interaction. The currently recommended approach to range management would seem to be an oversimplification and ultimately lacks credibility. An adaptive management approach, coupled with the incorporation of planted pastures (where practicable) may provide a suitable alternative.

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1. INTRODUCTION

1.1 Background to the study

Commercial ranching in South Africa is characterized by an almost absurd contradiction. On the one hand, a sophisticated philosophy and level of expertise relating to the management and utilization of the natural pasturage has developed. On the other, the alleged deterioration of the country's natural rangelands as a result of grazier mismanagement is a cause of national concern. In respect of the latter, the following statement, drawn from a report tabled as early as 1914, has been restated periodically up to the present :

> "the occupiers of the land, from the earliest times to the present day, have gradually destroyed the vegetation, whether trees, shrubs or grasses, which formed the natural protection of the soil". (Report of the Select Committee on Droughts, Rainfall and Soil Erosion, 1914).

According to the findings of this report, the denudation referred to was caused by veld-burning, felling of trees for

fuel or timber and, significantly, by the grazing of livestock. Seemingly little or no action followed the publication of this report.

During 1920 a Drought Investigation Commission was appointed. This commission concluded that the practice of "overstocking farms is very prevalent, (which) overstocking leads to overgrazing and all its attendant evils" (Final report, Drought Investigation Commission 1923). The Drought Investigation Commission seriously considered recommending legislation to eliminate overstocking, but decided that guidance would be better for the farmer than coercion.

In 1946, the first Soil Conservation Act was proclaimed, with the stated aims of combating and preventing soil erosion, and conserving, protecting and improving the veld and soil of the country. That this Act did not achieve the desired effect is evidenced by the several further commissions of enquiry, appointed over the following decades, which generally concurred with the findings of the 1914 Select Committee (e.g. Commission of Enquiry into Agriculture, 1968-1972; Department Committee for the Control of Veld Deterioration in the Karoo and Adjoining Areas, 1980; Committee on Pastures, 1981).

The concern on the part of the authorities culminated, in

1983, in the proclamation of the Conservation of Agricultural Resources Act (Act 43 of 1983). The regulations of this Act demonstrate a clear commitment to the conservation and improvement of the country's natural vegetation and soil.

Research into rangeland management and utilization in South Africa has recognized the often mentioned deterioration of the veld, and guidelines for the socalled "optimal" utilization of natural rangeland have been developed and refined over the decades (Tainton, 1981).

The vexing question which then arises is: Why has the vast majority of the ranching community seemingly failed to implement the recommended management systems? It is the purpose of this study to address this, and other, related questions, by examining and interpreting certain ecological, sociological and economic/financial factors affecting extensive ranching in an area of savanna in the North Western Transvaal. The framework within which this enquiry operates developed from certain thoughts expressed by Smuts (1926) who implored that "... Biology not only continued the acquisition of knowledge, but also developed new view-points from which to envisage all our vast accumulated material of knowledge". Smuts (1926), in his essay on the concept of holism, stated that it would not help merely to accumulate details of which the masses are already becoming more than any individual mind can bear. He wrote:

"New co-ordinations are required, new syntheses which sum up and explain and illuminate the other wise amorphous masses of material".

Through the current enquiry, it was hoped to establish how the components (ecological, sociological and economic) interact and gain form and expression (Gestalt) through the actions of the land-user. Previous studies conducted locally largely addressed either ecological or socio-economic factors (eg Coetzee, 1971; du Plooy, 1981; Rix, 1984; de Klerk, 1986). However, as Block (1975) stated, range issues should not be addressed by themselves, they need to be blended with other economic, social and environmental questions.

1.1.1 Land use in savanna regions

The major form of land use in the savanna regions, which occupy approximately 35% of the land area of South Africa, is extensive beef cattle ranching (Grossman and Gandar, 1981). According to the 1976 Agricultural census, about 2,5 million cattle, 2,25 million sheep and 0,3 million goats occur in savanna. In addition, an unknown but undoubtedly significant number of indigenous game animals occurs in savanna.

Much of the savanna occurs in zones receiving an average annual rainfall of 600mm or less. Cultivation is minimal and it has been estimated that as much as 70% of the area is still under natural vegetation. This then forms the basis of animal production in the region - indeed the basis of most of the economic activity (other than mining). The deterioration of the vegetation, with the resultant decline in animal production, has implications for the economic stability of the region as a whole. In fact, depopulation of the area, resulting in "abandoned" farms, has been cited by the 1981 Committee on Pastures as being a strategically unacceptable consequence of veld deterioration. In some areas, up to 60% of ranches are not permanently occupied.

