A SOCIO-ECOLOGICAL STUDY FOR THE MANAGEMENT OF THE MTHETHOMUSHA GAME RESERVE AS A TRIBAL RESOURCE AREA

BY

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Opsomming

Die meeste bewaringsgebiede in Suid-Afrika, veral met die politieke vernuwings wat plaasvind, is verplig om die sosio-ekonomiese situasie waarin die omringende bevolking hul bevind in ag te neem. Die bestuur van die Mthethomusha wildtuin in KaNgwane poog, daarom, om aan die behoefte van die plaaslike bevolking te voorsien, terwyl daar steeds aan die bewaringsdoelwitte voldoen word. Ten eerste was daar 'n sosiologiese studie onderneem om die demografiese profiel van hierdie mense vas te stel. Verder is daar gepoog om vas te stel wat die behoefte van die mense is t.o.v. die hernubare hulpbronne in die reservaat en ook wat hul ontwikkelings behoefte is. Om die houtbron kwantitatief te meet is daar eers 'n loots ondersoek gedoen om die hulpbron te lokaliseer. 'n Meer breedvoerige studie was daarna gedoen om die digtheid en deursnee van voorkeur brandhout spesies te meet. Die basis lyn inligting was gekombineer met allometriese afmetings om biomassa te bepaal. Met die inligting was dit moontlik om houtproduksie te beraam.

Die mees ekonomiese manier om die wild as hulpbron te bestuur, is deur die beste spesie samestelling vas te stel wat optimaal benut kan word. 'n Waarde was bepaal vir elke benuttingsvorm, dit sluit in 'n trofee jag-, karkas-, lewendige verkoop- en toeristewaarde vir elke spesie. Die benuttingswaardes is alternatiewelik as prioriteit gebruik in die doelwitprogrammering model wat ontwikkel is, saam met die ekologiese en bestuursbeperkings asook die aannames wat gemaak moes word. Verskeie oplossings is verkry. Die oplossing met trofee jag as prioriteit het die mees geskikte spesie samestelling tot gevolg om aan die wild besigtiging behoefte van toeriste te voldoen en ook die meeste trofee diere vir jag produseer.

Aangesien die oorbenutting van die hulpbron basis die gevolg is van ekonomiese dryfvere, is die enigste manier, om mense se houding teenoor die omgewing te verander, die verandering van hulle ekonomiese omstandighede. Natuurbewarings ontwikkeling moet gesien word as volhoubare ontwikkeling, en al dra die benutting van natuurlike hulpbronne relatief min by tot die ekonomie, beinvloed dit die houdings van mense. Dit is egter met die skep van werkgeleenthede waar daar werklik 'n verskil gemaak word. Dit kan egter net verkry word deur optimale ontwikkeling. Om voorsiening te maak vir regverdige verspreiding van voordele, is dit belangrik om die regte institusionele strukture te skep. Natuurbewarings instansies moet in hierdie omstandighede inisieer en fasiliteer.

Abstract

Many conservation areas in South Africa, especially with the political changes that is taking place, are forced to consider the socio-economic situation of the people surrounding the reserves. The management of the Mthethomusha Game Reserve in KaNgwane therefore aimed at providing in the needs of the people while still maintaining conservation objectives. First a sociological study was under taken to determine the demographic profile of the people living next to the Mthethomusha game reserve and also to determine their needs regarding resources from the game reserve as well as their development needs. The wood resource was quantitatively measured by first having a pilot study done to determine where the resource is located and then a base line study was done where the density and diameter of the different fire wood species were measured. The base line data was then combined with the allometric data to determine biomass. It was then possible to estimate production.

The best way in which the wildlife resource could be managed was to determine the best species composition that could be optimally used. The utilisation values of game which include trophy hunting-, carcass-, live sale- and tourism values were determined, for each species. A goal programming model was developed where the utilisation values were alternatively run as priority with the ecological and management constraints and assumptions. Several solutions were obtained, the solution with trophy hunting as priority resulted in the most suitable species composition to satisfy game viewing and to produce the most trophy animals for hunting.

Because the over-utilisation of the resource base is economically driven, the only way to change people's attitude towards the environment is to change their economic circumstances. Conservation development is sustainable development and although the harvesting of natural resources from conservation areas contribute a little to the economy it influences peoples attitudes. However, job creation makes a real difference. This can only be achieved with optimum development. To allow for fair distribution of benefits, it is important to create the right institutional structures. Conservation agencies have to play the role as initiator and facilitator.

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CHAPTER 1

1.1 INTRODUCTION

The conflict between human needs and nature conservation was recently highlighted with the announcement by the President of Namibia, Mr Sam Nuyoma, that the game in the Ethosha National Park must be "used to feed the nation" during the 1992 drought., (Anon. 1992). This stresses the fact that the crisis in conservation is perhaps nowhere more sharply drawn than in Africa, where the problems of Parks are intimately intertwined with basic human needs and the full range of resource conservation issues which face the continent. (Cumming 1990).

The crisis has its roots in the past where preservation laws were introduced to stop the over-exploitation of our wildlife but where the needs of the local people were not duly considered.

1.2 PRESERVATION

National Parks originated in North America where they were essentially a cultural expression of values about pristine landscapes and nature. In central Africa they originated as game reserves of which many remained as such until today. The first game reserve in South Africa was established in 1849 in the Pongola area (it was de-gazetted later). Three years later four game reserves were proclaimed in Zululand, of which three still exist.

Protective legislation has been rather ineffective and indeed has often had a negative impact amongst the indigenous people of Africa. The history of conservation in South Africa clearly demonstrates the swift about-turn between two extremes; mindless destruction on the one hand and complete preservation on the other. At the time that preservation legislation began to be promulgated, the vast majority of black people in Africa were still dependent on wildlife as a source of food and this legislation made of the hunter a poacher.

Almost invariably the establishment of a conservation area impacted negatively on the local population. Access to the land resources which they had traditionally exploited for food , building materials and medicine, was denied. The Chief Warden of Tanzania National Parks quoted: "The local people were suddenly banned from the parks. And the parks were established with wrong laws." (Abrahamson 1983). The preservation approach resulted in negative sentiments by most locals. Resources that were once important to them became irrelevant because they were denied access to these resources.

Although most of the conservation areas gazetted during the colonial era have been maintained, it is uncertain what the future holds for them. "The parks have always been unpopular with the people of Africa, and the governments of Africa are sufficiently responsive to popular feelings to avoid such disruptions where possible". (Marnham 1981).

1.3 CONSERVATION

International research on the conservation of the environment has, in the last decade, been characterised by an increasing awareness of the role played by human factors, both in the utilisation and in the conservation of the environment. This implies that the various needs of people cannot summarily be dismissed or separated from nature conservation actions (Odendal 1991).

In 1980 the International Union of Conservation of Nature and Natural Resources (IUCN) published the "World Conservation Strategy" (WCS) (Anon 1980a). (See Appendix 3 for list of abreviations). The very word "conservation" was redefined as "the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations." Thus the IUCN recognised the immediate needs of people and pledged itself to assist in satisfying these needs while, at the same time, stressing the importance of ensuring the long-term viability of development (Infield 1986).

The term "natural resource" is not a new concept. The so-called "Arusha Manifesto" which resulted from the famous Arusha Conference in 1961, stated: ".... wild creatures, and the wild places they inhabit, are not only important as a source of wonder and inspiration but as an integral part of our natural resources and of our future livelihood and well being." (Curry-Lindahl 1974). Sustainable use of the renewable natural resources was to be the solution to environmental problems. It is disappointing that so little has been achieved in the field to date.

Infield (1986) justifiably states "The only significant development which has occurred to exploit the value of wildlife in most of Africa is the tourism trade." Tourism aside, the highly vaunted economic rewards of conservation did not materialise. Part of the problem was that the major surviving animal populations were within the parks and reserves where their exploitation was precluded. The rural people are beginning to exert stronger pressure on the reserves in their attempts to satisfy basic needs for food and shelter.

"If the world wishes to conserve natural habitats and genetic diversity, it must enable impoverished rural communities to turn elsewhere to meet their basic needs. Only when these are met can these people afford to relax their pressure on natural resources" (Infield 1986).

By ignoring the needs of the local communities and not involving them in the process of conservation, a situation is created where these areas no longer have any value to the people living around them. This point was recognised almost a decade ago by Hanks (1984) who stated: "Though the point may be debated, I support the contention that no conservation programme can be expected to have a long-term success without the support and assistance of the people living in the vicinity."

The rationale behind the concept is simple. If local communities had a direct stake in conservation areas and were benefitting from their existence, it is reasonable to assume that their perceptions of the reserve would change. (Infield 1986). Any programme of utilisation should as a priority, "aim to improve the life standards and well being of the community in which the reserve is located." (Anon. 1983a).

In Nepal's Royal Chitwan National Park, for example, 83 500 metric tons of thatching grass, valued at U.S. $750 000 are harvested annually by local villages, involving 30,000 to 50,000 people. The harvesting of this grass has become "one of the most powerful educational and public relation tools for the National Parks." (Mishra 1982).

To incorporate the needs of the surrounding people in the management of conservation areas , we need to ask: "To what extent can conservation areas themselves contribute to basic need development in the communities surrounding them?." (Anon. 1983b).

This study aims to answer this question as applied to a conservation area in KaNgwane, namely the Mthethomusha Game Reserve which is a resource area belonging to the Mpakeni Tribe.

1.4 TRIBAL RESOURCE AREAS

The establishing of new areas or even maintaining existing areas became a very serious issue. As the Chief Minister of KaNgwane said "How can we, in KaNgwane, when we are so land-hungry, penalise ourselves by establishing a wilderness sanctuary" (Mabuza 1979). He also felt that it is the bread and butter issues that count in the lives of his people and the "very mention of the words wilderness conservation cannot be made without making oneself irrelevant to the issues of the day". The needs and viewpoints of the local people are important factors that has to be considered in any scientific study into the establishment of sustainable conservation areas in KaNgwane.

The establishment of tribal resource areas was initiated in KaNgwane by the KaNgwane Parks Corporation (henceforth KPC) during 1985. These areas were identified as land not suitable for conventional or traditional agricultural development. Excessive grazing pressure and removal of plant resources for building, medicine and fuel from the natural woodlands in these mountainous areas could lead to severe degradation. The establishment of tribal resource areas results from the KPC's concern for the conservation of these resources.

The establishment of Mthethomusha Game Reserve (henceforth MGR) was based on the following principles:

- the land still belongs to the Mpakeni Tribe,
- the boundaries were negotiated with the Tribal Authority,
- a legal agreement was drawn up between the Tribal Authority and the KPC as well as stating other benefits which will accrue to the tribe from the development and management of the area, and
- the intensive multiple use of the natural system and its resources are therefore clear objectives, be they tourism related or resource harvesting.

The Mpakeni tribe occupies four distinct areas; Luphisi, Mpakeni, Daantjies and Zwelisha. The head of the tribe is Chief Bongani Charles Nkosi with four indunas (Headmen) representing each area comprising the Tribal Authority.

Although the management plan stipulates that the area will be managed to provide for the needs of the surrounding people, it also stipulates that the area will be managed to maintain the character and sustainability of the resources and ecological processes in accordance with the objectives of the WCS.

With the increasing population pressure on the boundaries of the Reserve the harvesting of resources must be carefully monitored and controlled to ensure sustainability. From 1970 to 1980 alone, KaNgwane's population grew from 82 327 to 299 776, which represents an increase of more than 260% within a single decade (Odendal 1991). The MGR is already surrounded by communities which show the highest population density in KaNgwane, and this density appears to be increasing even more.

1.5 AIM OF THIS STUDY

The aim of this study is to devise the best methods for managing a natural resource area in a savanna ecosystem located in a rural tribal area. These methods must ensure the long term viability of these resources while being utilised for the benefit of the surrounding people.

1.6 RESEARCH OBJECTIVES

The research objectives are:

(a) to undertake a social impact evaluation in order:
- to describe the needs and aspirations of the community surrounding this area concerning the utilisation of resources (vegetation and wildlife),
- to describe the attitudes and the perceptions of people surrounding this area concerning the reserve, its resources and the role it could play in the improvement of their quality of life, and
- to develop a sound demographic profile of the community living in proximity to the MGR.

(b) to carry out an ecological survey which will:
- determine on a quantitative basis what plant resources as expressed by the peoples needs, are available to be harvested,
- determine ways to optimise the wildlife resources, and

(c) to determine in conclusion:

- to what extent can the resources in the Resource Area contribute to the needs of surrounding people,
- in what way can other benefits eg. job opportunities and wildlife utilisation profit contribute towards satisfying the basic needs of local people, and
- if the management of the area as a Tribal Resource Area is economically viable compared to other land use options.

1.7 JUSTIFICATION OF THE PROJECT

The rationale underlying the concept of establishing tribal resource areas, is to fulfil conservation objectives, while enabling local communities to continue their traditional utilisation of certain resources within the area. The scope of this study will be concentrated on what animal and plant resources can be produced by this resource area and how management can be adjusted, to obtain maximum benefit from these resources for the surrounding communities. It is felt that an attempt to make this reserve more relevant to these people in economic terms would benefit conservation of this area.

The (MGR) and its surrounding communities were felt to be particularly suitable for this type of socio-ecological study because:

- it is surrounded by dense human populations and increasingly degraded subsistence farming land,
- good relations exist between the KPC and the Mpakeni Tribal Authority,
- it was not fully utilised by the people before the reserve was established due to its mountainous terrain and lack of surface water,
- the Lowveld veld type (Acocks 1975), is representative of most of the veld type in KaNgwane.

- only one tribe is involved in the study, and
- the' area is relatively unspoilt, allowing for realistic projections of the production potential of the resources.

1.8 STUDY AREA

1.8.1 Locality

The Mthethomusha Game Reserve of approximately 7 200 ha, is situated between latitude 25°25' and 25°32' South and longitude 31°11' and 31°20' East. It lies ca. 30 kilometres east of Nelspruit (Fig. 1.1). The Kruger National Park abuts the Mthethomusha Game Reserve on its eastern side. Four villages border the Reserve, Matsulu to the south-east, Luphisi to the north-east, Mpakeni to the south-west and Pienaar to the north-west.

1.8.2 Geology

The greater part of the MGR is underlain by ancient migmatites and potash-rich gneisses. These are foliated rocks representative of the turbulent interaction between the early-formed "granite-greenstone" assemblage of the primeval crust, and contemporaneous intrusive acid igneous activity (Anon. 1986). The rocks show a strong "grain" trending generally in a north-easterly direction and contain scattered, partially digested and shredded remnants of the more basic Swaziland "greenstones". These are present as altered "xenoliths" and "schlieren" which range in size from a few meters to over a kilometre and are caught up and orientated into the fabric of the country gneisses. Older re-crystallised, sodium-rich tonalitic-trondhjemitic augen gneisses also occur along the eastern margin of the area, and form an enclave with less pronounced topography toward the Nsikazi river.

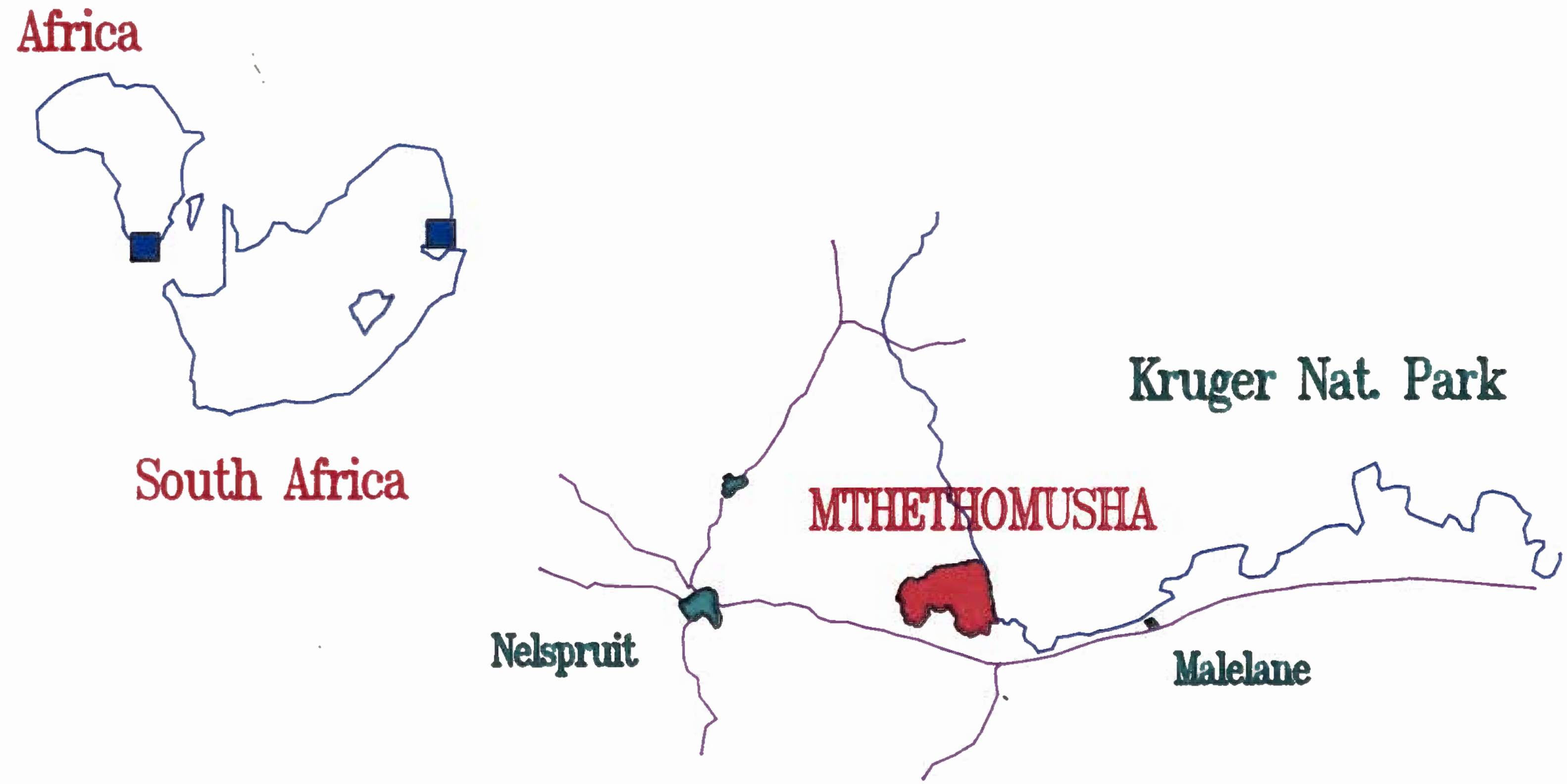

FIG 1: LOCALITY MAP

To the south-west, the relatively younger (2 496 Ma) oval-shaped Mpakeni granite pluton givès rise to rugged topography. This intrusive igneous rock is pink, medium to coarse grained and potash rich. The Mpakeni granite is intruded by medium to fine-grained grey "syenitic" dykes and more recent dark, mafic dykes which invade both it and the surrounding gneisses. These dykes follow an intersecting system of fractures which trend north-east and north-west across the country (Anon. 1988).

Because no known mineralisation occurs in the area, due to the nature of the underlying rock types, the MGR is considered to have no mining potential.

1.8.3 Physiography

The MGR forms part of a mountainous triangle immediately west of the Kruger National Park, at the confluence of the Crocodile and Nsikazi Rivers. The area can be divided into two broad physiographic regions:

- the Nsikazi Highlands, and
- the Krokodilpoort Gorge.

The Nsikazi Highlands, which form the south-eastern corner of the Nsikazi district of KaNgwane, are predominantly mountainous with steep, incised valleys. Altitudes in this area range from 488 m asl to 1034 m asl (Mpakeni). Numerous dry streams dissect the area.

The Krokodilpoort Gorge forms part of the southern boundary of the reserve. The Nelspruit/Komatipoort railway runs through this steeply incised area, where altitudes range from 366 m asl to 1 032 m asl. (Fig. 1.2).