1.1.2 Problems associated with rangeland management and utilization

The report of the 1981 Committee on Pastures found that pasture scientists, ecologists, extension officers and farmers differed widely in their assessment of the problems besetting rangeland management in savanna regions. The Committee found that the reasons for this diversity of opinion resulted from the fact that most information and management recommendations relating to this region were based on "personal observations, superficial research results and speculation".

The Committee nevertheless cited the following problem areas as being of importance (translated from Afrikaans) :

(i) bush encroachment;

(ii) sensitivity of the savanna ecosystems to utilization and management manipulation, particularly the instability of the herbaceous layer in various successional stages;

(iii) poor species composition, cover and vigour of the herbaceous layer;

(iv) incorrect balance between grazers and browsers and lack of information concerning browsers and the potential of browse;

(v) unreliable fodder flow as a result of variable rainfall;

(vi) lack of grazing capacity norms;

(vii) lack of information concerning the potential of planted pastures and fodder species; there was also a lack of information concerning the integration of veld, planted pastures and forage crops into forage flow programmes for the development of more intensive adapted stock ranching systems;

(viii) the presence of toxic plants;

(ix) in more than 60% of cases, farm size was below that considered to be economically viable for the traditional extensive ranching systems.

1.1.3 Current hypotheses relating to rangeland deterioration

Point (ix) above referred to the fact that the majority of ranches in savanna regions were considered too small to be economically viable. Several further reasons for the deterioration of savanna rangeland were cited by the Commission of Enquiry into Agriculture (1968-72) (translated from Afrikaans) :

(i) increasing production and marketing costs reduced the profitability of extensive ranching;

(ii) although the farming community contributed immensely to the welfare of the country, there still existed a section of this community which had neither the initiative nor the determination required to ranch successfully;

(iii) deep-rooted traditions, inherent conservatism, fatalistic and over-optimistic attitudes to

environmental factors, together with poor perception, interacted and resulted both in the deterioration of the environment and the precarious financial position of the farmer;

(iv) the relatively higher cost of living and lack of amenities and facilities in remote rural areas contributed to the loss of more able farmers from the area - the more conservative, tradition bound element remained;

(v) disproportionately high land prices militated against the infusion of younger, able, prospective farmers;

(vi) the education system in South Africa was described as being "city-orientated"; as a result it was thought to have increased the "backward and inferior" image of the rural ranching environment.

Duvel (1970, 1982) alleged that the poor perception of the farmer vis-a-vis the factors associated with production was one of the major constraints limiting implementation of recommended management strategies. Ranchers, especially in semi-arid regions, were simply not aware of the limitations imposed by environmental variables (chiefly rainfall).

1.2 Objectives

In the light of the situation described above, it was the purpose of this study to determine the relations and interactions between ecological, sociological and economic/financial factors affecting extensive ranching in an area of savanna vegetation. Explicitly, the aim was to test, in the light of the previously mentioned contradiction, the extent to which the following set of hypotheses apply to the study area:

H1 : limiting farm size results in veld deterioration;

H2 : poor management results in veld deterioration;

H3 : recommended management results in "good" veld and sound financial performance;

H4 : "poor" human characteristics (perception, lack of innovativeness, low aspiration) are prevalent and result in poor veld management practice.

The rationale underlying the study is that several decades of research and extension, using the above hypotheses as tenets or points of departure, have not apparently halted or reversed the alleged deterioration of the natural resource

base. (NB. A problem arises regarding the definition of "deterioration". On the one hand, changes in composition and productivity of savanna vegetation may be viewed as responses to current driving forces - the "ecological view". On the other, from an agricultural or production oriented view, the changes are undesirable and therefore regarded as "deterioration". The problem is further explored later.) It is conceivable that, in the past, certain unknown critical factors constraining the improvement of range management have been overlooked, or underestimated. It was felt that a "holistic" approach, as adopted in this study, whereby ecological, sociological as well as economic/financial factors are investigated, may give fresh insight into the problem of unsatisfactory land use. Such insight will be of use in the development of suitable management strategies, as well as the communication thereof through programmed extension campaigns.

1.3 Approach to the study

In order to meet the objectives of the study, it was necessary to quantify certain selected variables related to each of the three components, namely ecological, sociological and economic/financial.