Scale 1:250 000

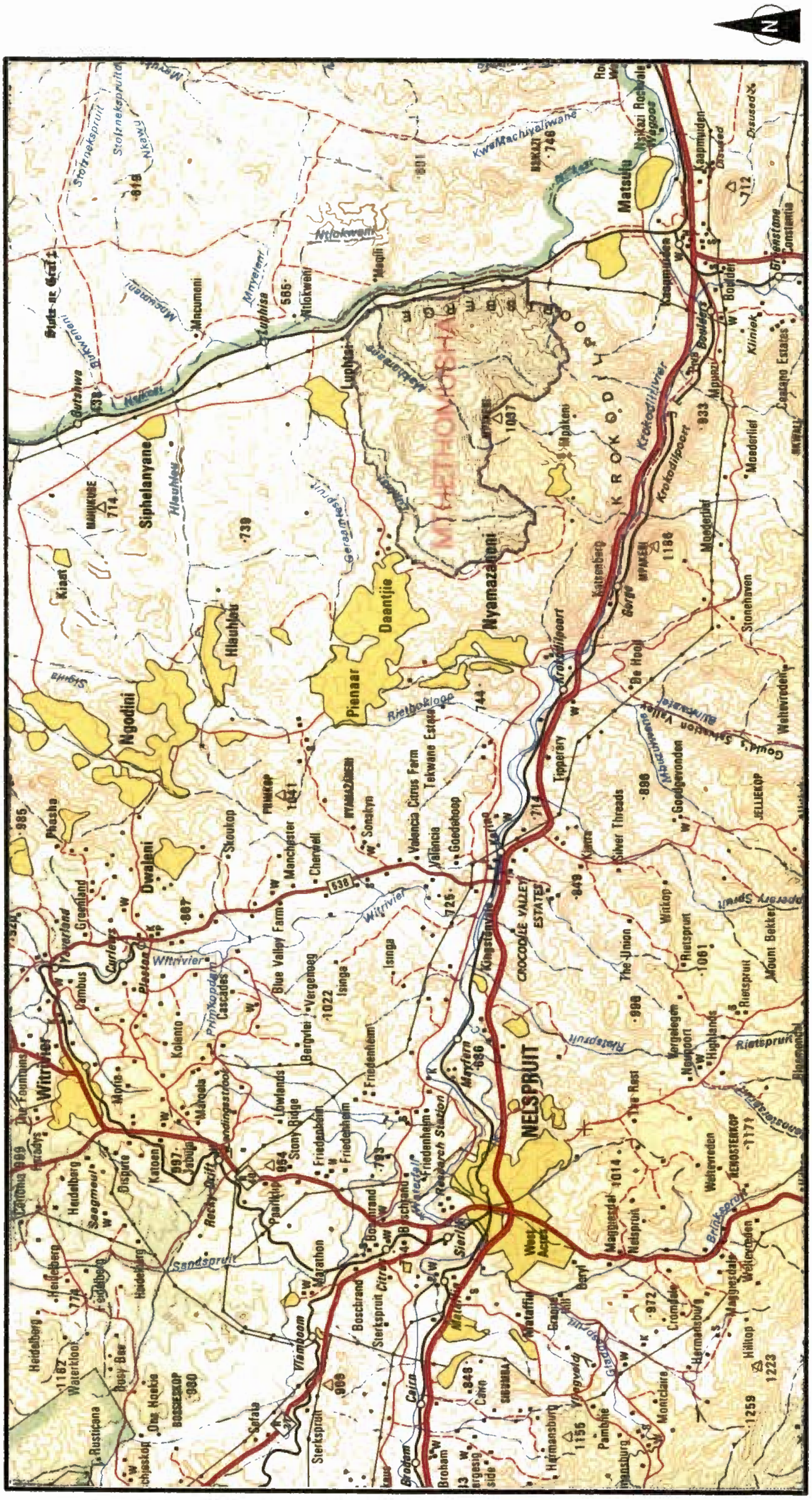

FIG. 1.2. MGR in relation to features named in text.

1.8.4 Climate

At altitudes above 900 m the mean annual rainfall is of the order 800 - 850 mm, diminishing to 650 - 700 mm at altitudes below 500 m. The mean annual rainfall for the MGR overall is estimated at 750 mm which is representative of most of the territory except for the mountain peaks and valley floors.

Maximum temperatures in all these regions are most likely to be attained during the months of October to December. These are likely to exceed 35,6° in the highest areas, but in the lowlands have reached 43,6° (Anon. 1988).

In mid-winter (July) the monthly mean of the daily minimum temperature is consistent throughout the MGR ranging from 6,9° in the highlands to 6,3°C in the lowlands.

1.8.5 Surface Water Resources

Numerous small drainage lines run in an easterly direction from within the MGR towards the Nsikazi river. These constitute the surface water resources of the MGR and can be divided into three principal drainage regions.

Although only 30 km² of MGR comprises part of the Luphisi Catchment, this water course, together with its tributary the Geraamtespruit, forms a large catchment (88 km² in size).

The second largest drainage region within the MGR is the Makhomane catchment. This river drains an uninhabited relatively wild region 23,2 km² in extent and flows towards the Nsikazi which it joins just outside the north-eastern boundary of the reserve. It is significant because 91,2% of the catchment lies within the MGR. This reduces the external catchment influences to a minimum, and makes the prospect of managing the area for conservation more feasible. Nothing is known about the seasonal flow of the river or the quality of the water.

The Sigabule river system (named only on the 1:250 000 map series) is almost wholly contained within the boundaries of the MGR. Its overall catchment size is only 12.3 km², of which 92% lies within the reserve. On these grounds it can be regarded as the third most important catchment in the MGR.

These streams generally carry very little water. This is because they drain a granite area which is characteristically devoid of underground resources or recharge areas, and is so steep that there is little opportunity for rainfall retention or similar processes which would regulate stream flow (Anon. 1988). Because of the outward flowing drainage pattern there is little danger of any possible adverse effects from pollution arising outside the MGR.

Other than the catchments mentioned above, the MGR is characterised by several minor streams that drain eastwards into the Nsikazi. Collectively these catchments comprise 9,65 km² of the MGR. They are low order streams on steep gradients and therefore likely to be characterized by high stream velocities following storms. They are dry for most of the year.

1.8.6 Vegetation

The vegetation of the MGR is characteristic of the Lowveld veldtype. (Acocks 1975). Gertenbach (1983) classifies this area as part of the Malelane mountain bushveld landscape.

Three major woodland types can be distinguished at Mthethomusha (Stalmans pers. comm.):

- low-elevation woodlands occur between 350 and 550 m elevation and have strong affinities with the arid/eutrophic savannas (Huntley 1982). Dominant species include the following trees; *Acacia nigrescens, Combretum apiculatum, Combretum collinum, Sclerocarya birrea* and *Lannea discolor*. Important grasses are *Themeda triandra, Heteropogon contortus, Eustachyus paspaloides, Digitaria eriantha, Eragrostis regidior* and *Panicum maximum*,

- mid-elevation woodlands occur between 550 and 750 m elevation. They are transitional between the low and high-elevation woodlands. Dominant woody species include *Dichrostachys cinerea, Combretum apiculatum, Pterocarpus rotundifolius, Rhus leptodictya, Vitex* sp., *Sclerocarya birrea* and *Strychnos madagascariensis*. Dominant graminoids are *Heteropogon contortus, Themeda triandra, Hyperthelia dissoluta* and *Panicum maximum*.

- high elevation woodlands are found above 750 m elevation. Dominant woody species are *Faurea saligna, Acacia davyii, Sterculia murex, Combretum molle, Heteropyxis natalensis, Pavetta edentula* and *Faurea speciosa*. Dominant graminoids are *Themeda triandra, Loudetia simplex, Trachypogon spicatus, Hyperthelia dissoluta, Setaria sphacelata, Panicum maximum* and *Tristachya leucothrix*. The high elevation woodlands belong to the group of moist/ dystrophic savannas (Huntley 1982) and are very sour.

The acceptability of the vegetation to the herbivores is linked to the woodland type. The low-elevation woodlands are generally favoured by most species with the exception of mountain reedbuck *(Redunca fulvorufula)*.

The reduction in nutrient value and palatability with age of the grasslayer in higher-lying areas is very evident in the pattern of use by the herbivores. Newly burned areas in the sour-veld are intensively used in spring and early summer, but are generally abandoned later in the season.

1.8.7 Land use history

The MGR was identified as an area with little or no agricultural value (Anon. 1980b). The reserve is largely mountainous and there is a severe shortage of water. Very few pastoralists made use of this area because of the lack of water and the inaccessibility of the terrain. Despite these drawbacks the area was suited to the establishment of a game reserve. The KPC negotiated the establishment of the MGR with the tribal authority during 1985 (Anon. 1986).

1.8.8 Fauna

The following game species have been reintroduced into the MGR: *Loxodonta africana* (elephant), *Ceratotherium simum* (white rhino), *Syncerus caffer* (buffalo), *Giraffa camelopardalis* (giraffe), *Kobus ellipsiprymnus* (waterbuck), *Equus burchelli* (zebra), *Tragelaphus strepsiceros* (kudu), *Tragelaphus angasii* (nyala), *Aepyceros melampus* (impala), *Phacochoerus aethlopicus* (warthog), *Procavia capensis* (rock dassie) and *Connochaetus taurinus* (blue wildebeest), *Hippotragus niger* (sable), *Taurotragus oryx* (eland) and *Panthera leo* (lion).

Species which occurred naturally in the area were: *Oreotragus oreotragus* (klipspringer) *Potamochoerus porcus* (bushpig), *Sylvicapra grimmia* (grey duiker), *Raphicerus campestris* (steenbok) and *Redunca fulvorufula* (mountain reedbuck) as well as a few *Tragelaphus strepsiceros* (kudu), *Panthera pardus* (leopard) and *Papio ursinus* (chacma baboon).

CHAPTER 2

A SOCIAL IMPACT EVALUATION FOR THE MANAGEMENT OF MTHETHOMUSHA AS A TRIBAL RESOURCE AREA

2.1 INTRODUCTION

The sociological portion of this study forms part of the original research proposal. This sociological research was undertaken in co-operation with Afrosearch. This chapter summarises the sociological research report by Odendal (1991) in order to provide the perspective for the ecological and economic sections of the study.

2.2 METHODOLOGY

The application of western research methodologies within the Third World context creates a number of problems. Lent (1985) describes factors which should be taken into consideration when doing research in developing communities. These relate to:

- the lack of applicability of the usual quantitative (questionnaire) type of research methods used for obtaining information due to constraints imposed by factors such as cultural orientation, communication ability, level of literacy, etc.;

- specific characteristics of the population such as age distribution, urban/rural components, number of persons engaged in migrant labour, etc.;

- the nature of the phenomenon being studied and factors which have an effect on obtaining honest answers to direct questions in questionnaire- or interview-based studies;

- the problem is frequently encountered in research where attitudes measured in questionnaires and in interviews do not necessarily hold a consistent relationship with behaviour. The questionnaires and interview schedules *per se* thus provide us with very little insight into the cultural determinants that 'colour' the respondent's view of his environment and the way in which he reacts to it;

- the fact that Lent (1985) states that it is "patently absurd" to assume that one can give a carbon copy of an interview schedule to different cultures, as methods of data collections differ because of language and culture; and

- the phenomenon encountered in practice that, depending on particular cultural dynamics in play, women sometimes do not express their opinion since they believe their opinions are less important than those of their husbands.

As a result of the above it is usually recommended that research in developing areas be done by means of qualitative data collection methods, or techniques which combine qualitative and quantitative techniques rather than using only quantitative techniques (Lent 1985).

Qualitative research methods (indirect techniques of data gathering) make use of specific strategies which allow respondents to answer questions without feeling discourteous, embarrassed or threatened. Direct questions are avoided and instead projective techniques are used which are regarded as 'safe' to respondents. This allows for the exploration of specific areas of potential conflict by, for example, the use of photographs or other visual material which should be sorted in order of preference, etc. The underlying rationale is to supply an open-ended and unstructured stimulus (e.g. a picture) to the respondent, and give him the opportunity to elaborate freely on what he sees. Viewed from the perspective of communication, projective techniques offer the most effective way for the researcher and respondent to communicate their specific needs.

Four sets of projective drawings were developed which were used to study the following issues:

- the environmental knowledge of the members of the local community. In this regard the respondents were requested to identify mammals from drawings given to them, as well as grass and tree species shown to them;

- needs and perceptions in respect of the utilisation of natural resources from the reserve. These needs included the utilisation of thatch grass, muti , wood-fuel, honey and venison;

- the needs and perceptions of the local people to utilise facilities within the reserve. These needs include visits to the lodge, sleeping at the lodge, game watching, picnicking within the reserve, environmental education, the visiting of graves within the reserve; and

- the needs and perceptions of the community in respect of the utilisation of funds generated within the reserve and deposited in a community conservation trust. The community needs that were compared were : the building of schools; the building of clinics; the building of day care centres; job creation; the creation of communal gardens; the enhancement of the planting of trees by individuals; the planting of woodlots; the improvement of the water supply within communities; and the improvement of electricity supply within communities.

The cards utilised in this regard were created by an artist and these artistic impressions were taken to the community in a pilot survey. The impact and efficiency of the drawings were tested and evaluated until a final set of protocol cards, which could be regarded as an accurate measuring instrument, were created. These protocol cards were then given to the KPC for ratification.

In the application of the protocol cards the respondents had to indicate their preferences by sorting the cards, as well as supply demographic information and answer basic questions. The main body of research was undertaken during August 1990 and members of the community, who held a minimum of a matric qualification, were trained to serve as field workers. The interviews were recorded in the respondents home language. These field workers were supervised by the researcher and his collaborators and the researcher is satisfied that the findings represent an accurate description of the perceptions, attitudes and needs of members of the local community.

The typical problems normally associated with sampling procedures in rural Third World settings (Eapen 1979), were clearly illustrated in the area around the MGR. Population statistics for this area are inadequate and outdated. This situation was compounded by the constant influx of refugees from Mozambique. No recent maps of the three villages selected for the study were available and sampling procedures had to be adapted in order to develop as accurate and scientific a sampling grid as possible under the circumstances. In utilising ortho-photographs of the region, the various blocks in the villages were used to develop a grid for obtaining a relative representative sample of the region. Equal sections were allocated to the field workers, who had to approach respondents in every third house. Information obtained from the questionnaires was adapted for computer by members of Afrosearch cc. and the SAS data analysis system was used by the Department of Statistics, Unisa to analyze the results.

2.3 DEMOGRAPHIC PROFILE OF THE STUDY AREA

2.3.1 Introductory comments

A total of 1 100 people were interviewed in the towns of Daantjie, Mpakeni and Luphisi during August 1990. Of these 1 100 questionnaires, 970 were utilised with 718 derived from Daantjie and 126 each from Mpakeni and

Luphisi. The sample has an equal number of males and females scattered over the age group categories 16 to 19 years, 20 to 39 years, 40 to 59 years and 60 years and above.

2.3.2 Demographic summary of the villages

2.3.2.1 Daantjie village

The village of Daantjie is on the south-eastern border of the MGR and is linked to KaNyamazane. High levels of modernisation exist in the town in that the transport network enables residents to have a very high level of mobility. The infrastructure in terms of roads, electricity and water supply is much better than that of villages of Luphisi and Mpakeni. Their medical infrastructure is sound as there are three clinics which are operational in the area on a permanent basis. In addition the residents have access to a regional hospital. Preventative primary health care programmes have been launched and are operational (no real medical statistics could be generated because of the fact that this is incorporated into KaNyamazane). There is a very good infrastructure in terms of schools and literacy levels are much higher for Daantjie than for the other two villages. Overall one could say that the socio-economic structure of the village of Daantjie is sound and relatively well integrated when compared to the other two villages.

This probably explains the fact that no really crucial problems were identified in this village during this study. Neither did the formation of the MGR really impact on the people of Daantjie by loss of land. The extremely high population density in the town of Daantjie results in residents having very little contact with the natural environment. The relative neutrality of the residents of Daantjie concerning environmental issues could most probably be explained by the fact that a high level of modernisation exist in the town, that the infrastructure is of such a nature that the people are not truly in a battle for survival and that they can sustain their quality of life by means other than depending directly on the natural environment.

2.3.2.2 Luphisi village

The village of Luphisi is on the north-eastern border of the MGR and the majority of people lead a very traditional life. There is an extremely poor infrastructure in terms of transport in Luphisi. The infrastructure in terms of roads and the provision of water and electricity is relatively poor. There is a fair medical infrastructure in that there is one well equipped clinic in the town. It is interesting to note that tropical diseases and gonorrhoea are far more prevalent in Luphisi than in the other two towns and this would suggest that the preventative medical infrastructure needs to be improved. There is one primary school in Luphisi. Of these three towns, Luphisi appears to have the highest number of migrant labourers. The vast majority of the adults living in Luphisi work at the Delta Manganese Company in Nelspruit and a gradual process of disintegration of traditional family structures can be predicted. (Odendal 1991). The socio-economic status of residents in the village of Luphisi is extremely poor when compared to other regions. It should be kept in mind that the people still tend to uphold a traditional lifestyle and this appears to neutralise the negative impact of a poor infrastructure to some extent. The residents of Luphisi still have sufficient access to the natural environment. The land lost to the MGR was largely utilised for grazing. The area around Luphisi is, however, still relatively intact and no real need exists to extend the parameters of the town at this stage. Most of the people in the town own cattle and, at this stage, it would appear that the cattle owners have enough land to graze their cattle.

The most outstanding features obtained from the demographic questionnaire suggest that, on average, the residents of Luphisi are significantly older than the residents of the other two towns, that the educational standard in the town is extremely low and that the people remain largely involved in traditional utilisation practices concerning the environment.

2.3.2.3 Mpakeni village

The village of Mpakeni lies on the south-western border of the MGR. It is very difficult to evaluate the level of modernisation in this village. Despite the fact that it is relatively isolated geographically, the village has all the signs of the typical problems normally associated with a village in transition towards modernisation and urbanisation. Mpakeni's isolation has severe negative effects on the transportation infrastructure, the "roads" are in an extremely poor condition and the extreme poverty in the town impacts negatively on the availability of funds to use public transport.

There is no electricity infrastructure in the village and there is only one pump with fresh water in a village with at least 1 500 residents. Medical service infrastructure in the town is very poor in that a mobile clinic is only scheduled to visit the town every second week. Despite this schedule, it was found that the service is extremely erratic and no statistics of any nature could be generated in order to assess the medical status of the community. There is one primary school in Mpakeni and the general socio-economic status of the village could be described as extremely poor.

On the basis of an analysis of the demographic profile and questionnaire results it would appear that several social issues have become problematic at Mpakeni. The educational status of the community is very low. 74% of the residents of this village are unemployed and it is significant to note that far more adult males are to be found in Mpakeni than in the other two towns. Most of the residents in the town do not support a traditional way of life and this is illustrated in the confusing array of architectural styles to be found in this town. The residents of the village tend to be strongly opposed to the formation of more game reserves in KaNgwane. This may be related to the fact that most of the family graves within the MGR are close to Mpakeni, and that they lost proportionally most land.

2.4 THE NEED FOR UTILISATION OF NATURAL RESOURCES FROM WITHIN THE RESERVE

A projective sorting technique was designed and applied on the basis of a similar technique which had been used successfully in previous studies (Odendal 1988). Respondents were requested to sort various natural resources which could be utilised from the MGR in order of personal need and preference. The following natural resources were offered for comparison and sorting:

- fuelwood
- thatch-grass
- meat (venison)
- muti (traditional medicine) and
- honey

The respondents were also requested to indicate what other resources they wanted to utilise from the reserve. Nothing significant was identified in this regard. The need for the utilisation of the different resources is illustrated in Table 2.1.

Table 2.1 The need for the utilisation of different resources from the MGR. Data adjusted from accumulative percentages (Odendal 1991) to weighted average

Natural Resources	Weighted Average
Meat	74
Fuelwood	64
Muti	58
Thatch grass	56
Honey	47

From the survey it is clear that the people regard meat as the most important resource with fuelwood as second most important. Muti and thatch grass differs only by two points in third and fourth place. Honey is the least important.

2.4.1 The need for the utilisation of fuelwood

The need for the utilisation of fuelwood is illustrated in the Table 2.2:

Table 2.2 The need for the utilisation of Fuelwood

Rating	Frequency	Percentage	Cumulative frequency	Cumulative percentage
1	223	23,0	223	23,0
2	217	22,4	440	45,4
3	230	23,7	670	69,1
4	130	13,4	800	82,5
5	170	17,5	970	100,0

The first column of Table 2.2 indicates the level of priority assigned to fuelwood ranging from first to fifth priority. Level 5 therefore indicates a "least preferred" rating. The third column shows the percentage of respondents who rated fuelwood in accordance with the levels of priority set out in the left hand column. The strongest need for the utilisation of woodfuel is found amongst respondents from the village of Mpakeni. The poor electricity infrastructure at Mpakeni appears to reinforce this demand. The lowest need was expressed from the village of Luphisi. This may be explained by the fact that the people of Luphisi still have access to fuelwood from their immediate environment.

2.4.2 The need for the utilisation of thatch-grass

The need for the utilisation of thatch-grass is illustrated in Table 2.3.

Table 2.3 The need for the utilisation of Thatch-grass

Rating	Frequency	Percentage	Cumulative frequency	Cumulative percentage
1	155	16,0	155	16,0
2	180	18,6	335	34,5
3	182	18,8	517	53,3
4	264	27,2	781	80,5
5	189	19,5	970	100,0

It is significant to note that the respondents from Mpakeni again express a stronger need for the utilisation of thatch grass as compared to the respondents from the other two villages. It is once again found that variables such as age, gender, educational standard and ownership of cattle do not show any significant correlation with the variable thatch grass. An in-depth analysis of the respondent group who rated thatch grass as the most important commodity from the MGR shows a high incidence of support for maintaining a traditional way of life and having lived in the region for a far longer period than other respondent categories.

2.4.3 The need for the utilisation of venison

The need for the utilisation of venison is illustrated in Table 2.4.

Table 2.4 The need for the utilisation of Venison

Rating	Frequency	Percentage	Cumulative frequency	Cumulative percentage
1	367	37,8	367	37,8
2	210	21,6	577	59,5
3	205	21,1	782	80,6
4	115	11,9	897	92,5
5	73	7,5	970	100,0

The communities around the MGR rate the utilisation of venison from the reserve as a high priority as compared to other resources.This appears particularly true for the village of Luphisi in that nearly 50% of all the respondents, who rated venison as the most important commodity, came from this village. It is interesting to note that there is a tendency for younger people to rate venison as a higher priority. It is very important to note that respondents from this category did not visit the area before it was fenced or subsequent to its formation.

They show very little insight into the mechanisms of the functioning of the reserve and do not support the formation of new reserves in KaNgwane as strongly as the rest of the sample. There appears to be a strong correlation between the utilisation of venison and the utilisation of muti.

The above information suggests that the need for venison is based on nutritional needs rather than anything else. (Odendal 1991).

2.4.4 The need for utilisation of herbal medicines (muti)

The following table indicates that the need for the utilisation of herbal medicines from the MGR does exist although not as strongly as the need for venison and fuelwood.

Table 2.5 The need for the utilisation of Muti

Rating	Frequency	Percentage	Cumulative frequency	Cumulative percentage
1	124	12,8	124	12,8
2	248	25,6	372	38,4
3	171	17,6	543	56,0
4	261	26,9	804	82,9
5	166	17,1	970	100,0

2.4.5 The need for the utilisation of honey from the MGR

As seen in Table 2.6, there is not a strong need for the utilisation of honey.

Table 2.6 The need for the utilisation of Honey

Rating	Frequency	Percentage	Cumulative frequency	Cumulative percentage
1	101	10,4	101	10,4
2	115	11,9	216	22,3
3	177	18,2	393	40,5
4	198	20,4	591	60,9
5	379	40,0	970	100,0

2.5 THE NEED FOR THE UTILISATION OF FUNDS FROM THE CONSERVATION TRUST

2.5.1 General introduction

According to the agreement with the tribe a substantial amount of money will be allocated to a conservation trust fund for the tribe for leasing the land as well as from hunting and the sale of animal products. This money is designated for utilisation by the community to improve specific facilities. An initial amount of R25 000 was allocated to this fund and has been earmarked for the building of a day-care centre for children. Decisions regarding the allocation of funds to specific projects are made by a committee representing the community. The KPC has also representation on this committee. As from 1993 an amount of R60 000 will be allocated to this fund annually for renting the land from the tribe. A percentage of the annual hunting quota will also be allocated to this fund. For the 1993 season it amounted to R39 000.

Preliminary research, as well as fieldwork, indicate that there is confusion in the community concerning all the aspects related to the utilisation of this money.

The following nine issues which were generated within the community and ratified by the KPC, were compared:

- the creation of job opportunities;
- the building of schools;
- the building of clinics;
- the building of day-care centres;
- the improvement of the infrastructure for fresh water;
- the improvement of the infrastructure for electricity;
- the planting of woodlots to be utilised for building material as well as woodfuel;
- the encouragement of the planting of communal gardens; and
- the encouragement of the planting of fruit trees at the individual homes of members of the community.

The results presented in Table 2.7, were generated by this section of the research.

Table 2.7: The needs for the utilisation of funds from the conservation trust. Data adjusted from cumulative percentage (Odendal 1991) to weighted averages

Variables	Weighted average
Job creation	78,8
Schools	70,3
Clinics	67,0
Water	58,3
Creches	51,9
Electricity	48,0
Gardens	42,0
Trees	42,0
Woodlots	41,2

2.5.2 Employment creation

Only 49,3% of all the respondents are presently employed. It is therefore not surprising that the majority of the respondents rate job creation as the most important option for the distribution of money from the conservation trust. (Odendal 1991). This need was especially strong in the village of Daantjie. The villages of Mpakeni and Luphisi did not rate this category as the most important priority, despite the low levels of employment in these villages. The variables such as gender and educational standard did not show any significant correlation with the variable job creation. A significant correlation, however, was found in respect of job creation and the variables of age and period of residence in the area. These respondents were predominantly in the younger age group and have resided in the region for a long time. (Odendal 1991).

They did not support the development of more game reserves in KaNgwane, but showed a high level of insight into environmental issues. This information would tend to support the hypothesis that the people did not necessarily expect job opportunities within the reserve, but rather that they were looking at the creation of job opportunities outside the reserve by means of the utilisation of available funds.

2.5.3 The need for the creation of more schools

When the results of the first five categories are taken into consideration it is evident that the local people regarded this need as relatively important. In a comparison of data between the three villages, Daantjie was identified as the village which saw the establishment of more schools as a very important issue. (Odendal 1991). This is probably related to the high level of urbanisation which exists in this region, the modernisation needs within this particular village, and pressure placed on the secondary school by pupils from Mpakeni and Luphisi. The villages of Luphisi and Mpakeni did not clearly show a need for more schools and the results would appear to indicate that there was adequate provision for schooling in these areas. Despite this it should be remembered that the only secondary school is in Daantjie and that the children from Mpakeni and Luphisi go there for schooling.

2.5.4 The need for the creation of clinics

The information reflected in Table 2.7 shows more or less the same type of information as that obtained from the results with regard to the need for the building of schools. As could have been predicted from the information provided in the demographic overview of the communities, it is evident that the strongest need for the building of clinics is found in the village of Mpakeni.

2.5.5 The need for the creation of day-care centres

The results obtained in this category indicate that the need for the development of day-care centres is not rated as highly as either the need for the building of schools or for clinics. It is significant to note, however, that the Mpakeni village has already previously shown a high need rating in this regard. The fact this need manifested itself most strongly at Mpakeni, could probably be explained by the fact that the people in Mpakeni appeared to attach very little importance to the maintenance of a traditional lifestyle.

2.5.6 The need for the improvement of the infrastructure for fresh water

The fact that the Mpakeni village has only one equipped water point, makes it obvious that the majority of people who rated the establishment of water supplies as critically important, would come from this town. It is recommended that this basic need at Mpakeni should be regarded as the single most important priority in all the communities at present.

2.5.7 The need for the improvement of the electricity infrastructure

The need ratings obtained in respect of this particular category do not appear to indicate that there is a significant need for the improvement of the electricity infrastructure at this stage.

It is interesting to note that the people in the Daantjie village appear relatively neutral in terms of this need and that the people of Luphisi did not rate this need as having any importance when compared to other needs. The results at Luphisi could most probably be explained by the fact that they still supported a traditional way of living and that they had relatively free access to woodfuel. The need for the improvement of the infrastructure for electricity once again seems to be the strongest at Mpakeni, although this need was not rated as highly as the need for clinics and the improvement of the water infrastructure.

2.5.8 The need for the creation of woodlots

It is significant to note that very little importance is attached to this need as compared to other needs. The need for woodlots is expressed relatively strongly at Luphisi village.

This could probably be explained by the fact that the local people still live a relatively traditional lifestyle and that they therefore utilised wood for fuelwood and building significantly more than the inhabitants of the other villages do.

There was a basic rejection of woodlots as a need in the village of Mpakeni. A woodlot does exist at Mpakeni which would imply that the people obviously did not regard this as a need that should be addressed.

2.5.9 The need for the creation of communal vegetable gardens

In a study being undertaken by Schoeman (in prep.) it is clearly indicated that the need for the utilisation of open spaces for the development of communal vegetable gardens did not receive great support from individuals or communities throughout South Africa. This tendency is also clearly reflected in the results obtained in this study with regard to the creation of communal gardens.

2.5.10 The need for the planting of fruit trees for individuals

This need was not seen as a priority at the time when this survey was conducted. However there is definitely a need for fruit trees now with the development of Permaculture in KaNgwane, although this need was not measured against other needs.

2.6 THE NEED FOR THE UTILISATION OF FACILITIES WITHIN THE MGR

2.6.1 Introductory comments

The results discussed in the previous three sections point to a strong need for members of the communities around the MGR to utilise the reserve in order to improve their quality of life. It is interesting to note that the analysis of the needs for the utilisation of facilities within the MGR does not show any significant results (with the exception of the need for environmental education). These communities are involved in a day-to-day battle for survival. It can therefore be expected that their needs will be in respect of commodities and facilities, which will aid them in uplifting their standard of living and assist them in meeting their daily needs. Consequently it is predictable that their needs for utilising facilities within the reserve will not be developed.

The research programme also evaluated and compared the needs of the local communities in respect of the utilisation of the following facilities within the MGR.

- facilities within the MGR for environmental education;
- picnic facilities;
- game-watching within the MGR;
- visiting the Bongani Lodge;
- overnight at the Bongani Lodge;
- visiting traditional graves within the MGR.

The same projective sorting technique described earlier was used to evaluate these needs in the local communities.

The following results were generated by this section of the research and is illustrated in Table 2.8.

Table 2.8: The need for the utilisation of facilities within the MGR. Data adjusted from cumulative percentages (Odendal 1991) to weighted averages.

Variables	Weighted averages
Environmental education	71
Game watching	66
Picnic	65
Visiting lodge	53
Visiting graves	49
Sleep at lodge	43

2.6.2 The need for the utilisation of facilities within the MGR for environmental education

Table 2.8 illustrates clearly the overwhelming need for participation in environmental education programmes as expressed by respondents from the different communities.

Table 2.8 indicates that the majority of the respondents rated environmental education as the most important need in respect of the category utilisation of facilities within the MGR. This need received a high priority rating by the residents of Luphisi but a low priority rating by those of Mpakeni. The high rating at Luphisi suggests that, together with the demographic data, the local community would need to know more about nature and the environment in order to find ways and means for coping with it. It is suggested that the low rating at Mpakeni is due to the fact that the environment does not play a very significant role in meeting their survival needs. Their need priority is therefore a socio-economic one, excluding a need for programmes which will promote environmental management. (Odendal 1991).

2.6.3 The need for the utilisation of picnic facilities within the MGR

Table 2.8 suggests that there was a relatively strong need within the community for picnicking and picnic facilities at the reserve. This need was particularly strong at Daantjie.

2.6.4 The need for game watching within the MGR

The need for game watching within the MGR received the same priority rating as picnicking. The possibility of going on game watching excursions was given strong support by respondents from the village of Mpakeni. This is significant in that this is the only reaction thus far in this study where the people of Mpakeni expressed a very strong need to relate to the MGR.

2.6.5 The need for visiting the Bongani Lodge

Table 2.8 indicates that members of the community did not rate visits to the Lodge as having a high priority as compared with the other needs.

2.6.6 The need for over-nighting at the Lodge

No real need existed within the local community to overnight at the Lodge.

2.6.7 The need for visiting traditional graves within the MGR

Several family graves were enclosed within the MGR when it was fenced initially. The large majority of respondents who indicated that they would like to visit traditional graves within the MGR resided in the village of Mpakeni. The KPC has provided gates to make it possible for these people to visit these graves, the keys to these gates are with the local induna.

CHAPTER 3

PLANT RESOURCE SURVEY

3.1 INTRODUCTION

From the sociological study it is clear that there is a strong need for the utilisation of plant resources from the MGR. Of the plant resources needed, fuelwood seems to be the most important with medicinal plants and thatch grass close together in second and third place (Odendal 1991). The management objective (Section 3.2.1) of the MGR includes the sustainable use of these resources. In order to ensure this, any harvest limit must be based on a reliable assessment of the size of the resource available and its production. Good management is impossible without an inventory to determine the status of the resources. The results from the inventory are used to determine the different utilisation options. An inventory is therefore an important component of a series of activities to ensure the sustained use of forest and woodland resources (Geldenhuys 1990).

No quantitative information on biomass or production existed prior to this study. Studies in the KNP in a similar landscape are only descriptive (Gertenbach 1983).

The aim of this chapter is to provide quantitative estimates of the amount of fuelwood and thatch grass available for use and to draw up a list of medicinal plants which occur in the MGR and their uses. (Appendix 1).

3.2 OBJECTIVES

3.2.1 Management objectives

The management objectives of the MGR are to:

- manage the resource in such a way that it could be utilised by the local people to provide for their needs, and

- manage the utilisation of the resource in such a way that:
  - utilisation is sustainable,
  - the essential processes and functions of the ecosystem are preserved, and
  - diversity is maintained.

3.2.2 Study objectives

The study objectives are to:

- determine which plant species are utilised,
- make an inventory of those vegetation resources available in the MGR that could provide in the needs of the people,
- determine production of those species used, and
- make recommendations for resource harvesting.

3.3 FUELWOOD INVENTORY

3.3.1 Two phase inventory design

In order to achieve the study objectives it was necessary to collect information on the vegetation of the MGR using an acceptable sampling technique. The sampling design and information collected had to be relevant to the objectives of the specific study. Geldenhuys (1990) proposes an inventory in two phases for a new area in order to achieve maximum output of relevant information with a minimum amount of effort.

The objective of the first phase inventory is to determine the resource potential of the total area and to determine the subdivision of the resources for the different potential uses. If this first phase inventory indicates that timber utilisation is a viable option, then the areas of greatest potential for timber production should be identified. Those areas should be covered by a second, more detailed inventory of the available timber volumes of the different tree species over different diameter classes for detailed yield regulation.

3.3.2 Pilot study

3.3.2.1 Methods

3.3.2.1.1 Selection of species

For the first phase of the inventory of the fuelwood resource, it is necessary to know what woody species the local women prefer. Gandar (1983) and Bembridge and Tarlton (1990) list favoured firewood species for KwaZulu and Ciskei. In KaNgwane, *Dichrostachys* and *Combretum* spp. seem to be preferred for firewood (Anon. 1986).

To determine local preferences, three women of each of the three villages adjoining the MGR were randomly selected. They were taken in a group through the MGR and were asked to indicate woody species which they use for woodfuel purposes. A branch of each species indicated was collected. A total of 13 species were sampled. At the end of the visit they were asked if there were any other species not as yet indicated. Another three species were named of which samples were collected. Each woman was asked to arrange the 16 species in descending order of preference. Some woman were very sure about their order of preference for all 16 species and a descending value was allocated to each species. Others were able to select only the first five or seven indicating no preference difference between the rest. The same value was then allocated to the remaining species. The average values were calculated for the 16 species. (Section 3.3.2.2, Table 3.1).

3.3.2.1.2 Stratification of the resource area

The MGR falls within the Malelane Mountain Bushveld landscape as described by Gertenbach (1983). Although the landscape unit as defined by Gertenbach (1983) is homogeneous, it is also true that heterogeneity occurs within a landscape and the variability in vegetation composition of an area is caused by both edaphic factors (such as nutrient status, soil moisture, soil depth) and biotic factors (such impact of wildlife and geographical range of species). Acknowledgement of the observable differences in vegetation, for example by suitable stratification into homogenous vegetation units and sub-sampling, can contribute to higher precision of estimates and reduction of sampling effort (Geldenhuys 1990).

By using the most recent aerial photographs (1989) on a scale of 1:15 000 the homogeneous strata in the MGR were identified and marked.

3.3.2.1.3 Demarcation of study area

Although the first phase inventory should have the objective to determine the resource potential of the total area (Geldenhuys 1990), it was decided to exclude areas that did not fall into the criteria for harvesting of firewood. The selection criteria were as follows:

- Distance allowed to travel on foot into the MGR from a manned gate.
  It is a policy decision by the KPC that firewood can only be gathered by members of the Mpakeni tribe on foot and that the quantity which may be removed on any single visit is limited to a bundle which can be carried on the collectors head. This is a control measure to ensure the resource available only to the bona fide tribal members and also to impose an easily acceptable limit to the volumes per family. Large quantities such as bakkie loads and tractor-trailer loads are only permitted by special consent from the Chief for tribal functions and funerals.

Gander's (1983) observation, in a Valley Lowveld area where firewood is reasonably abundant, is an average collection time per head load of two hours 35 minutes with an average travelling distance of 3.6 km. Bembridge & Tarlton (1990) found that the average collection time in the Amatola basin was two hours and five minutes for an average distance of 3 km.

At the MGR the distance from any of the entrance gates to the villages varies from 1 to 3 km. The maximum distance that people can therefore be allowed into the MGR on foot from any of the gates will be 4 km. This will allow for a round trip of 8 km in the MGR which will take about 5 hours to complete. Allowing one to three hours to travel from the village to the gate and back brings the time spent on firewood collection up to eight hours. Gandar (1983) encountered an extreme case where a group of women spent 9.5 hours gathering a single head load each and walked a round trip of 19 km.

- Gradient of slope and ground rockiness

The steeper more rocky slopes will be more vulnerable to erosion with the removal of vegetation. Although a slope index to determine vulnerability is not available, it can be assumed that gradients of 45 degrees and more are very vulnerable and any utilisation on these slopes should be avoided. The gathering of firewood on these gradients would also be extremely difficult.

3.3.2.1.3 Sampling methods

By applying the criteria for the demarcation of the study area, the homogeneous units that need to be sampled were reduced considerably (Fig. 3.1). All areas outside the radius of 4 km from an entrance gate or with a gradient greater than 45 degrees were not sampled. Twenty seven units as identified with a stereoscope on the aerial photographs, fall within the remaining area.

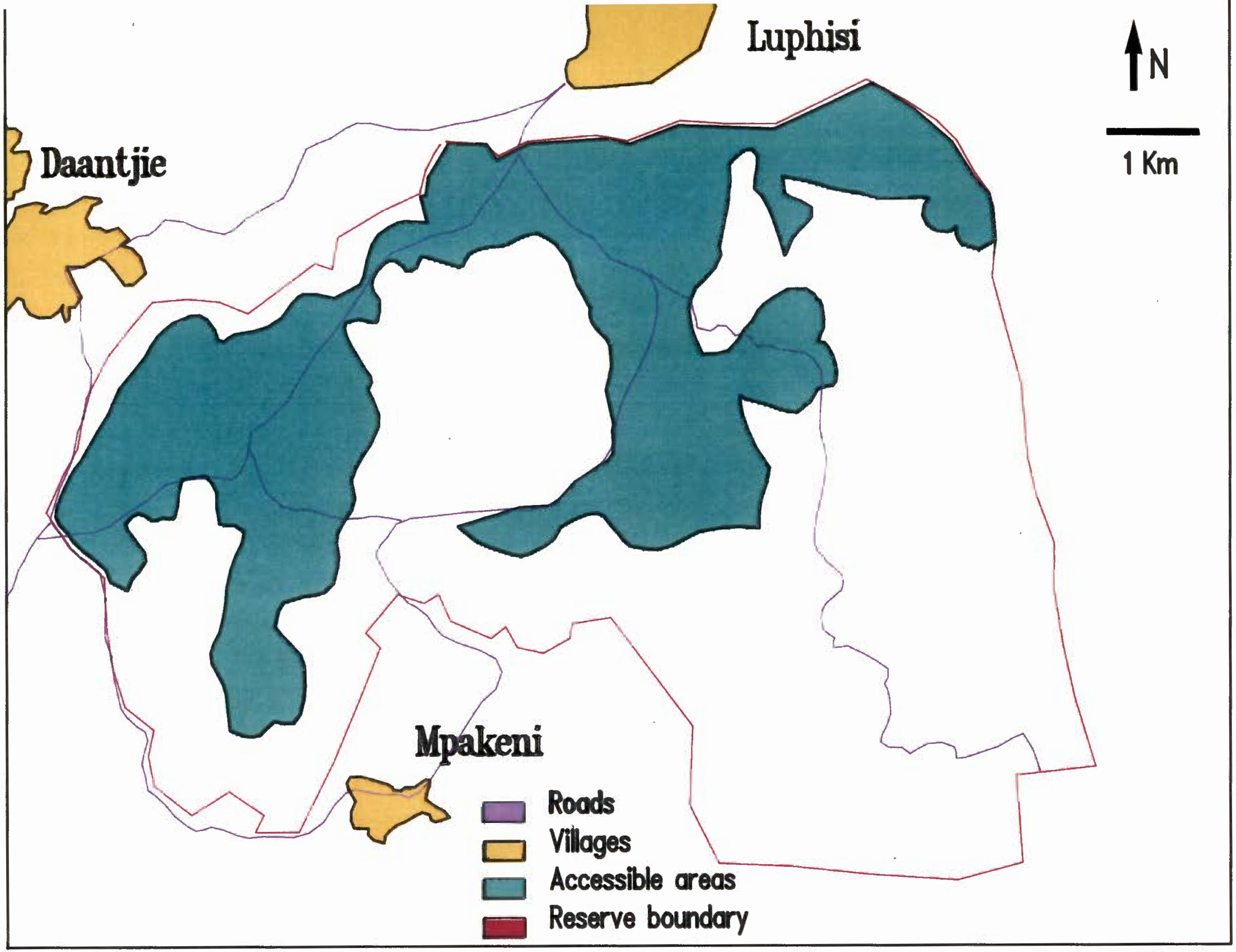

Fig. 3.1 Area accessible for firewood harvesting in the MGR

(a) Fuelwood parameters

The number or type of vegetation parameters which can be measured is limited by time and manpower considerations. The parameters of main concern were density and diameter class distribution for the selected firewood species. In Ciskei the average diameter of wood collected in head loads varied between 2 and 6 cm with over 50% of the bundles having no pieces over 6 cm in diameter. The average diameter of the sticks in the bundles was 4,4 cm (Bembridge & Tarlton 1990). Gandar (1983) found that in piles of firewood in Zululand, 80% of pieces have diameters between 1,5 and 4,5 cm.

All stems with a diameter of 1,5 cm or more were therefore counted, dead stems were recorded separately. Some working definitions were necessary to avoid sampling bias. A stem was recorded as dead when the upper part of the stem above 5 cm of the ground was dead, even if it was coppicing at the base. Stems of the same tree were counted as individuals if branching occurred within 5 cm above ground level.

(b) Plot size and shape

The merits of different plots were discussed by Greig-Smith (1983) and Mentis (1984). A rectangular plot is likely to incorporate more environmental and floristic variation than a square or circular one, especially in the MGR which has a very broken relief. Because the pilot study only serves as a reconnaissance survey to determine resource potential and to determine the subdivision of the area it was necessary to cover an area as large and diverse as possible.