First, in terms of current practice the present composition

and density of the herbaceous layer was considered to be the most obvious and readily determined variable. In addition, correlation of current herbaceous composition with past rangeland management history should provide a basis for evaluating various management practices (Tainton, 1981, Barnes, 1982).

Second, in terms of the personality traits of the ranchers, measurements of innovativeness, ability and aspiration were deemed necessary. These could then be evaluated in relation to management strategies applied, and constraints limiting efficient management identified.

Third, an indication of the profitability and financial performance of ranchers was needed, in order to evaluate the relative success of various management systems.

Finally, an analysis of the interactions between the three components should answer the following questions.

(i) Why do ranchers do what they do?

(ii) What effects do different management options actually have on rangeland herbaceous composition?

(iii) What financial performance is achieved by the

various management systems?

In order to obtain the above information, an area within the extensive ranching region that met the following criteria was selected:

(i) the area needed to have a relatively stable farming community - in order to interpret current rangeland herbaceous composition in relation to management history, it was necessary that sample farms were ranched by the same rancher for several years (an arbitrary five years was chosen);

(ii) the topography, climate and vegetation needed to be as uniform as possible.

Various parts of the Transvaal savanna region were visited and, in conjunction with local extension officers, assessed in terms of the above criteria.

The selected study area (see Fig 1) was thoroughly traversed and a homogenous area of Combretum apiculatum woodland selected for the "intensive" study area. The intention was to survey all farms within this area. Ultimately, 42 farms meeting the necessary criteria were used. The farms covered

a total area of 80 182 hectares. The survey procedure is described in subsequent sections.

1.4 The study area

1.4.1 Geographic location and topography

The greater study area is located in the Thabazimbi Magisterial district, north-western Transvaal. It is bounded on the south by latitude 25°S, on the north by latitude 24°15'N, on the east by longitude 27°20'E and on the west by a line south from the Limpopo river at 26°53'E (see Figure 1). The Crocodile river flows through the area in a north-westerly direction, from an elevation of 1028m asl near the town of Thabazimbi, to ca 850m at the confluence with the Marico river. The topography is a gently undulating plain to the north-east of the Crocodile river (elevation 860-1000m). To the south, the terrain is interspersed with quartzite and norite ridges (Irvine, 1941).

1.4.2 Geology and soils

The rocks underlying the study area are old granite, gneiss of the Northern-Cape - Transvaal belt of granitization and