For practical purposes, a 12,5 m x 200 m strip transect was selected as the sample unit. Where possible the transect ran perpendicular to the pattern of topographic variation. Four transects were located randomly in each unit which meant that effectively one ha was sampled in each of the 27 homogeneous plant strata.

In all the plots individual stems for the 16 woody species were recorded for different size classes. The following size classes were used, 1 to 5 cm, 5 to 10 cm, 10 to 20 cm and everything > 20 cm. Dead stems were recorded separately.

3.3.2.1.4 Analysis methods

Classification techniques with a hierarchical approach was deemed suitable for the following reasons (Gauch 1982, Walker 1987):

- it shows sample relationships,
- the sample sequence in a dendrogram can convey a gradient effectively, and
- the hierarchical levels may aid in indicating objective strata cut-off points.

Of the hierarchical techniques available, two-way indicator species analysis (TWINSPAN) (Hill 1979) was preferred because of its effectiveness and robustness (Gauch 1982). TWINSPAN is a polythetic divisive technique based on reciprocal averaging ordination (Gauch 1982). TWINSPAN is a development of a method described under the name of "indicator species analysis" (Hill, Bunce & Shaw 1975).

The most significant feature is that the programme first constructs a classification of the samples, and then uses this classification to obtain a classification of the species according to their ecological preferences (Stalmans 1990). The two classifications are then used together to obtain a two-way table that expresses the species synecological relations as succinctly as possible (Hill 1979).

A classification based on the available data for the reconnaissance plots was attempted. Data was transformed to Braun - Blanquet cover values using COMPOSE (Mohler 1987), A TWINSPAN (Hill 1979) classification was performed on the transformed matrices.

Density of individual species was calculated on a hectare basis.

3.3.2.2 Results

3.3.2.2.1 Species selection

The plant species used for fuelwood in order of preference are given in Table 3.1.

Table 3.1: List of selected plant species for firewood in order of preference

Species	Abbreviations	Percentage Preference (weighted average)
Combretum apiculatum	*C. api*	*85,63*
Combretum imberbe	*C. imb*	*81,88*
Pappea capensis	*P. cap*	*65,00*
Combretum collinum	*C. col*	*57,50*
Acacia nigrescens	*A. nig*	*55,00*
Berchemia zeiheri	*B. zei*	53,75
Dombeya rotundifolia	*D. rot*	51,25
Pterocarpus rotundifolius	*P. rot*	47,50
Ziziphus mucronata	*Z. muc*	41,88
Olea europea	*O. eur*	41,88
Dichrostachys cinerea	*D. cin*	40,63
Combretum hereroense	*C. her*	40,00
Peltophorum africanum	*P. afr*	39,38
Cassine transvaalensis	*C. tra*	36,88
Acacia nilotica	*A. nil*	36,88
Strychnos spp.	*S. spp*	31,25

This table indicates the preference of the local people should there be a choice. In practice they choose the best of what is available.

3.3.2.2.2 Classification

A dendrogram of the resultant hierarchical division was produced for both species composition and density of stems. (Fig. 3.2).

Groups at a specified division level were always counted from left to right. The left group and right group at any particular division were respectively called the "negative" and "positive" groups.

Divisions at level 3 are recognisable in the field. Units below this level could not be readily distinguished. As the study is aimed at a practical management level rather than at a fine botanical description, it was decided to use the classification of groups at division level three.

The TWINSPAN dendrogram gives the first three levels of hierarchy of the sampled plots (Fig. 3.2).

Six woodland communities (Fig. 3.4) were identified at level 3 of the dendrogram. The total area of each community was calculated (Table 3.2).

Table 3.2: Total area (ha) of the six woodland communities

Community	Area (ha)
A	727
B	499
C	370
D	291
E	240
F	168

The six woodland communities make up only 32,78% of the MGR. This means that two thirds of the MGR is not accessible to utilisation.

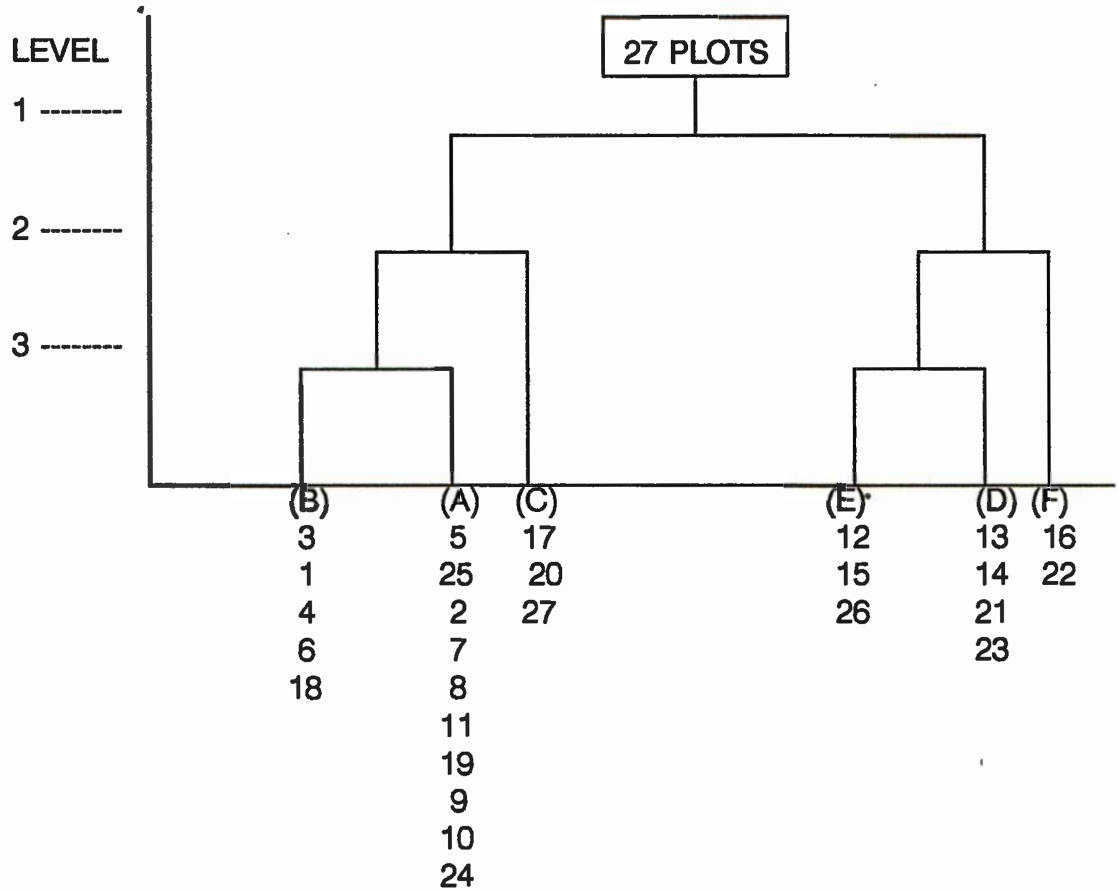

Fig. 3.2: **TWINSPAN dendrogram of pilot sample plots.**

(Combined woody composition and stem density data for different size classes).

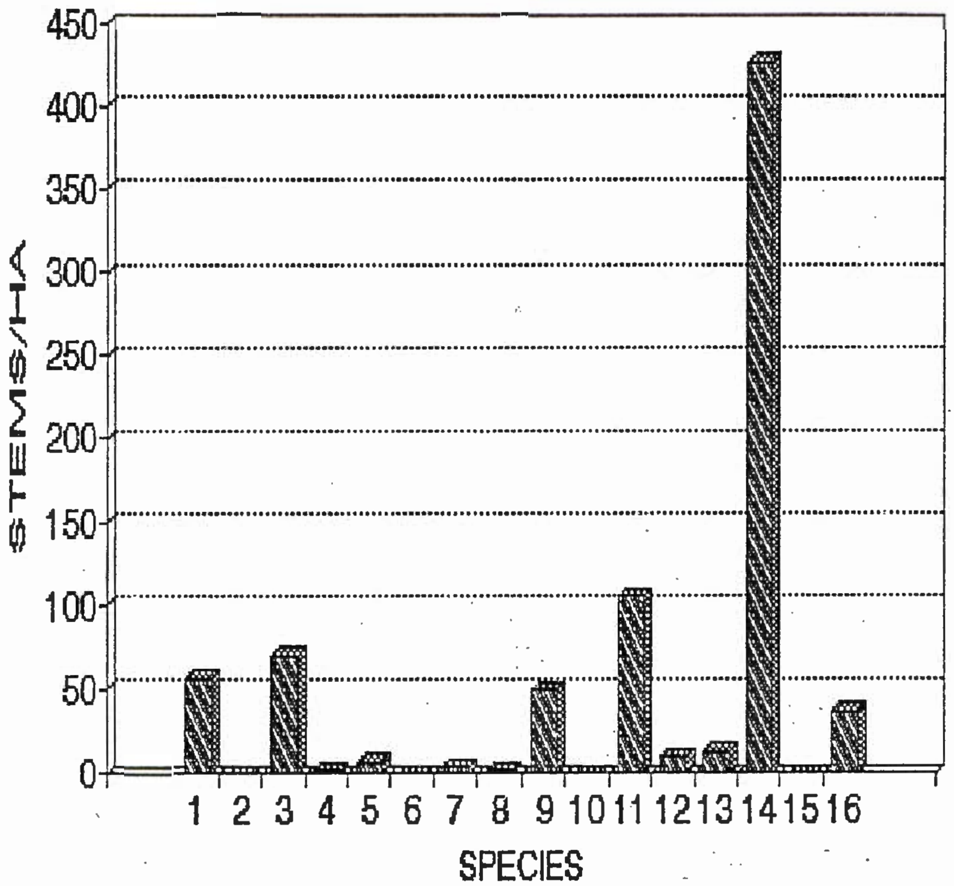

FIG. 3.3 Density of plant species (stems/ha) from a Pilot study.

Combretum apiculatum	1
Combretum imberbe	2
Combretum collinum	3
Combretum hereroense	4
Pappea capensis	5
Berchemia zeyheri	6
Dombeya rotundifolia	7
Acacia nilotica	8
Acacia nigrescens	9
Olea europea	10
Pterocarpus rotundifolius	11
Peltophorum africanum	12
Ziziphus mucronata	13
Dichrostachys cinerea	14
Cassine transvaalensis	15
Strychnos spp.	16

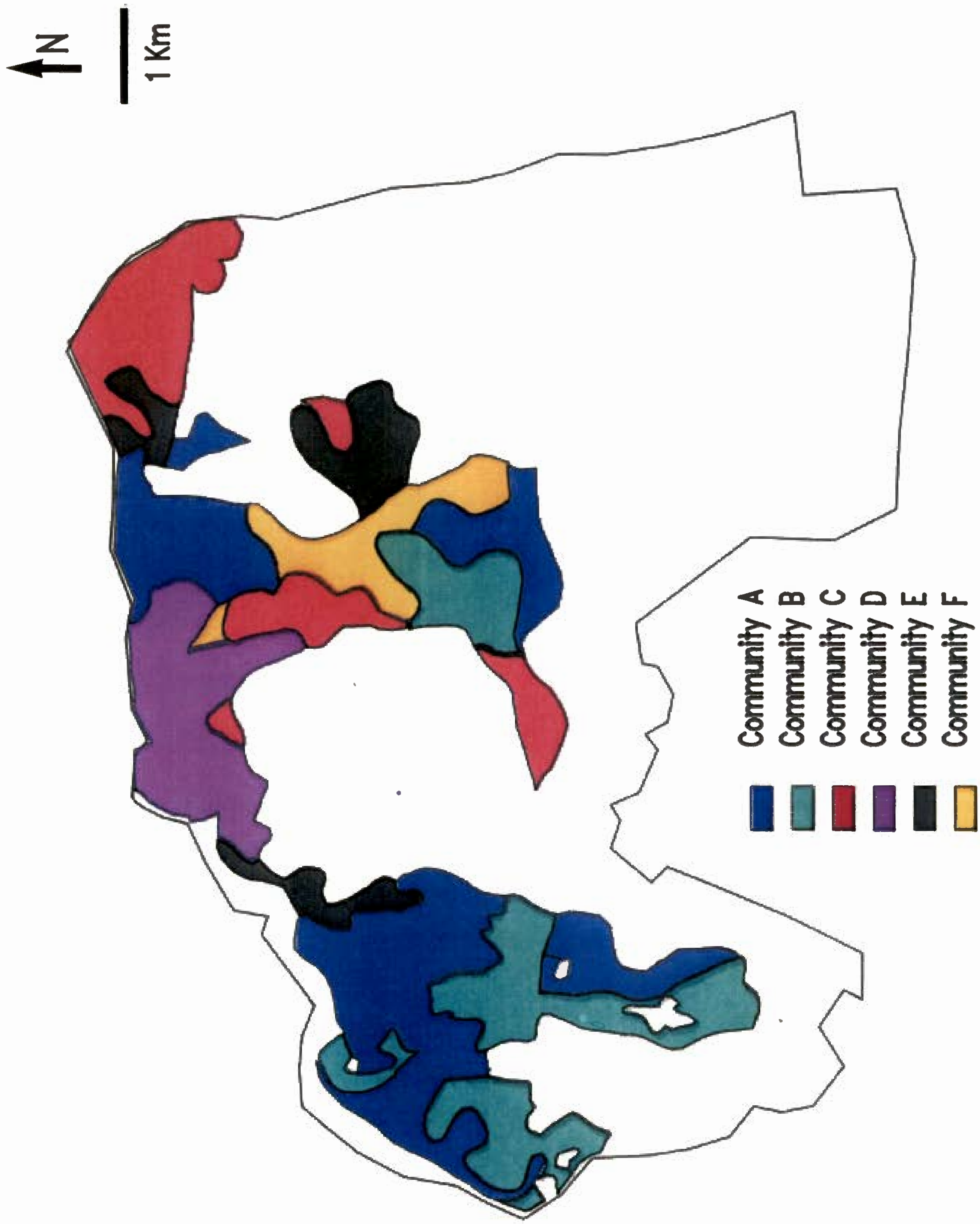

Fig. 3.4 **The six main plant communities on which the baseline study was conducted**

3.3.2.2.3 Species density

Density is defined as the number of individual stems per unit area. The stem density of the sixteen selected species is shown in Fig. 3.3.

The five species with the highest density (more than 50 stems/ha) were selected for detail measurement in the different size classes (Fig. 3.3). The species were *Pterocarpus rotundifolius, Combretum collinum, Combretum apiculatum, Acacia nigrescens and Dichrostachys cinerea.*

3.3.3 Baseline study

3.3.3.1 Objective

With the base line study it was attempted to:

- do a more detailed survey of the five different tree species over different diameter classes in the six woodland types for detailed density figures,
- develop allometric regression equations for the five different species, and
- determine biomass.

3.3.3.2 Methods

3.3.3.2.1 Allometry

The aim was to derive a relationship between a single variable, diameter, and the wood biomasses of the five selected fuelwood species. Stem diameter was chosen as the single most easily measured predictor variable. A major assumption of the method was that for any particular species there exists a single relationship that can be used for predicting mass of material distal to any point at which stem diameter is taken on the plant (Goodman 1990).

Wood biomass measurements included all live tissue, structurally functional wood and bark but excluded the mass of attached dead branches or twigs. All leaves were also removed.

(a) Destructive sampling

Destructive sampling was done within two weeks of the non-destructive measurement period during late summer. To save time and to minimize the impact on the vegetation, destruction was done according to Shinozaki's pipe model theory referred to by Goodman (1990). In essence, the assumption is that a branch of a large tree has the same mass and mass components as a small tree of the same basal (proximal) diameter. By moving successively down a large tree, with more and more branches being included, it is possible to obtain a full size range of so-called "individuals" from one individual.

Two large, typical specimens of each species with a base diameter of not more than 20 cm were selected. Measurement started with smaller diameter branches at the outer extremes of the canopy, proceeding through larger diameters with the final measurement being made at the base of the tree. Each branch was weighed and the diameter immediately above the basal swelling was measured. A representative sample of branches and stems was oven dried at 85° C for one week. These stems and branches were measured and weighed again to obtain a dry weight factor for each species.

(b) Asymptotic models

A regression model was drawn up to be used for further statistical analysis. Jongman, Ter Braak & Van Tongeren (1987) proposes the transformation of data to ensure a better fit of the values in a regression model. The relationship of dimension with plant mass is usually of the non-linear form (Rutherford, *pers comm.*). When this function type is transformed logarithmically, it reduces the problem and it linearizes the allometric equation for easier statistical manipulation. The logarithmic transformation of the relation can result in systematic error but according to Crow & Laidly (1980), alternative models do not assure improvement.

Hunt (1982), however stated that asymptotic functions can also be subjected to logarithmic transformation for the mathematical purpose of linearizing or simplifying the function to secure an easier method of fitting. Asymptotic functions are characterised by the value of the dependant variable which gradually ascends to a plateau which it never quite meets.

The following asymptotic functions using three parameters were fitted to the allometric data obtained:

- Chapman-Richards (Duckworth & Walker 1988)
  $\log(\text{Weight} + 1) = a^* (1 - \text{Exp}(-b^*D)^{(1/(1 - C))}$

- Monomolecular (Hunt 1982)
  $W = a + (b * \text{Exp}(C * D)$

where:
W is the weight,
D is the diameter,
a describes the asymptote,
b is the rate of change along the curve,
C determines the location of the inflection point, and
exp: base of natural logarithms

The appropriateness and validity of each asymptotic model was evaluated in terms of the R-squared value and randomness of residuals. Firstly, a runs test on the residuals was carried out to examine goodness of fit in each instance. A random distribution of the residuals means that the model can be safely used and does not yield a systematic bias (Zar 1974). Secondly, the R-squared value was calculated. This value indicates the amount of variability explained by the model. The closer the R-squared value is to 1.00 the better the model explains the data (Stalmans 1990).

3.3.3.2.2 Diameter class distribution

The most common plot sizes particularly in tropical forest, vary from 0,1 to 0,4 ha (Husch 1971). Circular plots of 30 m radius (an area of 0,283 ha) were found to give the optimum plot size for the Kavango and Caprivi survey for information on composition of trees and measuring time (Geldenhuys 1990).

Square plots of 50 m x 50 m (0,25 ha) were applied for this survey. A map of the MGR was subdivided into plot units. This grid was superimposed on the map units of woodland type. Each grid intersection was therefore a potential sample point, except when it fell on a physical feature not covered by vegetation (such as a road, pan or building). Usable sample points were numbered consecutively, but separately for each of the six vegetation types. The maximum number of 50 sampling points for the biggest vegetation type was determined by time available for the study. The number of sampling points for the smaller vegetation units was allocated proportionately to their size. Only the five species previously identified were used. A total of 170 plots were sampled.

The selected number of plots per vegetation type were randomly allocated to the potential sample points. A table of random numbers was used for this purpose. The diameter of each individual stem for each plot was measured on a scale of one cm intervals from 1,5 cm to 20 cm. Trees bigger than 20 cm were counted as trees >20 and not measured individually. Dead stems were recorded separately.

3.3.3.3 Results

3.3.3.3.1 Allometry

Constants and R-squared values for the different asymptotic functions were calculated by using the Chapman-Richard and Monomolecular models in Statgraphics to fit the non-linear model to the data (Table 3.3). An example is illustrated in Fig. 3.5 where the Chapman-Richard model was used to fit the curve for *Combretum apiculatum*.

Table 3.3: Constants and R-squared values for the asymptotic functions fitted to allometric data

SPECIES	FUNCTION	CONSTANTS			R-sq	*
		A	B	C		
P. rot	MM CR	2.3260 1.9405	- 2.7760 0.1757	-0.0932 0.5664	0.9062 0.8946	
C. api	MM CR	2.6207 1.9431	-2.9668 0.2152	-0.0826 0.6173	0.9742 0.9780	* *
D. cin	MM CR	2.9267 1.7515	-3.2845 0.2451	-0.0661 0.6921	0.9023 0.9138	* *
A. nig	MM CR	2.9999 2.0827	-3.4629 0.2330	-0.0811 0.6652	0.9760 0.9801	* *
C. col	MM CR	2.5115 1.8195	-2.9315 0.2157	-0.0799 0.6668	0.9726 0.9770	* *

MM: Monomolecular
CR: Chapman-Richards
* : function valid (residuals randomly distributed)

A - describes the asymptote
B - the rate of change along the curve
C - location of the inflection-point
P. rot - *Pterocarpus rotundifolius*
C. api - *Combretum apiculatum*
D. cin - *Dichrostachys cinerea*
A. nig - *Acacia nigrescens*
C. col - *Combretum collinum*

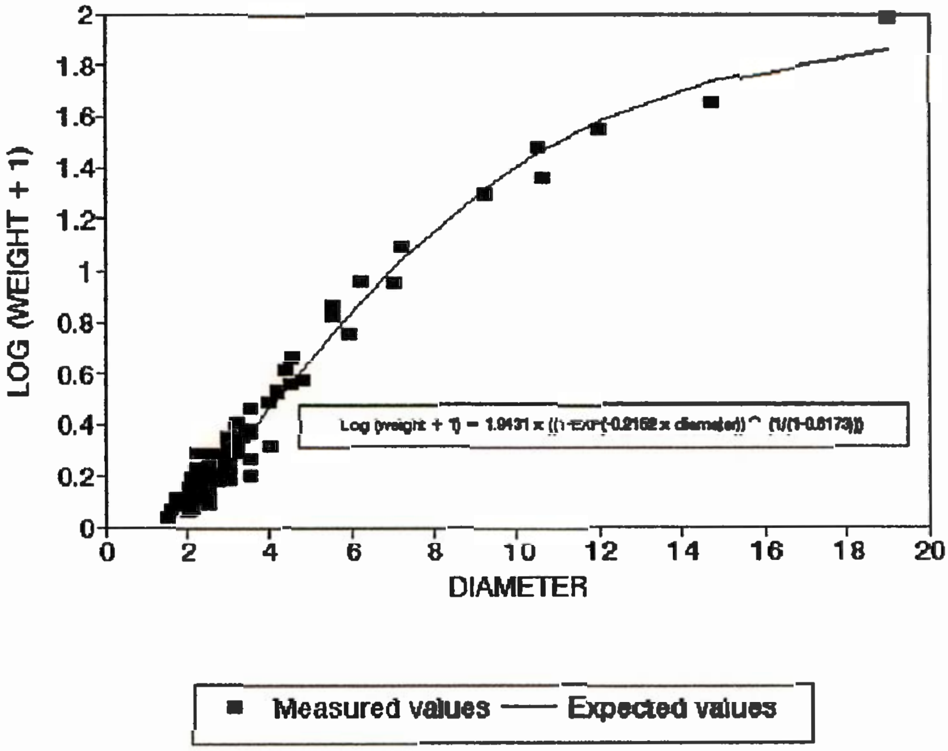

Fig. 3.5: **Chapman-Richard asymptotic curve of *Combretum apiculatum*** to describe the relationship between diameter and weight.

3.3.3.3.2 Biomass over different size classes

In the baseline study, diameter, as the predictor variable was measured for all species in all plots of known size. The predictive relations were applied to give the biomass for the various species in the six woodland types per unit ground area. The first three columns of Table 3.4 are graphically illustrated in Fig. 3.6. The relation between diameter, density (stems/ha) and biomass (kg/ha) for *Dichrostachys cinerea* in plant community A is illustrated as an example. The rest of the data for the six woodland types on the relation between diameter, density and biomass are presented in Tables 3.4 to 3.9.

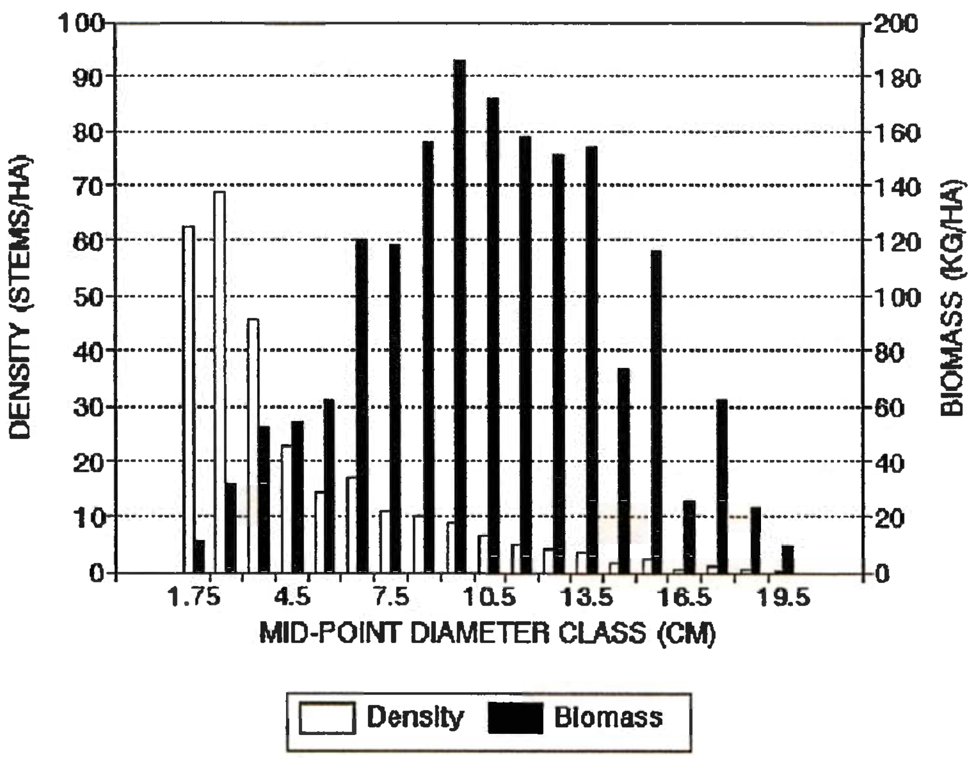

Fig. 3.6 **The relationship between diameter (cm), density (stems/ha) and biomass (kg/ha) for *Dichrostachys cinerea* in plant Community A**

Table 3.4 **The relation between diameter (cm), density (stems/ha) and biomass (kg/ha) for the different species in plant community A.** (The first three columns are graphically illustrated in Fig. 3.6)

Diam. cm	D. cin stem/ ha	D.cin kg/ha	P. rot stem/ ha	P. rot kg/ha	C. api stem/ ha	C. api kg/ha	C. col stem/ ha	C. col kg/ha	A. nig stem/ ha	A. nig kg/ha
1.75	62.48	10.97	25.28	0.74	6.64	2.16	7.36	1.60	0.80	0.22
2.50	68.96	31.59	24.64	12.72	9.20	6.97	14.20	7.61	1.12	0.78
3.50	45.68	52.66	15.60	24.84	9.68	17.07	12.90	16.55	2.08	3.65
4.50	23.04	54.59	10.48	33.27	7.28	25.30	9.76	25.16	1.60	5.93
5.50	14.48	62.32	8.08	43.44	6.56	40.42	6.96	32.19	1.28	8.96
6.50	16.88	120.16	7.28	60.35	8.24	82.82	6.80	51.90	1.12	13.54
7.50	10.88	118.25	5.04	60.38	5.76	87.87	8.08	94.70	0.72	13.86
8.50	10.08	155.89	4.24	69.84	5.84	126.84	7.52	126.96	1.20	34.19
9.50	8.96	185.34	3.36	73.09	3.60	105.19	6.48	148.82	0.64	25.27
10.50	6.56	172.03	4.72	131.09	4.56	170.59	4.32	128.32	0.40	20.66
11.50	4.96	157.59	3.76	129.52	4.64	212.95	3.36	123.54	0.40	25.73
12.50	4.08	151.23	2.88	119.99	4.64	251.94	3.36	147.28	0.32	24.59
13.50	3.68	154.26	2.88	142.00	2.96	184.43	3.76	190.33	0.48	42.58
14.50	1.60	73.96	3.76	215.20	4.00	278.83	3.04	173.07	0.08	7.96
15.50	2.32	115.87	2.16	141.10	3.20	244.37	2.48	155.33	0.24	26.18
16.50	0.48	25.48	2.64	193.91	2.32	190.78	1.36	92.03	0.00	0.00
17.50	1.10	62.39	1.60	130.41	3.44	300.33	2.40	172.89	0.16	19.91
18.50	0.40	23.14	1.44	128.73	2.24	205.26	2.00	151.53	0.24	31.27
19.50	0.20	9.54	1.28	124.20	2.40	228.67	1.36	107.32	0.00	0.00

Table 3.5 **The relation between diameter (cm), density (stems/ha) and biomass (kg/ha) for the different species in plant community B.**

Diam. cm	D. cin stem/ ha	D. cin kg/ha	P. rot stem/ ha	P. rot kg/ha	C. api stem/ ha	C. api kg/ha	C. col stem/ ha	C. col kg/ha	A. nig stem/ ha	A. nig kg/ha
1.75	88.70	15.57	5.49	0.16	0.69	0.22	1.03	0.22	0.00	0.00
2.50	70.20	32.14	1.49	0.77	1.83	1.39	0.46	0.24	0.00	0.00
3.50	46.70	53.89	0.57	0.91	1.26	2.22	1.37	1.76	0.00	0.00
4.50	27.30	64.72	0.69	2.18	0.46	1.59	1.71	4.42	0.00	0.00
5.50	20.70	89.03	0.57	3.07	0.23	1.41	1.94	8.99	0.00	0.00
6.50	17.40	123.66	0.57	4.74	0.11	1.15	0.91	6.98	0.00	0.00
7.50	12.50	135.39	1.37	16.43	0.00	0.00	1.37	16.07	0.00	0.00
8.50	10.20	157.31	0.80	13.18	0.46	9.93	1.26	21.22	0.00	0.00
9.50	8.23	170.21	1.37	29.83	0.34	10.02	1.14	26.25	0.00	0.00
10.50	4.46	116.88	1.03	28.57	0.00	0.00	0.57	16.97	0.00	0.00
11.50	2.51	79.88	1.26	43.30	0.23	10.49	0.69	25.21	0.00	0.00
12.50	2.63	97.43	1.03	42.86	0.11	6.21	0.46	20.04	0.00	0.00
13.50	1.37	57.49	0.91	45.08	0.00	0.00	0.46	23.14	0.00	0.00
14.50	1.14	52.83	0.69	39.25	0.23	15.93	0.46	26.02	0.00	0.00
15.50	0.57	28.54	1.03	67.19	0.11	8.73	0.34	21.47	0.00	0.00
16.50	0.46	24.27	1.03	75.55	0.00	0.00	0.34	23.20	0.00	0.00
17.50	0.69	38.20	0.57	46.58	0.46	39.91	0.23	16.47	0.00	0.00
18.50	0.11	6.61	0.34	30.65	0.00	0.00	0.00	0.00	0.00	0.00
19.50	0.11	6.81	0.34	33.27	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.6 The relation between diameter (cm), density (stems/ha) and biomass (kg/ha) for the different species in plant community C.

Diam. cm	D. cin stem/ ha	D. cin kg/ha	P. rot stem/ ha	P. rot kg/ha	C. api stem/ ha	C. api kg/ha	C. col stem/ ha	C. col kg/ha	A. nig stem/ ha	A nig kg/ha
1.75	25.60	4.49	3.20	0.09	9.06	2.96	13.47	2.94	4.80	1.33
2.50	33.10	15.15	3.20	1.65	11.87	8.99	12.67	6.77	6.93	4.83
3.50	24.80	28.59	1.73	2.76	16.40	28.92	15.87	20.39	11.60	20.37
4.50	18.10	42.97	1.73	5.50	14.53	50.52	14.67	37.80	10.53	39.06
5.50	13.70	59.11	0.93	5.02	7.20	44.37	11.47	53.04	6.40	44.82
6.50	9.87	70.24	1.06	8.84	7.60	76.39	14.27	108.89	5.87	70.91
7.50	6.93	75.36	1.20	14.38	7.60	115.94	9.33	109.39	2.67	51.33
8.50	5.73	88.67	0.13	2.20	4.80	104.25	5.87	99.05	2.00	56.98
9.50	6.27	129.63	0.40	8.70	3.20	93.50	4.27	97.99	2.00	78.97
10.50	4.00	104.90	0.40	11.11	2.93	109.74	3.07	91.09	1.73	89.55
11.50	1.20	38.13	0.40	13.78	1.73	79.55	1.87	68.63	0.80	51.47
12.50	1.73	64.25	0.26	11.11	1.73	94.11	1.20	52.60	1.33	102.48
13.50	1.47	61.48	0.66	32.87	2.40	149.54	1.07	54.00	0.53	47.31
14.50	1.20	55.47	0.53	30.52	1.20	83.65	1.07	60.72	1.20	119.41
15.50	0.27	13.32	0.26	17.42	0.80	61.09	0.27	16.70	0.67	72.72
16.50	0.40	21.24	0.13	9.79	1.20	98.68	0.40	27.07	0.53	62.60
17.50	0.27	14.86	0.13	10.87	1.33	116.41	0.27	19.21	0.40	49.76
18.50	0.13	7.71	0.40	35.76	0.80	73.31	0.67	50.51	0.13	17.37
19.50	0.00	0.00	0.00	0.00	0.53	50.82	0.13	10.52	0.40	54.06

Table 3.7 The relation between diameter (cm), density (stems/ha) and biomass (kg/ha) for the different species in plant community D.

Diam. cm	D. cin stem/ ha	D. cin kg/ha	P. rot stem/ ha	P. rot kg/ha	C. api stem/ ha	C. api kg/ha	C. col stem/ ha	C. col kg/ha	A. nig stem/ ha	A. nig kg/ha
1.75	18.14	3.18	1.43	0.04	23.43	7.64	10.00	2.18	19.29	5.34
2.50	24.29	11.12	0.29	0.15	31.71	24.03	10.29	5.49	24.43	17.03
3.50	40.71	46.94	0.29	0.45	44.71	78.84	14.14	18.18	24.29	42.64
4.50	38.57	91.39	0.00	0.00	36.14	125.63	11.43	29.46	18.43	68.33
5.50	15.14	65.18	0.00	0.00	21.43	132.04	7.43	34.36	14.00	98.04
6.50	10.14	72.20	0.29	2.37	16.43	165.12	7.43	56.70	10.14	122.59
7.50	7.14	77.63	0.14	1.71	13.14	200.49	3.57	41.86	5.86	112.74
8.50	2.43	37.56	0.14	2.35	6.29	136.52	1.57	26.53	3.29	93.61
9.50	4.00	82.74	0.00	0.00	5.57	162.80	2.57	59.06	4.00	157.94
10.50	1.29	33.72	0.00	0.00	2.43	90.85	1.71	50.92	1.86	95.94
11.50	0.29	9.08	0.29	9.84	2.29	104.90	0.86	31.51	1.00	64.34
12.50	0.57	21.18	0.00	0.00	1.71	93.08	1.14	50.09	1.57	120.78
13.50	0.86	35.93	0.00	0.00	2.57	160.22	0.29	14.46	1.00	88.70
14.50	0.14	6.60	0.14	8.18	1.71	119.50	0.43	24.40	0.29	28.43
15.50	0.00	0.00	0.00	0.00	0.71	54.55	0.00	0.00	0.00	0.00
16.50	0.29	15.17	0.14	10.49	1.43	117.47	0.00	0.00	0.14	16.77
17.50	0.14	7.96	0.00	0.00	0.57	49.89	0.00	0.00	0.14	17.77
18.50	0.00	0.00	0.00	0.00	1.71	157.08	0.00	0.00	0.14	18.61
19.50	0.29	17.03	0.00	0.00	0.86	81.67	0.14	11.27	0.71	96.54

Table 3.8 The relation between diameter (cm), density (stems/ha) and biomass (kg/ha) for the different species in plant community E.

Diam. cm	D. cin stem/ ha	D. cin kg/ha	P. rot stem/ ha	P. rot kg/ha	C. api stem/ ha	C. api kg/ha	C. col stem/ ha	C. col kg/ha	A. nig stem/ ha	A. nig kg/ha
1.75	159.70	28.04	8.53	0.25	4.00	1.30	2.40	0.52	0.00	0.00
2.50	163.50	74.88	5.07	2.62	2.40	1.82	4.53	2.42	0.53	0.37
3.50	86.93	100.23	3.47	5.52	3.47	6.11	4.00	5.14	0.27	0.47
4.50	27.47	65.08	0.27	0.85	2.93	10.20	2.40	6.19	0.00	0.00
5.50	16.53	71.16	0.00	0.00	1.87	11.50	0.80	3.70	0.00	0.00
6.50	9.07	64.54	0.00	0.00	2.13	21.44	1.07	8.14	0.80	9.67
7.50	6.67	72.46	1.07	12.78	1.07	16.27	1.33	15.63	0.27	5.13
8.50	5.60	86.61	1.07	17.57	4.00	86.88	1.07	18.01	0.53	15.19
9.50	3.73	77.22	0.27	5.80	2.40	70.13	0.53	12.25	1.07	42.12
10.50	4.27	111.89	0.80	22.22	2.13	79.81	1.33	39.61	0.80	41.33
11.50	2.67	84.73	0.27	9.19	1.60	73.43	0.53	19.61	0.27	17.16
12.50	1.60	59.31	0.27	11.11	2.13	115.83	0.80	35.07	0.53	40.99
13.50	0.53	22.36	1.33	65.74	1.07	66.46	0.27	13.50	0.00	0.00
14.50	0.27	12.33	0.27	15.26	1.60	111.53	0.27	15.18	0.53	53.07
15.50	0.00	0.00	0.27	17.42	1.07	81.46	0.53	33.40	0.00	0.00
16.50	0.53	28.32	0.53	39.17	0.80	65.78	0.53	36.09	0.00	0.00
17.50	0.53	29.71	0.27	21.74	0.53	46.56	0.53	38.42	0.00	0.00
18.50	0.27	15.43	0.53	47.68	0.27	24.44	0.00	0.00	0.27	34.75
19.50	0.27	15.89	0.00	0.00	0.53	50.82	0.27	21.04	0.27	36.04

Table 3.9 The relation between diameter (cm), density (stems/ha) and biomass (kg/ha) for the different species in plant community F.

Diam. cm	D. cin stem/ ha	D. cin kg/ha	P. rot stem/ ha	P. rot kg/ha	C. api stem/ ha	C. api kg/ha	C. col stem/ ha	C. col kg/ha	A. nig stem/ ha	A. nig kg/ha
1.75	181.00	31.77	0.00	0.00	1.00	0.33	11.67	2.54	0.00	0.00
2.50	178.00	81.53	0.00	0.00	1.67	1.26	9.67	5.16	0.00	0.00
3.50	87.67	101.07	0.00	0.00	1.00	1.76	6.33	8.14	0.00	0.00
4.50	23.00	54.50	0.00	0.00	1.00	3.48	4.67	12.03	0.00	0.00
5.50	6.33	27.26	0.00	0.00	1.00	6.16	0.67	3.08	0.00	0.00
6.50	9.00	64.07	0.00	0.00	0.33	3.35	0.33	2.54	0.00	0.00
7.50	3.67	39.85	0.00	0.00	0.33	5.08	1.00	11.72	0.00	0.00
8.50	5.33	82.48	0.00	0.00	0.00	0.00	0.67	11.26	0.00	0.00
9.50	2.00	41.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.50	2.33	61.19	0.00	0.00	12.47	12.47	1.33	39.61	0.00	0.00
11.50	0.67	21.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.50	1.00	37.07	0.00	0.00	0.00	0.00	0.33	14.61	0.00	0.00
13.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.50	0.33	16.65	0.00	0.00	0.00	0.00	0.33	20.88	0.00	0.00
16.50	0.67	35.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.50	0.33	18.57	0.00	0.00	0.33	29.10	0.33	24.01	0.00	0.00
18.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	43.43
19.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.3.3.3.3 Total biomass per plant community

The biomass (ton/ha) for each species in each community was calculated and presented in Table 3.10. The surface area for each plant community (Table 3.2) was multiplied by the biomass of each plant species.

Table 3.10 Biomass (ton/ha) for the different species in the different plant communities

Comm-unity	Species ton/ha					Total Ton/Ha	Total Ton/ community
	D. cin	P. rot	C. api	C. col	A. nig		
A	1.737	1.833	2.762	1.947	0.305	8.585	6241.94
B	1.350	0.523	0.109	0.258	0	2.241	1118.74
C	0.895	0.222	1.442	0.987	1.35	4.583	1695.72
D	0.634	0.035	2.062	0.456	1.266	4.455	1296.43
E	1.020	0.294	0.941	0.323	0.296	2.876	690.3
F	0.713	0	0.062	0.155	0.043	0.975	163.95
Total	1.058	0.484	1.229	0.687	0.543	4.743	11207.18

3.3.3.4 Discussion

3.3.3.4.1 Allometry

The runs test on the residuals resulted in both the Chapman-Richards and the monomolecular functions being valid for all the species tested except for *Pterocarpus rotundifolius*. The R-squared values of the Chapman-Richard function were higher than those for the monomolecular function for all species except for *Pterocarpus rotundifolius*. It was therefore decided to use the Chapman-Richards function for the calculation of biomass for the species *Dichrostachys cinerea, Combretum apiculatum, C. collinum* and *Acacia nigrescens*. The monomolecular function was used to calculate biomass for *Pterocarpus rotundifolius*, accepting the fact that a systematic bias exist.

3.3.3.4.2 Biomass

Although the density in the smaller diameter classes of some species is very high, these do not contribute as much to the biomass. That is also the reason why *Dichrostachys cinerea*, although present in most plant communities in a much higher density than *Combretum apiculatum* (Fig. 3.3) is contributing less to the total biomass of the area (Table 3.10).

The mean total biomass for the Nylsvley site is 16 273 kg/ha (Rutherford 1979). Dayton (1978) found that the biomass of *Combretum apiculatum* and *Combretum zeyheri*, the two dominant woody plant species in a savanna community in the Eastern Transvaal Lowveld, was 16 909 kg/ha. Kelly & Walker (1976) determine the average woody plant biomass for *Colophospermum mopane* veld to be 19 694 kg/ha.

The 4 743 kg/ha measured in the MGR cannot be compared to total biomass surveys in other African savannas, because:

- total biomass was not measured (e.g. leaves were removed),
- measurements were not done for all diameter classes (stems above 20 cm were only counted and not measured),
- only five species were measured which in some areas make up more than 80% of the vegetation but were not so dominant in others.

3.3.4 Management application

From the data (Table 3.10) it is evident that some species are dominant in some plant communities and not so abundant or even absent in others. There is however, in some of the different plant communities, a marked similarity in standing biomass for the same species and also for the whole plant community. From a management point of view it will be more practical to combine plant communities which have the same annual biomass production into one management unit. Plant community A (area 1) (Fig. 3.4) will be kept as is with a standing biomass of 8.5 ton per ha. Plant communities B and E (area 2) will be combined which will have a standing biomass of 2.2 - 2.8 ton per ha. Plant communities C and D (area 3) will be combined with a standing biomass of 4.5 ton per ha. Plant community F (area 4) will stay as is with a standing biomass of just below 1.0 ton per ha.