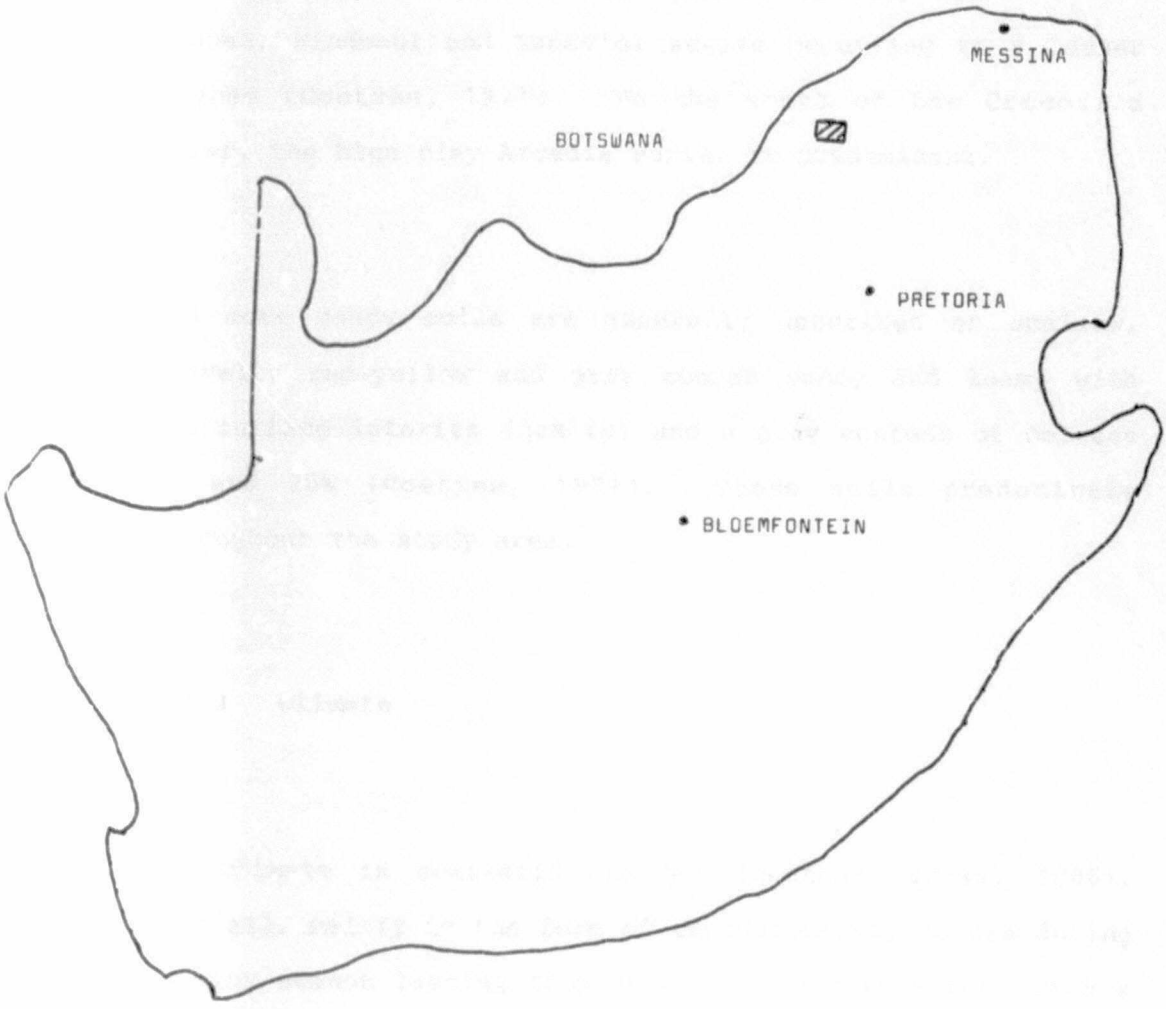

Figure 1. Outline map of South Africa showing approximate location of the study area (hatched block).

metamorphism (Geological map of South Africa, 1970). The predominant soils are, north of the Crocodile river, the sandy Portsmouth and Shorrocks (minus) series, with the Mispah, Windmeul and Sandvlei series occurring to a lesser degree (Coetzee, 1971). To the south of the Crocodile river, the high clay Arcadia series is predominant.

The more sandy soils are generally described as shallow, gravelly red-yellow and grey coarse sandy and loamy with sub-surface laterite (ouklip) and a clay content of between 10 and 20% (Coetzee, 1971). These soils predominate throughout the study area.

1.4.3 Climate

The climate is semi-arid and hot (Weather Bureau, 1986). Rainfall, mainly in the form of thunderstorms, occurs during a rainy season lasting from about November to March, with a peak in January. About 50 to 80 rain days per year may be expected. Rainfall is somewhat unreliable and in about 12% of all years rather severe drought occurs (Weather Bureau, 1986). The annual (July to June) rainfall, as measured at the Sentrum primary school, located within the study area, averages 482mm (Table 1.1). It ranges between 207mm and 750mm.

Table 1.1 Annual rainfall (July to June) from 1934/35 to 1983/84, recorded at the Sentrum primary school located within the study area.

Year	Rainfall(mm)	Year	Rainfall(mm)
1934/35	314	1961/62	318
1935/36	583	1962/63	223
1936/37	634	1963/64	334
1937/38	412	1964/65	303
1938/39	589	1965/66	207
1939/40	561	1966/67	-
1940/41	368	1967/68	458
1941/42	399	1968/69	433
1942/43	672	1969/70	314
1943/44	671	1970/71	616
1944/45	-	1971/72	574
1945/46	473	1972/73	437
1946/47	-	1973/74	628
1947/48	-	1974/75	670
1948/49	345	1975/76	734
1949/50	-	1976/77	673
1950/51	514	1977/78	750
1951/52	-	1978/79	404
1952/53	-	1979/80	465
1953/54	289	1980/81	727
1954/55	482	1981/82	447
1955/56	-	1982/83	395
1956/57	492	1983/84	479
1957/58	403	1984/85	519
1958/59	549	1985/86	448
1959/60	327	1986/87	557
1960/61	479	Average	482

Average daily maximum temperatures are 32°C in January and 22°C in July; extremes are of the order of 42°C and 31°C respectively. Average daily minima are about 18°C in January and 4°C in July, whilst extremes can reach 8°C and -7°C, respectively. Frosts occur during the months June to August.

Winds are mainly light to moderate and blow from the north east, except for short periods during thunderstorms when they are southerly.

The duration of bright sunshine exceeds 80% of that possible in midwinter and 60% in summer.