Dayton (1978) determined that 9 percent of the total standing crop in a *Combretum* woodland were shoots made up of twigs, leaves and fruits of the current season. For their *Colophospermum mopane* sites, Kelly and Walker (1976) obtained an annual shoot production of 8 percent of the total biomass. In a broad breakdown of biomass types, Rutherford (1979) found that trees consist of 5.4 percent leaf biomass. Deducting this from the 9 percent current shoot production will bring the annual woody component production to 3.6 percent. Rutherford (1978) recorded an annual increment of basal area of 3 percent per hectare to total biomass. Scholes (*pers. comm.*) used 4 percent woody production as a guideline for mopane veld. Shackleton (unpublished report) has measured a change in basal area of 2.6 percent and 4.5 percent in two different plots in the MGR for the 1992 - 1993 growing season.

It can therefore be assumed that a 3.5 percent production estimate would be realistic for a woodland savanna as represented in the MGR.

Working on an annual harvest of 3.5 percent will produce the following wood-fuel:
Area 1 - 300 kg/ha
Area 2 - 89,5 kg/ha
Area 3 - 158,1 kg/ha
Area 4 - 34,1 kg/ha

The accessible area in the MGR will produce an annual harvest of 392,25 tonnes. That is the total biomass (Table 3.10) multiplied by 3.5 percent. Gandar (1983) suggests a figure of 4 tonnes per year for a typical household of seven people as a guideline. This meant that the MGR can provide in the firewood needs of 98 households annually.

3.4 THATCH GRASS INVENTORY

Although thatch grass in the MGR is in relative abundance in some years there are other years where there is very little to harvest. Table 3.11 indicate the thatch grass harvested from 1989 to 1993 in relation to rainfall for the same period, measured from July to June. It is obvious that rainfall play a major role in annual thatch grass production. Other factors eg. management burns, accidental fires, grazing pressure and market price are also influencing the harvest potential each year.

Because there are so many factors influencing thatch grass production, it was realised that quantitative measurement of the thatch resource over one or two growth seasons will not be able to predict sustainable harvesting. Thatch grass harvesting is second to last on the priority list of the local people and contributes little compared to the overall income from the MGR. Specific management measures to enhance thatch grass production will not be justified.

The local people are therefore encouraged to harvest whatever thatch grass is available, free of charge every year.

Table 3.11 Bundles of thatch grass harvested from 1989 - 1993 in relation to rainfall for the same period in the MGR.

Year	Rainfall	Bundles of thatch grass
1989	730.2 mm	45 000
1990	513.3 mm	18 628
1991	586.4 mm	47 726
1992	474.8 mm	0
1993	575.0 mm	21 214

CHAPTER 4

OPTIMIZATION OF THE WILDLIFE RESOURCE

4.1 INTRODUCTION

Local people were questioned during the sociological survey (chapter 2) about their needs and attitudes towards the utilisation of resources from the MGR. Game meat was identified by the people as the most important resource available from within the game reserve. However, most people were in favour of using the money, generated by the MGR and earmarked for the community, towards job creation. If it is important to manage the wildlife resource to benefit the whole community, the following management options can be identified:

- maximizing meat production for local consumption,
- maximizing tourism as it provides more jobs. However the need to introduce large predators to achieve this, will result in less meat available to the local community.
- managing for trophy hunting where not as many jobs will be created but where the meat will remain for the people, or
- accommodating a combination of more than one of the above options.

According to Berry (1986) a wider spectrum of utilisation will generate a higher income from game utilisation than only one.

4.2 OBJECTIVE

The objective of this chapter was therefore to determine the most profitable mix of game species within a certain stocking rate, yielding maximum economic return on costs.

The logic sequence of events to solve the optimisation problem is described by means of a flow chart (Fig. 4.1).

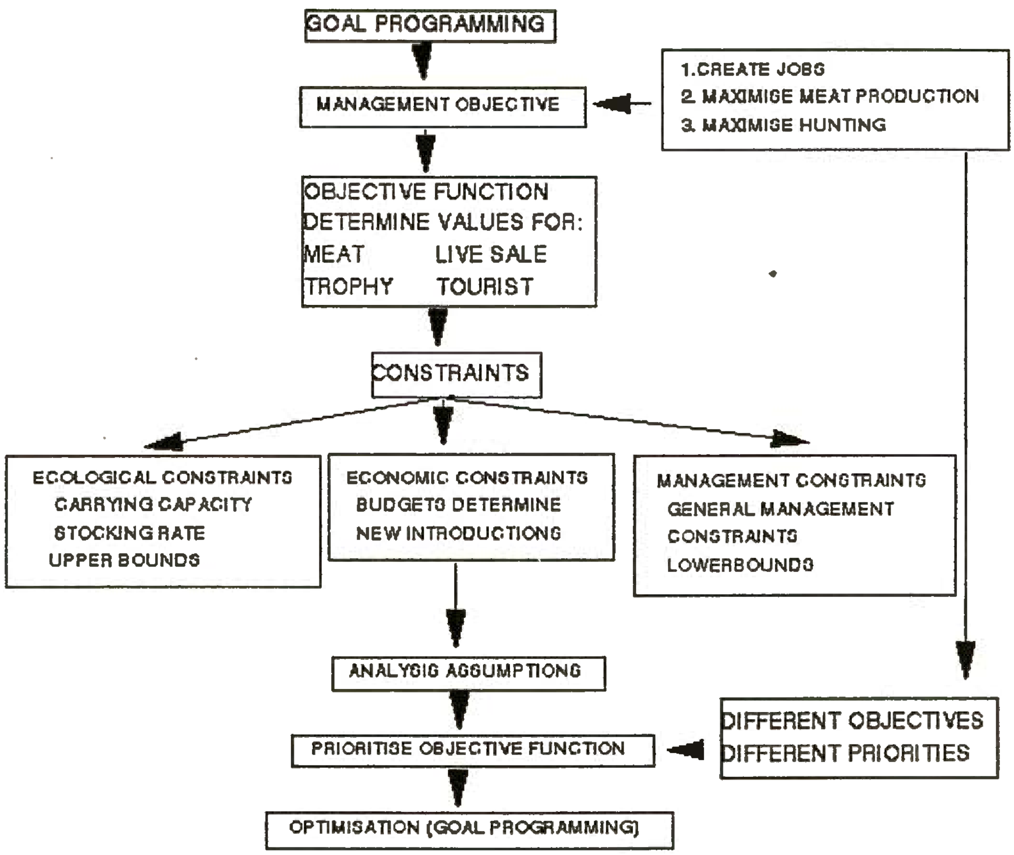

Fig. 4.1 **Flow chart of the logic sequence to achieve the best composition of game species with goal programming to obtain management objectives**

The species composition must, within the limits of the ecological carrying capacity, achieve an appropriate balance between high meat production for the local people, producing the maximum annual harvest of trophy animals for hunting, and optimising the game viewing for tourists.

The aim is to optimise a multi-species system. Mentis (1978) proposes that systems of four or more interacting species are probably beyond strict optimisation, and that the manager can therefore apply no more than intelligent guesswork. Jordi & Peddie (1988), however, describe how a multi-species optimisation problem can be solved using goal programming.

4.3 MATERIALS AND METHODS

4.3.1 Definition and concepts

One of the most common techniques used to assist in the decision process is linear programming (henceforth LP). The major weaknesses of LP in natural resource management is that only a single criterion for determining the optimal strategy is allowed (Bottoms and Bartlett 1975).

Goal programming (henceforth GP) has been discussed in the literature as an alternative to LP, particularly in decision-making environments involving multiple objectives (Bouzaher & Mendoza 1987). The concept of GP evolved as a result of unsolvable LP problems and the occurrence of conflicting multiple goals (Bottoms & Bartlett 1975).

In GP, there is no requirement that the objectives be defined in the same value terms. The only requirement in goal programming is that the manager can attach ordinal priorities or rankings to the goals. These rankings must reflect the importance of each goal. The procedure is then to minimize the deviational variables of the highest priority goal, and proceed to the next lower goal. Thus the value of the deviational variable is minimized in an attempt to achieve the goal. Optimality occurs when the deviational variables of the different goals have been minimized to the smallest possible value in order of importance.

(GP) was first used by Charnes, Cooper & Ferguson (1955). The authors had to deal with a problem of determining a plan for executive compensation. Instead of tackling this problem with a least square regression they resorted to "restraint regression" where the sum of the absolute deviations is minimised. Since then, an extensive amount of literature has appeared, developing the theoretical and operational aspects of GP as well as its application to real decision making problems in many different areas. Multi Criteria Decision Making (MCDM) is nowadays well established, with GP as perhaps the oldest and most widely used approach (Romero 1991). In a categorized bibliographic survey of 240 articles dealing with GP, Zanakis & Gupta (1985) have investigated their functional areas and field of application. One out of four published articles is of a theoretical or general nature, whereas the vast majority (90%) of the remaining articles contained either a simple example (58%) or a real-life case study (32%). This illustrates the potential of GP to be applied in practice.

Despite the obvious success of GP, the approach is not free from difficulties. Several drawbacks were specifically pointed out by Zeleny (1981). In this paper the author, after pointing out some positive characteristics, stated that it is an approach with serious practical shortcomings which should be avoided in favour of other more sound MCDM approaches. These criticisms have initiated an on-going debate on the merits and demerits of GP. Romero (1991) stated that although the problems in GP are important and deserve attention they can nevertheless be overcome. He argued that in many cases the problems are not inherent in the logic underlying the GP structure but are the result of an unsatisfactory use of the approach. The outcome of a literature search conducted by him showed that there were many instances where a GP model produced misleading or even erroneous results simply because of a careless formulation of the problem.

4.3.2 Procedure

The following steps were followed in the GP procedure, in order to determine suitable solutions.

Firstly, values for the objective function were defined. The value of each species for each type of utilisation was calculated. (See paragraph 4.3.3).

Secondly, ecological, economic and management constraints were needed to be set. These constraints set practical limits to individual species numbers. Upper and lower bounds for each species were determined. (See paragraph 4.3.4).

Lastly, a number of assumptions were made (See paragraph 4.4) before the optimisation model was run using the SAS/OR package (SAS Institute Inc, 1989: 227).

4.3.3 Values for objective functions

Hannan (1985) as well as Keeny & Raiffa (1976) suggest the development of a decision makers (DM) value function for each objective and choosing goal targets to maximize these value functions. Value functions must be expressed as the total economic value of the animal resource. It is recognised in resource economics that the total economic value of a natural resource is made up of both "utilisation" values and "preservation" values (Barnes 1990). Utilisation values are those values derived from the actual use of the resource. Preservation values are derived from the preservation of the option to use the resource somewhere in the future or, simply, from the preservation of the existence of the resource.

4.3.3.1 Utilisation values

Four types of utilisation values are applicable for the MGR, namely, meat values, live sale values, trophy hunting values and tourist values. Utilisation values are relatively easy to measure and realise as they are manifested in terms of production and known market prices.

4.3.3.1.1 Meat values

The meat value must be expressed as the average carcass weight of the species multiplied by R3.00 /kg.

The MGR is situated behind the "red-line", a legal boundary imposed by the Department of Veterinary Services as a control measure against the spread of foot and mouth disease. Veterinary regulations restrict the movement of unprocessed meat from the area. However local people adjacent the MGR are willing to pay R3.00 per kg for cooked meat of any species. The meat value is determined subjectively, taking into account the amount of meat to become available, the need of the people and a value which is affordable to most people (Table 4.1).

4.3.3.1.2 Live sale values

The red-line status of the MGR restricts the movement of live cloven hoofed animals from this area. The common species usually have a very low live-sale value because of the restricted market to other properties behind the "red-line". The price for the more valuable species (sable and giraffe) is reduced because of the cost and the risk of mortality involved to quarantine the animals before they can be sold. The mean price paid for animals from red-line areas by local game dealers for 1993 was used to obtain the live sale value for these animals. These prices are "on the hoof" prices based on the assumption that there is a viable number of animals to catch and that a market for these animals does exist (Table 4.1).

These values are not stable and will have to be adjusted annually. Game prices depend solely on supply and demand which is linked to rainfall and the condition of the game farming industry and level of "Business confidence" in the country.

Table 4.1: Values for the objective function, sustained yield and trophy co-efficient for each species. (Trophy, live sale and carcass values expressed in Rands and tourist values expressed as a percentage).

Species		Trophy R	Live sale R	Carcass R	Tourist %	Sustained yield %	Trophy yield %
1	Buffalo	11 250	2 000	765	64	10	5
2	White Rhino	60 000	20 000	1 500	79	8	5
3	Zebra	1 500	750	447	28	10	5
4	Waterbuck	2 700	750	336	23	15	5
5	Blue wildebeest	1 425	350	312	29	20	5
6	Warthog	420	-	84	10	25	5
7	Sable	25 000	13 000	297	60	10	5
8	Mountain reedbuck	750	-	36	28	25	5
9	Eland	3 000	1 200	705	56	15	5
10	Impala	300	-	66	10	20	5
11	Nyala	2 700	750	150	49	25	5
12	Elephant		5 000	-	90	4	-
13	Kudu	2 100	400	258	56	15	5
14	Giraffe	4 800	2 800	990	71	10	5

4.3.3.1.3 Trophy hunting values

Only 5% of a natural population can be regarded as trophy animals (Du Toit & van Rooyen 1986). Trophy prices as indicated on the 1993 Swazi Hunters brochure were used as the trophy values (Table 4.1). Swazi Hunters is the trade name under which the KaNgwane Parks Corporation markets and outfits its trophy hunting.

Trophy values have to be adjusted annually. The currency exchange rate effects real income from trophies as most trophy hunters are from overseas.

4.3.3.1.4 Tourist value

Non-consumptive game viewing tourism is one way in which utilisation values of game can be obtained. The tourist facility provides most of the job opportunities in the MGR and also contributes towards the management cost of the game reserve. The game viewing experience must therefore be of the highest standard to ensure that the lodge is a desirable vacation destination which run at a profit.

The Bongani lodge was established in the MGR to make use of the tourism opportunities of the MGR. This up-market tourist facility can accommodate 68 visitors and is presently being managed and marketed by the Southern Sun Group. The facility is being marketed as a destination for conference groups as well as for tourists seeking up-market accommodation in a wilderness environment with the opportunity of seeing the "Big Five".

In order to determine those species most important to tourists, and therefore most important in achieving high occupancy rates in the lodge, a questionnaire survey was undertaken. Visitors to Bongani Lodge were asked to complete a questionnaire where a value had to be allocated for each game species in each feeding class. The tourist guide who conducted the game drive asked the guests to complete the questionnaire at the end of their stay. The guests were requested to indicate his or her preferred species on a scale from 1 to 5. See Appendix 2 for a copy of the questionnaire. The values as indicated by the tourist were added up and the weighted value was then calculated. To obtain a better spread of the results, the species indicated as least preferred was set at 10 and the species most preferred was set at 90. The value for the rest of the species was calculated relative to these values and a tourism value was determined for each species (Table 4.1).

It is important to note that the introduction of consumptive uses (due to disturbance and increased flight distances in animals) are not always compatible with the non consumptive tourism industry. For example, according to Barnes (1990), cropping and safari hunting of elephant would reduce growth in tourism benefits by 0,5% per annum in Botswana. Citizen hunting would reduce growth in these areas by a further 1.5%, and a combination of all uses would reduce these by 2.5%. The tourist operator in the MGR has also indicated that trophy hunting will have to be limited as not to influence their tourism operations.

4.3.3.2 Preservation values

Preservation values are more difficult to measure than values for utilisation. This entails the use of contingent valuation techniques in which the "willingness to pay" for preservation is assessed.

The conservation value is based on the assumption that the rarer and more endangered a species, the more valuable it is (Daniels, Hedge, Joshi & Gadgil 1991). However, because this area is not unique, as similar habitat is duplicated in the Kruger National Park, the conservation of endangered species is not seen as a priority in the management of this area. The results of a survey in Kenya (Brown & Henry 1989) suggest that preservation values are likely to be high in relation to the utilisation values. It is also likely that they are similar for all the management options in question. They were therefore left out of the optimisation problem.

4.3.4 Constraints

The constraints fall into three clear groups, ie: ecological - , economic - , and management constraints.

4.3.4.1 Ecological constraints

Ecological constraints relate to the variety and number of animals which can be supported by the local environment. Overall carrying capacity was explored, while habitat suitability was determined for individual species.

4.3.4.1.1 Carrying capacity

The concept of carrying capacity (henceforth CC) is directly applicable to a game reserve where the upper limits at which herbivores can be stocked without damage or drastic change to the habitat , are of immediate concern (Mentis & Duke 1976). It is therefore necessary to determine some sort of figure for expressing CC. Caughley (1976) proposed the terms "economic carrying capacity" to describe the density of animals for maximum sustainable yield and "ecological carrying capacity" as the density at which an equilibrium exists between the animal species and the resource upon which they depend. In this study the ecological CC was used for the MGR to set an upper limit to the density of herbivores. CC depends upon several variables which include; the types and ratios of the herbivore species stocked, the net primary production, the proportion of the net primary production that is edible to the species stocked, topography and veld condition (Shackleton 1989).

Because of the interrelationships between these variables and the fact that they are constantly changing renders the quantification of a static CC a rather meaningless pursuit (Shackleton 1989). Coe, Cumming & Phillipson (1976). Duke & Mentis (1976), East (1984), Meisner (1982), and several others described different methods for determining CC.

Shackleton (1989) used five different methods for determining CC which ranges from less than 100 animal units (AU) to over 15 000 AU for a given area. This wide range in results emphasizes the difficulties and ignorance surrounding the calculation of the CC for a given area.

A significant relationship exist between large herbivore biomass and rainfall. In the semi arid wildlife areas receiving less than 700 mm per annum there was also a significant relationship between large herbivore biomass and the predicted above ground primary production. The following regression equation was used to determine the biomass of animals which could be carried in the MGR (Coe et al 1976).:

Biomass of large herbivores = 8.684 (± 2.25) AP-1205.9 (± 156.6).

(With AP being the mean annual precipitation, 700 mm for MGR).

The annual precipitation in the MGR varies between 650 mm on the low lying areas (<500 m a.s.l.) and 750 mm on the high lying areas (>800 m a.s.l.). An overall annual precipitation of 700mm was assumed to calculate the mean biomass for the MGR as 4872.9 kg/km². Upper and lower limits of 6991.3 kg/km² and 3453.5 kg/km² were calculated by adding and subtracting the constants in the Coe equation. Mentis & Duke (1976) propose that 20% of the total biomass be allocated to browsers. The grazer biomass is then 3898.3 kg/km² (mean), 5593.0 kg/km² (upper) and 2763.6 (lower) kg/km² respectively, with browser biomass standing at 974.6 kg/km² (mean), 1398.3 kg/km² (upper) and 690.9 kg/km² (lower).

4.3.4.1.2 Stocking rate

Stocking rates or standing crops of ungulates are a measure of the amount of ungulates per unit area of land (Mentis 1977). The concept of the grazer unit (GU) and browser unit (BU) as discussed by Peel, Peel & Montagu (1993) and Snyman (1991) are used to express stocking rates. The grazer stocking rate is expressed as a grazer unit GU which is defined as an animal of 450 kg which grazes exclusively (100%). The browser unit (BU) is defined as an animal of 140 kg which browses exclusively (100%). Mixed feeders are regarded as both grazers and browsers. GU and BU replacement values are calculated using the animals metabolic mass ($w^{0.75}$) and reference norm of 450 kg and 140 kg for the GU and BU respectively (Peel *et al* 1993).

The number of grazing animals of species x, which make up one GU is calculated as follows:

$$\frac{450^{0.75}}{(\text{Average body mass of species X})^{0.75} * \%\ \text{graze in diet}}$$

The number of browsing animals of species X , which make up one BU is calculated as follows:

$$\frac{140^{0.75}}{(\text{Average body mass of species X})^{0.75} * \%\ \text{browse in diet}}$$

Table 4.2 gives these replacement values for game in the MGR in terms of a grazer unit (GU) and browser unit (BU). Average body mass of species (Table 4.2) were obtained from Coe *et al* (1976) and Jordi & Peddie (1988).

The small, non-gregarious species such as grey duiker (*Sylvicapra grimmia*), bushbuck (*Tragelephus scriptus*) and klipspringer (*Oreotragus oreotragus*) were ignored because they can not be counted easily and unless present in large numbers contribute little to stocking rates.

The recommended stocking rate for the MGR using the Coe model and subtracting 20% for browsers is 8.7 GU/100 ha (mean), with upper and lower limits given as 12.4 and 6.1 GU/100ha. The BU is calculated as 7.0 BU/100 ha (mean), with upper and lower limits of 10.0 and 4.9 BU/100 ha.

The relevance of the Coe method in the MGR was assessed by establishing current stocking rate and determining its effect on veld conditions.