1.4.4. Vegetation

The vegetation of the study area is typically savanna - comprising a distinct herbaceous layer, containing mainly grasses, and an open canopied woody stratum. Phytogeographically, the vegetation is a component of the Zambesian domain of the Sudano-Zambezi region (Werger and Coetzee, 1978). The study area occurs mainly in Acocks's (1975) veld type 18 (Mixed Bushveld), described by Irvine (1941).

The major vegetation type in the intensive study area is (Irvine, 1941) Combretum apiculatum veld, with a variation being Combretum apiculatum - Pterocarpus rotundifolius veld. According to Irvine (1941), these vegetation types cover some 11,000 km^2 at an elevation of 770-1100m asl, and receive an annual rainfall of 350-625mm. Soils throughout are shallow but in Combretum apiculatum - Pterocarpus rotundifolius veld, they are very shallow indeed with impeded drainage - a shallow layer of gritty yellow-grey sandy loam is underlain by 'ouklip' (laterite).

The vegetation is very uniform, Combretum apiculatum being dominant throughout. Other woody species are Acacia caffra, Dichrostachys cinerea, Grewia flava, Lannea discolor and Sclerocarya caffra. The principal grasses are, according to Irvine (1941), Aristida barbicollis, Digitaria eriantha*, Eragrostis sp (probably rigidior) and Schmidtia pappophoroides*. Less abundant species are Brachiaria nigropedata*, Eragrostis superba, Heteropogon contortus and Themeda triandra. Elionurus muticus is common in places.

In the Combretum apiculatum - Pterocarpus rotundifolius variation, the veld is described as being a uniform mixture

---

* Generally considered as being "good" species for ranching purposes

of these two species, less varied than Combretum apiculatum veld. Grewia flava, Dichrostachys cinerea and Terminalia sericea occur. There is more Elionurus muticus than in true Combretum apiculatum veld, but little Themeda triandra (Irvine, 1941).

1.4.5 Peopling

The recent human prehistory of the region probably influenced the current status of the vegetation. Early quantitative descriptions of the area have not been found. Qualitative personal memories of older inhabitants have a recurring theme - namely that the woody vegetation has increased markedly. This is in keeping with similar observations, globally, throughout the savanna region (van der Schijff, 1964). However, evidence in support of this assertion has not been found.

According to Innskeep (1978), South Africa's first farming communities were established at least by the end of the third century. Pennisetum spp were cultivated, and an early iron-age technology had developed and spread, primarily along the eastern and south eastern seaboard. Iron-age settlements (ranging from 900± 65 BP to about 100 years BP) are scattered throughout the savanna regions of the Transvaal (Revil Mason, 1962).

Iron-age artefacts have been recovered from a farm forming part of this study, near the iron-ore bearing hills around Thabazimbi. Archaeological evidence presents a picture of a pastoralist society, utilizing wood for the hearth, stockade, dwelling and smelting furnace. There are no estimates of wood use during this period, but current wood usage among rural African populations is of the order of 1 ton per capita per year (Gandar, 1983).

The picture painted by early European travellers in the Northern Transvaal region (some 140 years BP) "depict a land of luxuriant grass, abundant water, dense forests along the mountains, broad rivers and reedy marshes all teeming with game (Irvine, 1941). Mention is made of "large native towns and of cultivated and bare ground in the vicinity thereof".

That the "native towns" were of substantial size is illustrated by Becker (1967). Dimensions of reconstructed royal kraals north of present-day Pretoria indicate that substantial amounts of timber were used in constructing dwellings and stockades. Indeed, Becker (1967) refers to expeditions by ba-Pedi slaves far to the north of the royal kraal to gather wood - a sure indication of the depletion of local resources.

The first European settlers to utilize the pastures of the study area were "trekboers" (i.e. not resident in the area). These people settled in the climatically more hospitable regions, e.g., south of the Magaliesberg, during the late nineteenth Century (Irvine, 1941). Cattle and boer would spend the summer months in the cooler, high lying, relatively disease-free "sourveld" areas. During the cooler winter months, when the pasturage of the sourveld lost its nutritional value, the boers would trek into the now cooler, lower lying savanna, where the grass retained its nutritional value during the dormant winter period (sweetveld). It is thus probable that the vegetation of the study area was not subjected to a continuous domestic grazing animal presence until the area was surveyed and proclaimed into farms in about 1910 (Atherstone*, pers. comm.). Game is locally abundant, kudu (Tragelaphus strepsiceros) and impala (Aepyceros melampus) predominate.

Permanent European settlement from this time undoubtedly had profound influences on the vegetation. Wood use by indigenous people gradually decreased, large browsing herbivores all but disappeared, fire regimes probably changed. A variety of indigenous herbivores was largely replaced by a

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* Mr N Atherstone, Atherstone, Game Reserve, P.O. Dwaalboom.

single grazing species, cattle. Additional water points were created (boreholes). Opportunistic utilization of vegetation by partially nomadic native animals was thus replaced by a systematic, thorough utilization by sedentary stock. This permanent utilization of natural rangeland continues in the study area to date.

During the 1930's several parts of the area were planted to cotton (van Rensburg, pers. comm.*). The remains of these old lands are today clearly identifiable, primarily by the dense stands of Acacia tortilis and A.nilotica. Cropping occurred intermittently up to the present, but extensive ranching still predominates.

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2. RANGELAND COMPOSITION

2.1 Introduction

An objective of this study was to determine the effect of various range management systems on the herbaceous composition. Implicit in this objective is the assumption that current composition of the herbaceous layer does in fact reflect past land use. This assumption is in line with the philosophy or current wisdom underlying local rangeland management (Tainton, 1981). For example, Tainton (1981) stated that:

> "Overgrazing (in savanna) encourages degeneration of the grassveld cover to species of Eragrostis, Bothriochloa, Hyparrhenia and Aristida congesta subsp. congesta, and the development of impenetrable thickets of Acacia karroo, A. nilotica, Dichrostachys cinerea and Maytenus heterophylla".

Similarly, Cumming (1982) asserted that overstocking resulted in a depletion of perennial grasses and palatable herbs, an increasing proportion of annuals and unpalatable species, coupled with reduced herbaceous ground cover.

Barnes (1982) stated that it was common experience that, other things being equal, continuous grazing, or grazing in paddocks for long periods during the growing season each year, may lead to undesirable changes in botanical composition or a reduction in plant cover, or both.

Mentis (1982) stated that it was explicit or implicit in much of current theory on local pastoralism that plants differed in their tolerance of grazing. Consequently, the proportional species composition of veld may change in response to the grazing regimes applied (Mentis, 1982).

In a review of experiments comparing systems of grazing management in various parts of the world, Gammon (1978) drew the following conclusions:

- there was no conclusive experimental evidence to indicate the superiority of any one form of rotational management system over any other (in terms of animal production or rangeland condition);

- none of several rotational systems reported on produced consistent benefits over continuous grazing
  - when there were benefits, these were of a modest order and continuous grazing, in fact, frequently produced a higher output of animal products than rotational systems (Gammon, 1978).

Hardy and Mentis (1986) reported that during the early part of the growing season, animals on sourveld performed better under continuous than rotational grazing on veld with a "poor" species composition. The only long-term grazing system experiment in the vicinity of the present study area, is that at Towoomba Research Station, near Warmbaths (lat 24° 54'S long 28°20'E). This experiment, initiated in 1934, was evaluated in 1971 (Louw, 1973), and subsequently in 1982 (Donaldson and Rootman, 1983). The experiment compared the effect of different seasonal grazing/resting combinations on the composition of the herbaceous layer and on animal production. The results indicated that grazing during the early growing season generally had a "detrimental" effect on the composition of the herbaceous layer, the more palatable species such as Digitaria sp, Brachiaria eriopedata and Themeda triandra were replaced, over the period of the study, by generally less palatable species such as Aristida spp. and Cymbopogon sp. (Louw, 1973). O'Connor (1985) in a review of experiments concerning the grass layer in savanna regions, concluded that fluctuations in species composition were the norm in savannas, and were related to the degree of rainfall variability. Grazing exercised an indirect effect.

From the foregoing, an important point emerges : the effect of various rotational grazing/resting systems on the herbaceous composition does not always appear to be clearly distinguishable from that due solely to grazing intensity (i.e. differing stocking rates). Should this in fact be so,

it is perhaps surprising to note that historical emphasis in the development of grazing management systems in South Africa has been towards the definition of the "optimum" rotational grazing system (as relates to, for example, the number of paddocks, period of occupancy, etc.). The numerous management systems periodically propagated (and often subsequently retracted) and even the present debate surrounding the merits of short duration grazing (as advocated by Savory, 1983) versus controlled selective grazing support the observation of the 1981 Committee on Pastures that most management recommendations relating to savanna regions were based on "personal observations, superficial research results and speculation."