Table 4.2: Grazer unit (GU) and Browser unit (BU) replacement values

Species		Mass (kg)	% Graze	Animals per GU (450 kg)	% Browse	Animals per BU (140 kg)
1	Buffalo	450	90	1.1	10	4.2
2	White Rhino	1 500	80	0.5	20	0.8
3	Zebra	210	100	1.8	0	0.0
4	Waterbuck	165	100	2.1	0	0.0
5	Blue Wildebeest	160	100	2.2	0	0.0
6	Warthog	40	100	6.1	0	0.0
7	Sable	185	85	2.3	15	5.4
8	Mountain reedbuck	28	100	8.0	0	0
9	Eland	360	30	3.9	70	0.7
10	Impala	40	50	12.3	50	5.1
11	Nyala	78	30	12.8	70	2.3
12	Elephant	1 800	28	1.3	72	0.2
13	Kudu	140	18	13.3	82	1.2
14	Giraffe	750	0	0	100	0.3

Stocking rates were calculated using the animal numbers of game count results for 1990, 1991 and 1992. During 1990 and 1991 game counts were conducted at waterholes for the MGR and during 1992 a census was carried out from a helicopter.

All the counts were conducted during the months of September and October when all the natural waterholes had dried up and water had to be pumped to selected water points. This is also the time of the year when there are virtually no leaves on the trees and visibility is at its best. Waterhole counts were done by placing people in existing or temporary hides close to all known waterholes. The waterholes were observed simultaneously for a continuous period of 24 hours. The times chosen corresponded with the full moon to gave maximum visibility at night.

During the helicopter count the whole reserve was covered using a Bell Jet Ranger flying from west to east in strips of 300 m wide. Accurate strip width was maintained with the use of a Global Positioning System (GPS). The pilot and three observers recorded species, numbers and where possible sex and age of all game. These records were directly entered on a note book computer which was connected to a GPS. The latitude-longitude coordinates of all sightings were transferred to the IDRISI GIS (Eastman 1992) system in order to obtain an representation of actual spatial distribution of the game in the reserve.

The results for two different 24 hour counts during 1991 differ considerably from each other and from the 1990 figures. The waterhole count method could be inappropriate to precisely (reflecting repeatability) or accurately (reflecting true population size) determine game numbers (Stalmans 1991).

Impala, kudu and nyala numbers in 1991 were only 15 to 25% of the 1990 figures. Waterbuck numbers were down 25%, while differences for zebra and buffalo are not statistically significant. Although repeatability is low for waterhole counts, predation by wild dog also played a role in the low impala, nyala and kudu numbers (Stalmans 1991). The helicopter count for 1992 (Table 4.3) reflect probably real population figures for buffalo, giraffe and wildebeest. A certain under-count of zebra and waterbuck was expected because incremental calculations of the known introduced numbers put the actual numbers at approximately 200 zebra and 100 waterbuck.

Although the impala numbers had certainly been significantly reduced by the presence of a pack of 19 wild dogs over the previous two years (English, Stalmans, Mills & Van Wyk 1993), the figure of 138 impala is considered to be an under-count. The number of smaller species such as warthog or species which prefer a more closed habitat (nyala, bushbuck and kudu) are certainly much lower than the actual population numbers.

Using the recorded game numbers and allowing for under counting, a maximum stocking of 7.5 GU/100 ha and 8.8 BU/100 ha is possible (with nyala = 200, kudu = 150, waterbuck = 100, zebra = 200 and impala = 300) (Table 4.3). At present bulk feeders represents 60% of the total stocking rate. The high proportion of bulk grazers is appropriate for the high production of tall sour grasses in the MGR. According to Mentis (1970) the stocking composition of relatively undisturbed rangelands do indeed show a predominance in terms of biomass and energy consumption, of large, gregarious primarily grazing ungulates.

Table 4.3: Results of the 1992 helicopter game census and the estimated number of game present in the M.G.R. (Estimated numbers were calculated using the number of animals introduced since 1987, multiplied by the expected annual increase and deducting the known mortality and off-take)

Species	1992 Helicopter	Estimated 1992
Blue wildebeest	60	60
Buffalo	202	202
Bushbuck	15	20
Giraffe	43	43
Grey duiker	26	100
Impala	138	300
Klipspringer	14	50
Nyala	17	200
Kudu	103	150
Sable	3	3
Warthog	11	50
Waterbuck	53	100
White rhino	13	13
Zebra	163	200

4.3.4.1.3 Veld condition

The aims of the grassland monitoring are to:

- document the indicator species on a yearly basis and to monitor any change in the species composition,
- obtain a quantitative estimate of available forage for game and fuel for veld burning, and
- assess the trend of those two parameters over time.

The Trollope key species method was applied in the MGR. The key species technique is based on the premise that veld condition and trend are influenced by relatively few grass species in a particular veld (Wills & Trollope 1987).

The grass species are classified according to their response to defoliation into three groups (Trollope 1990):

- decreaser species which tend to decrease when the veld is under- or over-utilised,
- increaser 1 species which tend to increase when the veld is under utilised, and
- increaser 2 species which tend to increase when the veld is over-utilised.

Trollope (1990) identified the key species and calculated forage and fuel scores for the Kruger National Park (KNP). Forage is defined as that portion of a living plant that is available for consumption by animals. Fuel load is defined as the mass of fuel per unit area that is available for combustion during a fire - kg/m^2 (Trollope, Trollope & Bosch 1990). The MGR borders the KNP and the Trollope method is deemed applicable in view of similar habitats on both sides of the common boundary.

Seven permanent transects have been sampled yearly since 1988. A further 7 transects were sampled yearly since 1989, and another two transects have been sampled yearly since 1990. A total of 100 point-observations were obtained per transect using the step-point method and the nearest rooted plant criterion (Mentis 1981). All key species were recorded, while non-key species were lumped together for analysis purposes in a synthetic species known as "others". The 1988-1993 data were compared on a yearly basis in order to assess changes in veld condition.

Direct herbaceous biomass measurement through clipping and weighing is extremely time consuming. Herbaceous biomass was therefore determined indirectly using the disc pasture meter. The attractiveness of the technique lies in the rapidity with which estimates of the amount of grass could be made and the non-destructive nature of the sampling (Trollope & Potgieter 1986). The herbaceous measurement was done at 100 points in each transect.

(a) Forage scores

The average forage and fuel scores over the 1988 - 1993 period are presented in Table 4.4. The difference in average forage scores over this period is 9%. This difference can most probably be explained in terms of sampling error and variability even if no change at all occurred. The average score shows very little difference in the plots over time. This would indicate that the stocking rate over the last five years had no negative impact on the plant species composition.

(b) Fuel scores

In contrast to the forage score that remain constant, there was a marked change in the fuel score over time. Biomass was reduced over the years with a difference in average fuel score of 58% between 1988 and 1993. The dramatic reduction in biomass can be explained by:

- the introduction of a burning program for the MGR. On average a third of the MGR is burnt annually. The post-fire biomass in the next 18 to 24 months will be lower because of the reduction in fuel load and the increased grazing pressure on these areas.
- the introduction of herbivores and the increased stocking rate from nearly zero in 1988 to 7.0 GU/100 ha and 8.0 BU/100 ha in 1993.
- fluctuation in rainfall and specifically the drought during 1991 and 1992 with decreasing biomass. The high rainfall at the beginning of 1993 resulted in an increase in biomass.

In conclusion, the average veld condition, measured over a period of six years, changed very little. The marked reduction in biomass reflects both the effect of abiotic factors (rainfall, soil nutrients, fire history etc) and the effect of herbivory. It could therefore be assumed that, if veld condition can be used as a parameter, that the existing stocking rate is still within the bounds of that which the MGR can carry. The existing stocking rate is also within the limits of the CC as determined by the Coe model. The CC expressed as GU/100 ha and BU/100 ha as determined by the Coe model will therefore be used as the food constraint in the calculation of production values for the wildlife species. (Table 4.2).

Table 4.4: Average Forage and Fuel scores for the Mthethomusha Game Reserve from 1988 to 1993

Year	Forage Score	Fuel Score	Rainfall
1988	383	5 661	732.3 mm
1989	409	4 262	730.21 mm
1990	378	4 190	513.3 mm
1991	376	3 161	586.4 mm
1992	407	2 036	474.8 mm
1993	349	2 382	570.0 mm

4.3.4.1.4 Habitat suitability

Habitat suitability was determined for individual species. Because the terrain and topography are so different for each habitat, the area was divided into different strata, and an expert opinion was used to determine the upper-bound for each species.

(a) Expert approach

Upper-bounds can be determined by a detailed vegetation survey and quantification of CC for each plant community in the reserve. Although a detailed vegetation survey will have to be done to fine tune management in the MGR, the magnitude and time constraint of such a task fell beyond the scope of this study. Jordi & Peddie (1988) proposed the estimation of what could realistically be expected to be found in a habitat in the opinion of an expert. Existing information in the literature on habitat preference of game species together with expert opinion was used to subjectively decide on the upper-bound for each species.

(b) Stratification

Before a panel of experts was asked to evaluate the suitability of the area for the different game species, the area was stratified into three main ecological zones.

A zone was made up of different plant communities but were homogeneous in so far as the attributes height above sea level, slope and aspect are concerned. Although the strata were divided using abiotic attributes, the position of the strata is recognisable in the landscape with certain indicator plant species separating the different strata.

Zone one consists of the lowest lying areas in the MGR and started at 340 m.a.s.l. This strata consists primarily of valley bottoms, dominated by *Acacia* woodlands and foot slopes, dominated by *Combretum* woodlands. At a height of 500 m.a.s.l. there is a gradual change to the next strata. On the northern slopes this strata can reach an altitude up to 650 m.a.s.l.

The second strata shows a marked difference in habitat for the different aspects. The grass in this strata is generally more sour than the first one and is dominated by *Hyperthelia* and *Hyperhenia spp.* "After fire" grazing pressure keeps some of these areas palatable for game. This strata consist mainly of foot and middle slopes that are inaccessible to certain game species.

At a height of 750 m.a.s.l. there is an abrupt change in grass and trees type. *Faurea spp., Heteropyxis natalensis* etc. are characteristic of the woody species. Although some areas in this strata are being utilised, the major part of the area is inaccessible to most species, mainly because of the steepness of the terrain. The surface areas of the three strata were determined by means of a geographic information system (GIS) (Table 4.5).

(c) Expert opinion

To determine a subjective upper-bound by experts, the following procedure was used. The agricultural CC for this general region is set at 5 ha per livestock unit (LSU). The local agricultural extension officer was asked to identify an area inside the MGR with a CC representative of this general region. The area was marked and used as a benchmark for further subjective estimations of CC for the game reserve.

Table 4.5: Surface area of the different ecological zones in the M.G.R.

Zones	Site	Ha	%
Strata 1	Flat	324	4.53
	North	924	12.93
	South	32	0.45
	East/West	583	8.16
Strata 2	Flat	729	10.2
	North	664	9.29
	South	194	2.72
	East/West	1 410	19.73
Strata 3	Flat	324	4.53
	North	470	6.58
	South	324	4.53
	East/West	1 167	16.33

Five experts were invited to form a panel to subjectively rate the suitability of the different strata for 12 different game species. The panel was made up of the following persons who are all working in the eastern Transvaal lowveld and can be considered experts in the field of veld assessment and habitat suitability ratings:

Dr. J. Venter - Private consultant and stationed at Klaserie. Previously ecologist for Natal Parks and now advisor on private game farms.

Dr.J.L. Anderson - Director of the KaNgwane Parks Corporation, more than 20 years experience in wildlife management.

Mike Peel - Senior ecologist for the Roodeplaat Institute for Grassland Research, Nelspruit.

Marc Stalmans - Senior ecologist for KaNgwane Parks Corporation.

Francois Swart - Senior ecologist Transvaal Provincial Administration.

Four representative sites were subjectively chosen in each strata; two sites on reasonable level areas one site on a north and one on a south aspect. On the day of the expert assessment the five experts were first taken to the benchmark site. The experts were asked to individually rate the CC for the benchmark in terms of ha per LSU. They were then asked to rate the suitability of the site on a scale of 1-5 for each of the 12 game species concerned with 1 as not suitable and 5 as best suited. These values were then compared on site and a consensus value determined. It was very important to standardise the ratings for the benchmark at this stage because all the suitability ratings for all the other sites were to be compared to the benchmark i.e. the same, better or worse than the benchmark.

The experts were then taken through the MGR on a pre-planned route to visit each of the 12 sites. They were asked not to discuss their ratings as not to influence each other. An average of 15 minutes was spent at each site where the experts looked at the plant species composition, soils, utilisation by herbivores, and general condition of the veld. They were also informed on general information such as rainfall, distance from water and fire history.

(d) Results

The benchmark site was rated 8 ha/LSU and 40 ha/BU by the experts. The suitability of the benchmark for different species was agreed upon after detailed discussion in the expert panel (Table 4.6). To keep the rating process simple, all the other sites were rated against the benchmark site. If a site was rated similar as the benchmark a value of 3 was allocated, worse than the benchmark was either a 1 or 2 and better than the benchmark was a 4 or 5. The total rating values for all sites from the individual experts were compared. Four of the expert's ratings were within

10% of the mean, while the fifth expert differed 22.7 % from the mean. This difference has a significant impact on the results and it was therefore decided to exclude the ratings of the fifth expert from the calculation.

CALCULATION PROCEDURE FOR DETERMINATION OF UPPERBOUNDS FOR INDIVIDUAL SPECIES USING EXPERT PANEL APPROACH

PHASE 1: BENCHMARK ASSESSMENT

Step 1:

Selection of a site similar to the Agricultural Benchmark in the sub-region in consultation with an agricultural extension officer.

Step 2:

Assessment of carrying capacity in terms of hectares needed per domestic cow by a panel of four experts. Individual assessment was followed by the determination of a consensus value (8 ha/LSU).

Assessment of carrying capacity in terms of hectares needed per Kudu by panel of experts. Individual assessment was followed by the determination of a consensus value (40 ha/Browser unit).

Step 3:

Assess suitability of this site for a range of game herbivores on a 5 point scale to set benchmark value for each individual species (Table 4.6).

PHASE 2: SITE ASSESSMENT

Step 1:

Division of the MGR in three main ecological zones (strata) which represent a consistent combination of environmental factors and vegetation.

Step 2:

Four representative sites were subjectively chosen in each stratum; two sites on level areas, one site on a north and one on a south aspect. This yielded a total of 12 sites (or 9 different site types for the three strata). No sites were selected on the east or west aspects to limit visiting sites and chances for confusion. The average of the ratings on the north and south aspects was used as the east/west rating.

Step 3:

Assessment of each of those 12 sites by expert panel. Each expert considered plant species composition, soil, utilisation by herbivores and general veld condition to rate its suitability for each herbivore species relative to the benchmark (on a five-point scale).

PHASE 3: UPPERBOUND CALCULATION

Step 1:

Value of each site relative to the benchmark was determined by summation of ratings of the four experts, followed by division of this sum by 12 which represents the average value for the benchmark (value 3 on the 5-point scale) for the four experts.

Step 2:

This site value was multiplied with the number of hectares occupied by this particular site type (determined using IDRISI GIS, Table 4.5). The resultant value was then multiplied by a percentage value, converted from the benchmark value for each species (Table 4.6). The scale on which the percentage value was determined was based on the assumption that the CC for game is lower than for cattle (Mentis &Duke 1976) and the top value was therefore set just under the benchmark at 90%. Because no veld has a zero value the bottom value was set at 10% (other percentage values, Table 4.6). Finally, the number of LSU of each species was obtained by dividing this total by 8, which is the agricultural carrying capacity determined for the area by the experts (Phase 1, Step 2).

Step 3:

These LSU values were then multiplied with the replacement values for game (Table 4.2) to obtain the maximum number of individuals per game species which can be carried on the MGR (Table 4.8).

Total animal numbers were converted to GU and BU for each species. This figure was used in the optimisation problem to achieve the best species composition. (Table 4.9).

Table 4.6: Consensus opinion of the suitability benchmark for different game species.

Species	Value	Percentage
Buffalo	3	50
White rhino	3	50
Zebra	4	70
Waterbuck	3	50
Blue wildebeest	2	30
Warthog	2	30
Sable	3	50
Mountain reedbuck	2	30
Eland	2	30
Impala	2	30
Nyala	1	10
Kudu	2	30
Giraffe	2	30

Table 4.7: Suitability of ecological zones for each species in relation to benchmark, expressed as a combined value by expert panel on a scale of 0 - 20.

L = Level S = South Slope N = North Slope E/W = East/west Slope

	Strata 1				Strata 2				Strata 3			
Species	L	S	N	E/W	L	S	N	E/W	L	S	N	E/W
Buffalo	10	12	10	11	12	7	7	7	12.5	13	11	12
White rhino	15	12	8	10	12	7	6	0.5	9	8	7	7.5
Zebra	10.5	13	11	12	14	9	9	9	14	13	13	13
Waterbuck	15	14	13	13.5	11	8	7	7.5	8	8	8	8
B. wildebeest	15.5	9	8	8.5	11	8	5	6.5	6.5	7	6	6.5
Warthog	15	9	10	9.5	11	7	5	6	7.5	5	4	4.5
Sable	9.5	12	7	9.5	12	7	6	6.5	11	10	10	10
M. reedbuck	7.5	12	11	4.5	12	16	15	15.5	17.5	16	16	16
Eland	11	15	14	14.5	15	14	14	14	14.5	13	10	11.5
Impala	16.5	12	13	12.5	14	13	9	11	8.5	6	8	7
Nyala	15.5	16	18	17	13	16	16	16	9.5	8	9	8.5
Kudu	15	17	20	18.5	16	16	16	16	15.5	16	15	15.5
Giraffe	17	14	12	13	16	6	6	6	10	7	6	6.5

(e) Discussion

This method of expert opinion was used to determine the upper bound for a species in the game reserve, should there be no other species present to compete for the same food source. Although the results were not based on hard scientific data, they do illustrate a way to express quantitatively the opinion of a number of experts in the field. The experts came from a variety of backgrounds with considerable experience of wildlife management, and their opinion, especially when taken to a consensus view, should carry weight. Discussion of the method afterwards brought forward the following comments:

- Most of the participants felt comfortable with the technique.
- The calibration of the benchmark was an important first step of the method.
- Fire history, rainfall, distance from water point, etc are important information to have when rating a habitat on a first visit

Table 4.8 **Minimum and maximum population sizes. Column A, the minimum number of a species to ensure survival, Column B, the minimum number of a species to allow reasonable game viewing and to sustain 3 killing lions, Column C, the maximum number of a species that could be carried on the MGR if there were no competition from other species for the same food source.**

Species		A	B	C
1	Buffalo	50	200	375
2	White rhino	10	20	126
3	Zebra	50	100	1 107
4	Waterbuck	50	100	778
5	Blue wildebeest	50	100	364
6	Warthog	50	100	300
7	Sable	10	50	638
8	Mountain reedbuck	50	100	2 544
9	Eland	50	50	138
10	Impala	50	300	800
11	Nyala	50	100	374
12	Elephant	10	14	20
13	Kudu	50	100	294
14	Giraffe	20	25	41

4.3.4.2 Economic constraints

The economic constraints for the study refer to the limitations in buying more game to reach the most desired option. For example, certain species eg. sable antelope will have high values for all the objective functions. The model will then tend to benefit this species in the optimisation process. Although the species composition proposed would be the ideal, it would not be feasible to spend the money to purchase eg. 50 sable antelope because of budget constraints. The available number of each species will have to be used in the calculation and management will have to decide what budget is available for acquiring more game. Because future budgets are not available, economic constraints, was not used in the optimisation problem.

4.3.4.3 Management constraints

Management constraints in the study refers to limitations in the practical management of the MGR and the estimation of a lower-bound.

4.3.4.3.1 Management

- the annual game removal must not exceed the sustained yield.
- because of the sourish nature of the veld at least 60% of the animal biomass (GU) must consist of bulk grazers.
- the private company running the tourist facility requested hunting to be restricted to buffalo in order to minimize disturbance. However, because the aim of this study is optimisation, the trophy potential of all species has been investigated.

4.3.4.3.2 Lower-bounds

With the estimation of lower bounds, two different approaches were used. The first one is the survival of species approach. Unfortunately no scientific accepted norm exist what the minimum size of a population must be to maintain the genetic integrity of a species. Franklin (1981) suggests that for large mammals the effective population size be at least 50 individuals which represents a loss of variation of about 1% per generation, a rate that is readily accepted by animal breeders. The MGR is not big enough to sustain some of the larger herbivores eg. elephant and giraffe at population density of 50 animals (Table 4.8). However, because of their high tourism value it is essential that they are present and the maximum number for each of these species was included under the constraints. (Table 4.8).

The second approach was based on the minimum numbers of a species needed to ensure a satisfactory game viewing experience for the visitor and to sustain predators. To be successful in selling game viewing as a product, a 90% "hit rate" for the more important game species must be achieved in the average two day period that a guest stays at the lodge (Payne *pers. comm.*) There are many factors influencing that achievement of which stocking rate is but one. The social composition of the family groups for the different species was used to determine population size. Species with a gregarious nature and social units ranging in size from 50 to 100 and in some instances up to a 1 000 individuals, should be stocked at a different level, than do species which live in small family groups of 5 to 15 individuals or species which live in pairs or solitary. For example the chance factor of seeing a single herd of 75 impala in a 7000 ha area is much smaller than seeing one of 10 family groups of zebra of 7 individuals each.

Predators, especially lion, are a major draw-card for tourists. It is therefore important to have sufficient numbers of its prey species available to allow for the maintenance of a pride of lions. By determining the biomass needed to maintain three killing lions and divide it *pro rata* with the species preyed on by lions in the KNP it is possible to get an estimate of the species and numbers that could be utilised. The species and number of a species preyed on by lion depend on a number of factors. The three lion were however only recently introduced into the MGR (June 1993) and not enough data exists on their preferences in the MGR to determine preferred prey species and numbers.