This does not imply that the importance of stocking rates has been neglected. On the contrary, "overgrazing" (implying too high stocking rates) as a cause of veld deterioration has been a recurring theme in rangeland management philosophy. What is being postulated is that, in the past, an inordinate effort has gone into comparing and arguing the effects and relative merits of various grazing management systems; into propagating multi-camp systems through extension, while in fact evidence in support of the benefits accruing from the implementation of such systems is not conclusive (cf Gammon, 1978).

The effect of the above scenario is that the savanna rancher

is (and has been) faced with an array of management options, sometimes conflicting, rarely conclusive.

As far as the situation in other sub-tropical rangeland areas of the world is concerned, the erection of fences and implementation of rotational grazing systems does not appear to have developed to the extent that it has in southern Africa. In Australia, for example, Wilson, Harrington and Beale (1984) stated that systems of rotational and deferred grazing were rarely applied. These authors further stated that past experimentation revealed that rotational grazing systems "do not improve short-term animal production", and that grazing management systems should not be considered to be a general palliative for overgrazing - foremost considerations should be given to the overriding effects of stocking intensity (Wilson et al, 1984). They stated that as the economic benefits from a rotational grazing system were usually modest, and the period needed to show that advantage was long, such grazing systems would be applicable in only a few range types. These authors concluded that it was unlikely that advantage would arise from fixed rotational grazing systems, which were often based on "dogma rather than the requirements of the pasture species" (Wilson et al, 1984). Noble (1986) pointed out that in range ecosystems the abiotic environment often dominated and masked interactions between the biotic elements. He further illustrated the role of the fortuitous co-occurrence of several low probability events in triggering changes in arid

ecosystems.

With reference to American rangelands, which have allegedly undergone spectacular degradation, Heady (1975) concluded that "control of animal numbers is the most important single tool available to the rangeland manager". The emphasis in America has, in the past, been on the reclamation of degraded rangelands, rather than on the development of rotational grazing systems. More literature existed on range seeding, than on any other practice in range management (Heady, 1975).

The purpose of the studies reported in this section was to establish the relations between grazing management system applied in the past, and current "veld condition" as expressed by herbaceous composition and woody canopy spread cover.

2.1.1 Controlled selective grazing (CSG)

The Department of Agriculture and Water Supply, through the medium of the extension and information services, propagates the use of the controlled selective grazing management system (CSG). The underlying theory of this grazing system holds that light defoliation of only the palatable component

of the herbaceous layer would stimulate such species. Non grazing of unpalatable species would result in such species becoming moribund. The dual purpose of rangeland improvement and increased production per head of animal would thus be served. However, as far as the grass layer is concerned, the theory has not been tested experimentally, and is based on what may best be described as "gut feeling".

2.1.2 Assessment of rangeland condition

The term "rangeland (veld) condition" is used, in current South African rangeland management, to describe "the state of health of a particular sample of veld" (Tainton, 1981). However, this seems to be a subjective, normative concept:- implicit in the definition and usage of the term is the connotation of grazing utilization. In other words, a value judgement relating to the particular form of land use applied. It follows then that rangeland in "good" condition should result in greater, sustainable animal production, (in terms of the above usage) than should rangeland in a poorer condition. Obviously though, different norms may apply under a differing set of land use objectives (e.g. catchment management, botanical reserves). Throughout this discourse, veld/rangeland condition is used in the above sense.

The procedure commonly used to assess rangeland condition in

South Africa is based on the measurement of the species composition of the veld and its basal cover (Tainton, 1981). Tainton (1981) further stated that:

> "since the basis of veld condition assessment is the comparison of the veld of a particular site with veld in the same ecological zone which is in optimum condition, the first requirement... is to define the nature of such optimum veld."

This is then done by selecting sites in which the veld is in excellent condition. Such sites are known as benchmark sites, and all veld within the same ecological zone can be rated against such benchmark sites (Tainton, 1981).

The above method has been mainly utilized in the grassland areas of Natal, although Tainton, Edwards and Mentis (1980) asserted that the method seemed to apply equally well to the analysis of the herbaceous layer of bushveld (savanna) communities.

In Karoo areas, however, research has shown that this method of assessing veld condition was not suitable, in that similar results were obtained for ecologically dissimilar sites (Vorster, 1982). A method based on the indexing of plants according to their "ecological status", namely the

Ecological Index Method (EIM) was developed for application in Karoo vegetation (Vorster, 1982). This method differs from that employed in grassland areas in the sense that the contribution of each "ecological group" to the botanical composition is expressed in terms of actual (aerial) cover and not in terms of relative cover or nearest plant data (Vorster, 1982). Botanical cover and composition are thus used as one indicator and not two, as in the case of the grassland technique described by Tainton (1981).

As far as can be ascertained, the main problems associated with use of the method described by Tainton (1981) in savanna would appear to be the following:

(i) invariably savanna is characterized by a far greater degree of spatial heterogeneity (in terms of topography, soil and vegetation) than humid grasslands, necessitating an unrealistically large number of benchmarks;

(ii) the assignment of herbaceous savanna species to the various increaser/decreaser categories is even more of a subjective exercise than in other biomes (cf Mentis, 1982);

(iii) classification of woody species into the same categories is a matter which has thus far received scant attention (Westfall et al, 1983).

From the above, it is clear that the assessment of rangeland condition in savanna regions merits further attention particularly if the "benchmark" system is to be used. In that the soil, and more particularly, soil physical and chemical properties, profoundly influences the composition of the vegetal cover, an evaluation of soil status would seem logical. During the present study, the "conventional" approach, namely, measuring herbaceous species composition, was adopted, in line with current practice.

2.2 Methods

2.2.1 Choice of sampling techniques

2.2.1.1 Herbaceous vegetation

In keeping with the objectives of the study, an assessment of the current "condition" of the herbaceous vegetation was required. This value is usually determined by a combination of species composition and basal cover (Tainton, 1981). Mentis (1982) has, however, questioned the measurement and subsequent use of basal cover values. The arguments raised by Mentis (1982) based on research in moist grasslands, would appear to hold for semi-arid savanna. Mentis (1982) asserted that the measurement of basal cover was subject to

operater bias and was poorly repeatable. Indeed, given that recorded values of basal cover in such regions are generally about half those recorded for humid grasslands, the validity of such measurements is probably even more questionable.

In order to assess the use of basal cover, several sites (farms) were sampled initially, using a bridge point with 15cm spaces between adjacent points. This distance is greater than the size of the majority of grass tufts, so that double counting of a tuft was not likely. This spacing does not however cater for any possible influences of tufts on neighbouring tufts. Two thousand points were sampled per site. Follow-up measurements, on the same sites, were made 12 and 18 months later. On the basis of results obtained, it was decided not to use the data. The inter-seasonal variability together with the number of points needed for statistically valid comparisons further support Mentis's (1982) argument against the use of this technique, still however widely used by rangeland scientists.

After evaluating eight methods of botanical analysis on grassland in Acacia spp thornveld, Walker (1970) concluded that:

> "frequency was the only method to provide acceptable estimates of the importance of all (herbaceous) species without the expenditure of

excessive amounts of time".

In this study, proportional species composition of the herbaceous layer was accordingly measured using frequency of occurrence in quadrats.

2.2.1.1.1 Size and number of quadrats

Theoretical considerations underlying the choice of quadrat size require that size should be such that a frequency of occurrence of ca 86% is recorded for the most abundant species (Walker, 1970). Preliminary trials, using nested quadrats, indicated the use of a 1m x 0,5m quadrat.

At each site (farm), 200 randomly located quadrats were placed.

2.2.1.2 Woody vegetation

At each placing of the bridge point apparatus, upward vertical projections were made. The number of points falling under the canopy of each woody species was recorded. In this manner, percentage canopy spread cover (CSC) was obtained.

2.2.2 Choice of sampling site

The limits of the selected vegetation type (Combretum apiculatum woodland) were obtained from the Thabazimbi Extension office (based on the work of Coetzee, 1971). The entire area was reconnoitred, and the 42 farm units within the area that met the criteria described on page 12, were plotted on a 1:250 000 topocadastral map of the area.

Each unit was visited, and, whenever available, a map of the farm layout (paddocks, roads, passages, drinking troughs and dips) was examined together with the farmer. Paddocks forming part of a rotational grazing system were randomly selected. Visual inspection followed - "atypical" paddocks (eg markedly hilly topography, drainage lines, vleis, heterogenous soil types, other vegetation types) were excluded, as were markedly smaller or larger than average paddocks, such as maternity and nursing paddocks.

Within paddocks thus selected, intensive vegetation sampling was conducted as described, during the period December 1982 to March 1983. The rest of the ranch was traversed and subjectively rated. Farm size, management systems, physical planning, production systems, number of cattle and certain "sociological" variables (eg education, experience, motivation etc) were also quantified. Detailed explanation of the methods used to quantify these variables is provided in section 3.2.

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