The minimum population sizes of the herds for the different species to satisfy tourism needs was therefore subjectively determined by combining herd size, and minimum population size to maintain lions (Table 4.8). The numbers of eland and sable that were only recently introduced in the park were kept low because of the cost involved to relocate these expensive animals (Table 4.8) and the uncertainty as to whether eland would thrive or not.

4.4 THE MODEL

4.4.1 The following are the main assumptions used in the analysis:

- management cost is the same for each option.
- the meat of any carcass can be sold for R3.00/kg.
- a market for live game exist at the prices as indicated in Table 4.1.
- 5% of a population is annually available as trophy animals.
- the total herbivore biomass must not exceed 4872.9 kg/km².
- the total herbivore biomass for GU must not exceed 3898.3 kg/km².
- the total herbivore biomass for BU must not exceed 974.6 kg/km².
- at least 60% of the animal biomass (GU) must consist of bulk grazers.

4.4.2 The following variables are defined:

- x_i the total number of animals of species *i* to be stocked.
- y_{T_i} the number of animals of species *i* to be shot for trophies.
- y_{C_i} the number of animals of species *i* to be shot and sold as carcasses.
- y_{L_i} the number of animals of species *i* to be captured and sold alive.

N_2, N_3, N_4 "slack" variables used in the objective functions for trophy hunting, culling (carcass) and live sale respectively.

P_2, P_3, P_4 "surplus" variables used in the objective functions for trophy hunting culling (carcass) and live sale respectively.

(in each case i = l;...;14, i.e. for the 14 different species.)

4.4.3 The objective functions:

minimize $z_2 = N_2 + P_2$ for trophy hunting

minimize $z_3 = N_3 + P_3$ for culling (carcass)

minimize $z_4 = N_4 + P_4$ for live sale

The priorities on these objective functions were set (and changed) for the different alternatives stated in Table 4.10. The idea of these objective functions and the associated constraints is to "get as near as possible to a set target (goal value)".

4.4.4 The constraints:

- Goal constraints:

$$\Sigma^{14}_{i=1}\, {}^{c}T_i\, {}^{y}T_i + N_2 - P_2 = M_2 \quad \text{for trophy hunting}$$
$$\Sigma^{14}_{i=1}\, {}^{c}C_i\, {}^{y}C_i + N_3 - P_3 = M_3 \quad \text{for carcasses}$$
$$\Sigma^{14}_{i=1}\, {}^{c}L_i\, {}^{y}L_i + N_4 - P_4 = M_4 \quad \text{for live sale}$$

${}^{c}T_i$; ${}^{c}C_i$ and ${}^{c}L_i$ represent the constant values for trophy, carcass and live sale respectively for each species. These values are from table 4.1. In fact, for ${}^{c}T_i$ the trophy value plus carcass value is taken since each trophy also makes a carcass available. M_2, M_3 and M_4 are constants to be used as values set as goals for the three objectives respectively. M_2, M_3 and M_4 were experimentally chosen the program with different orderly chosen settings of these values in order to get an objective function with a value as high as possible.

- Biomass constraints:

$$\Sigma^{14}_{i=1}\, {}^{a}BM_i\, x_i \leq 350848.8 \quad \text{total biomass}$$
$$\Sigma^{14}_{i=1}\, {}^{a}GU_i\, x_i \leq 280677.6 \quad \text{total grazer biomass}$$
$$\Sigma^{14}_{i=1}\, {}^{a}BU_i\, x_i \leq 70171.2 \quad \text{total browser biomass}$$

where each ${}^{a}BM_i$ represents the total biomass per species i; each ${}^{a}GU_i$ represents the grazer biomass per species i and each ${}^{a}BU_i$ represents the browser biomass per species i. The constants 350848.8, 280677.6 and 70171.2 represent the maximum biomass, maximum grazer biomass and maximum browser biomass respectively possible in the MGR.

- Bulk grazer constraint:

$${}^{a}GU_1\, x_1 + {}^{a}GU_2\, x_2 + {}^{a}GU_3\, x_3 + {}^{a}GU_4\, x_4 \geq 0.6\, (\Sigma^{14}{}_{i}{=}_{1}\, {}^{a}GU_i\, x_i)$$

where each ${}^{a}GU_i$ is defined as above and x_1, x_2, x_3 and x_4 represent the four bulk grazer species.

- Upper and lower bounds:

$l_i \leq x_i \leq u_i$ and i = 1;...;14

where each l_i represents the lower bound on species i as stated in table 4.8, column A or B. The column to be used, depends on the lower bound to be in effect, see table 4.10. Each u_i represents the upper bound on species i as stated in table 4.9, column C.

- Sustained yield constraints:

$^{a}{P_i}\ x_i \geq {}^{y}{T_i} + {}^{y}{C_i} + {}^{y}{L_i}$ and i = l;...;14

where $^{a}p_i$ is the sustained yield for each species i as stated in table 4.1.

- Trophy yield constraints:

$^{a}{T_i}\ x_i \geq {}^{y}{T_i}$ and i = l;...;14

where $^{a}{T_i}$ is the trophy yield available for each species as stated in table 4.1.

- Nonnegativity constraints:

$x_i \geq 0$	and i	= l;...;14
$^{y}{T_i} \geq 0$	and i	= l;...;14
$^{y}{C_i} \geq 0$	and i	= l;...;14
$^{y}{L_i} \geq 0$	and i	= l;...;14
$N_i \geq 0$	and i	= 2,3,4
$P_i \geq 0$	and i	= 2,3,4

Table 4.9: Lower bounds using the minimum population size for species survival expressed in GU and BU and available habitat for species to determine upper bounds.

Upper and lower bounds				
Species	BU (kg)		GU (kg)	
	Upper	Lower	Upper	Lower
Buffalo	12 603	1 680.4	151 875	20 250.0
White Rhino	20 893	1 658.2	111 900	8 881.0
Zebra	-	-	281 264	12 703.9
Waterbuck	-	-	164 966	10 602.0
Blue wildebeest	-	-	75 421	10 360.1
Warthog	-	-	21 977	3 662.8
Sable	16 512	258.8	125 291	1 963.8
Mountain reedbuck	-	-	142 622	2 803.1
Eland	27 462	9 950.1	15 759	5 709.8
Impala	22 048	1 367.8	29 522	1 831.4
Nyala	22 950	3 068.3	13 170	1 700.7
Elephant	6 844	6 844.1	3 563	3 563.8
Kudu	33 751	5 740.0	9 920	1 687.1
Giraffe	20 212	4 298.8	-	-

4.5 RESULTS

The SAS/OR package was used to solve the goal programming problem for different objectives. The constraints and upper bounds were used as discussed. The tourism value for game (Table 4.1) could not be used as an objective function in the optimisation problem but was used in a more indirect way. The tourism value is applicable to all the individuals of a species. However this value changes for the tourist once the species has been seen on a game drive. The logic way to accommodate tourism value was to fix the lower bound on the minimum number of individuals needed. The lower bound population should ensure a satisfactory game drive (Table 4.8). The first three alternatives were therefore run by using this minimum number for tourism as lower bound and by rotating the different objective functions alternatively as priority. The next three alternatives were run, with the lower-bounds set as the minimum number of animals necessary in a population to survive, with the different objective functions alternatively used as priority (Table 4.10).

Table 4.10: Summary of procedures for the different alternatives in the optimisation problem.

Alternative No.	Minimum population size to satisfy tourism and to maintain predators.
1	Live sale the priority, culling second and trophy hunting least important.
2	Trophy hunting the priority, live removals second and culling least important.
3	Provision of carcasses the priority, with trophy hunting second and live sale the least important.
	Minimum population size for a species to survive.
4	Provision of carcasses the priority, with trophy hunting second and live sale the least important.
5	Trophy hunting the priority, live removals second and culling least important.
6	Live sale of animals the priority, culling second and trophy hunting least important.

Alternative 1 and 6

Live sale was set as the priority with culling second and trophy hunting least important. The management option that is the most reconcilable with the tourism objective is the live removal of animals. Five percent of the buffalo population which is 50% of the sustained yield will be trophy bulls that could be sold alive at the same price as the trophy value. This exception for buffalo has been worked into the model. Culling for carcasses is considered as a second option and the least preferred option is trophy hunting. Alternative 6 was run with the same priority for objective functions but with the lower bound as minimum population size for survival. In both cases a solution was found and the total potential income from game were calculated for each alternative (Table 4.11). The income from tourism is not used in the calculation to determine the potential income from game. At the moment the tourism contribution towards the management of the MGR amounts to R480 000. If this was added to alternative 1 which is the better option for tourism it exceed that of alternative 6.

Alternative 2 and 5

Trophy hunting was set as the priority with live removals second and carcass utilisation option least important. In alternative two the lower bound was set according to the smallest population size for tourism and in alternative 5 the lower bound was set for the smallest population needed for survival. A solution was found for both alternatives and the total potential income from game was calculated (Table 4.12). It is obvious that the best income from game is possible with this objective function as priority. Although this option will generate a large cash income for the tribe it does not provide the same number of jobs and therefore the direct benefit to the community as would be an eco-tourism industry.

Alternative 3 and 4

The provision of carcasses were set as the priority with trophy hunting second and live sale the least important. The lower bounds was set for alternative 3 as the smallest population needed for tourism and alternative 4 for the smallest population needed for survival. A solution was found in both cases and the potential game harvest was calculated. Although the provision of meat was stressed by the people as a very important resource needed, the income from this objective is significantly lower than for the other objectives (Table 4.13).

Table 4.11: The solution for alternative 1 and 6 of the optimisation problem with live sale value as priority.

		Alternative 1				Alternative 6			
Species		No.	Trophy	Carcass	Live	No.	Trophy	Carcass	Live
1	Buffalo	200			20	331.5			33.15
2	White rhino	20			1.6	10.63			0.85
3	Zebra	120			12	50			5
4	Waterbuck	266.5			41	50			7.5
5	B. Wildebeest	120			24	50			10
6	Warthog	120		30		50		12.5	
7	Sable	124			12.47	414			41.41
8	M. Reedbuck	100		25		50		12.5	
9	Eland	50			7.5	50			7.5
10	Impala	350		70		50		10	
11	Nyala	100			25	50			12.5
12	Elephant	14			0.56	10			0.4
13	Kudu	100			15	50			7.5
14	Giraffe	20			2	41			4.1
		Total value R330 837				Total value R664 626			

Table 4.12: The solution for alternative 2 and 5 of the optimisation problem with trophy hunting as priority.

		Alternative 2				Alternative 5			
	Species	No.	Trophy	Carcass	Live	No.	Trophy	Carcass	Live
1	Buffalo	200	10		10	77.71	3.88	0	3.88
2	White rhino	20	1	0	0.6	126	6.3	0	3.78
3	Zebra	120	6	0	6	50	2.5	0	2.5
4	Waterbuck	266.5	13.32	0	26.65	50	2.5	0	5
5	B. Wildebeest	120	6	0	18	50	2.5	0	7.5
6	Warthog	120	6	24	0	50	2.5	10	
7	Sable	124.7	6.23	0	6.23	414.17	20.71	0	20.71
8	M. Reedbuck	100	5	20		50	2.5	10	
9	Eland	50	2.5	0	5	50	2.5	0	5
10	Impala	350	17.5	52.5		50	2.5	0	7.5
11	Nyala	100	5	0	20	50	2.5	0	10
12	Elephant	14	-	-	0.56	10	-	-	0.4
13	Kudu	100	5	0	10	50	2.5	0	5
14	Giraffe	20	1	0	1	15.8	0.79	0	0.79
		Total value R605 744				Total value R1 360 998			

Table 4.13: The solution for alternative 3 and 4 of the optimisation problem with carcass as priority.

		Alternative 3				Alternative 4			
Species		No.	Trophy	Carcass	Live	No.	Trophy	Carcass	Live
1	Buffalo	200		20		50		5	
2	White rhino	31.07		2.5		126		10.8	
3	Zebra	120		12		50		5	
4	Waterbuck	153.6		20		102.89		15.43	
5	B. Wildebeest	282		56.4		364		72.8	
6	Warthog	120		30		145.42		36.36	
7	Sable	50		5		10		1	
8	M. Reedbuck	100		25		50		12.8	
9	Eland	50		7.5		50		7.5	
10	Impala	350		70		50		10	
11	Nyala	100		25		272.2		68.05	
12	Elephant	14			0.56	10			0.4
13	Kudu	100		15		50		7.5	
14	Giraffe	20		2		10		1	
		Total value R75 095				Total value R73 561			

4.6 DISCUSSION

The aim of this chapter was to determine the most profitable mix of game species for an optimal stocking rate, yielding maximum economic return on costs. From the different solutions obtained, it is obvious that there is no single correct answer to the optimisation problem. The species mix will change according to the management objective. And even for a specific objective these numbers are not fixed because the values of the different objective functions for the different species are changing all the time.

The management objective for the MGR is to manage the resource area to the greatest benefit of the people. The best way in which the reserve can contribute to this objective is to create as many jobs as possible (Chapter 2.5.2). The solution that suits this management objective the best, will be the species composition which is optimal for tourism. It is interesting that the number of individuals per species for solution one is exactly the same as for solution two. The difference is in the method of harvesting the sustained yield. In solution two the priority is trophy hunting but still providing the numbers necessary for tourism. The income from the game harvesting is however twice as much as for the live sale option. The number per species as expressed in solution one and two seems to be the best solution for the present management objective. However, solution two showed to be the most profitable utilisation of the resource.

The existing stocking of the MGR differs significantly from the best (tourism) option determined by G.P. (Table 4.14). Although the budget to purchase game was discussed under economic constraints, it was not included in the problem because future budgets to purchase game for the MGR is not known at this stage. This constraint can therefore have a significant influence on the result.

The different objectives were alternatively used as priority to obtain the different solutions. In the SAS/OR package the priority is considered absolute (not flexible). This meant that the first priority will have to be satisfied completely before the next priority will be considered. Although feasible solutions were obtained with this method, the following is proposed for future research:-

- the rigidity of the method will have to be addressed and ways will have to be investigated to make the method more flexible.
- not every game farm manager has access to a SAS/OR package. The model will be more applicable if it could be run on a goal programming package in a spreadsheet format on a standard PC.
- a management objective to obtain the best species composition is a problem for all game farm managers. Therefore, the development of a decision support system for game farm managers would be of great value in the optimisation of stocking rate.

Table 4.14: Present number of animals stocked in the Mthethomusha Game Reserve in comparison to the best stocking rate as determined by Goal Programming as the best option.

Species		Number stocked 1993	Number best option
1	Buffalo	200	200
2	White rhino	19	20
3	Zebra	200	120
4	Waterbuck	100	266
5	B. wildebeest	60	120
6	Warthog	50	120
7	Sable	3	124
8	M. reedbuck	30	100
9	Eland	6	50
10	Impala	350	350
11	Nyala	150	100
12	Elephant	8	14
13	Kudu	150	100
14	Giraffe	50	20

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 INTRODUCTION

The problem of reconciling economic viability and environmental conservation is not a new one. It has been the subject of much discussion over the last two decades and considerable progress has been made in the developed countries. In a document (Anon 1993) published by the RSA Department of Environment Affairs a new approach as a management philosophy is propagated. First, the mission of the relevant authorities is believed to be the pursuit of sustainable development rather than pure economic growth. Second, the immediate operational goal consistent with this mission is believed to be effective resource management, not only conservation. Third, the economic approach is believed to be necessary as a supplement to regulation to achieve this goal. The economic approach work on the principle that the free market coordinate the supply and demand of millions of different products. This fact prompted the question of whether similar incentives could be used to manage the environment. The solution proposed by the economic approach is straight forward: increase the price of those environmental resources that should be conserved. This will limit the demand for the resources and ration the available supply. Careful consideration will have to be given to the way raised prices will effect the various groups in society, especially the rural poor.

While in Europe and North America rural communities comprise less than 10% of the population, in Africa they comprise 60 - 80% of the population (Cumming 1990). With human populations doubling every 20 years the pressures of poaching, grazing, and harvesting timber are escalating. It was believed that this conflict can be solved only by first winning the "hearts and minds" of the people (Anderson 1983). Barbier, Burgess, Swanson & Pearce (1990) stated that we are only now beginning to realize that " elephant and the ivory trade is an economic problem".

People do not cut trees, for example, because they do not respect nature, but because it is the most economic way to provide in their needs. Fire wood is free, while paraffin or gas must be bought.

One can argue that the over- utilisation of the natural resource base is economically driven. It is therefore imperative that if you want to change peoples attitudes towards the environment, you first will have to change their economic circumstances.

The aim of this chapter is to discuss the financial implications of the management of the MGR and to determine what the harvesting of the resources contribute towards management cost and also how the tribe eventually benefits from this arrangement.

5.2 DEVELOPMENT OPTIONS

5.2.1 The null option

Without deliberate rural development in KaNgwane, it is unlikely that the under developed areas will transform spontaneously. Indeed, many of the unsatisfactory conditions eg. slow attrition of the natural resource base, limited physical and institutional infrastructure, high proportion of economically inactive people, dearth of local employment opportunities, low household income, etc are likely to aggravate.

5.2.2 Cattle farming

The only other form of land use for the MGR was cattle farming. The present overall stocking rate for KaNgwane is estimated at 0.9 AU ha^{-1} (equivalent to 1.1 ha per beast) (Mentis 1992). In terms of Caughley's (1976) model of plant-herbivore systems, traditional pastoral systems contrast with commercial ones in respect of the stocking rate. In the commercial systems, the herbivores are held at an economic carrying capacity, which is about one third of that of the typical traditional pastoral system. In the absence of artificial outside support (eg. supplementary feeding, extreme animal disease control and hygiene), and in the absence of catastrophic drought, the system is not about to collapse (Mentis 1992). The MGR will therefore be able to carry 6545 head of cattle.

No recent extensive data are available on turnover in the cattle herds. Annon (1988), give offtake of cattle from sales and slaughtering as 2.7% and 3.8% of the total herd for 1982-83 and 1983-84 respectively. Most of the offtake is via private butchers and cattle sales. An average offtake of 3.25% will generate an annual production of 212 cattle. At R1 000 per animal the MGR can generate an income off R212 000 for the stock owners. High animal performance is therefore not expected, given the traditional values of the pastoralists and the equilibration of animal numbers with the capacity of the range (at ecological carrying capacity).

The development of a commercial cattle farming industry was not considered since the Department of Agriculture and Forestry in KaNgwane has tried for many years to achieve this goal without success.

5.3 FINANCIAL IMPLICATIONS

Although the MGR has the potential to be self-sufficient in the future, a key question is: what was the cost of developing the area into a Game Reserve? Sustainable development requires us to maximise the net benefits of economic development, and also maintain the services and quality of natural resources over time. Cumming (1990) believes that economists, do not seem to have developed economic theory sufficiently, to deal with this question and the associated problems of option foreclosure in land use.

The capital and running expenditure for the MGR is well documented since 1988 when all major development started. The development cost and income will be discussed as follows:

(b) Capital investment in the MGR
(c) Running cost of the project
(d) Income from tourism
(e) The contribution of natural resource harvesting in relation to cash benefits (be it directly to the tribal authority as a lease payment or indirectly as salaries paid out to members from the community.)

5.3.1 Capital cost

Table 5.1 gives the schedule of the capital invested on a yearly basis since the inception of the KaNgwane Parks Corporation in 1988. The major part of the fencing of the reserve was done before this date and are therefore not reflected in the figures.

It must be noted that R4.5 million that was used to build the Bongani lodge is loan capital from a commercial bank to be paid back at prime interest rate. This forms part of the investment capital of the private operator, and the loan will be paid once the lease between the KPC, the tribe and the private operator is signed.

5.3.2 Running cost

Table 5.2 gives the schedule of the running cost on a yearly basis since the inception of the project in 1988. The running cost of the MGR was reduced when it reached the stage of being fully developed.

5.3.3 Income from tourism

The KPC has as its policy the privatisation off all tourist facilities.
The following is a summary of an agreement reached with the private operator for the leasing of Bongani lodge.

Table 5.1: Schedule of capital invested in the MGR from 1988 to March 1993

	1988	Addition	1989	Addition	1990	Addition	1991	Addition	1992	Addition	1993
RESERVE											
Buildings	238 236	521 167	759 403	- 49 700	709 703	12 881	722 584	923 142	1 645 726	0	1 645 726
Fences	17 402	38 900	56 302	16 513	72 815	2 104	74 919	16 533	91 452	0	91 452
Boreholes	93 840	19 283	113 123	2 829	115 952	7 275	123 227	0	123 227	183 074	306 301
Roads	7 896	18 872	26 768	25 882	52 650	1 180	53 830	0	53 830	0	53 880
Equipment/vehicles	63 480	125 862	189 342	- 3 658	185 684	- 18 142	167 542	69 937	237 479	53 994	291 473
TOTAL RESERVE	420 854	724 084	1 144 938	- 8 134	1 136 804	5 298	1 142 102	1 009 612	2 151 714	237 068	2 388 782
BONGANI LODGE											
Buildings	0	0	0	4 666 871	4 666 871	1 075 886	5 742 757	196 489	5 939 246	0	5 939 246
Equipment/vehicles	0	0	0	1 241 919	1 241 919	235 623	1 477 542	15 500	1 493 042	0	1 493 042
TOTAL BONGANI	0	0	0	5 908 790	5 908 790	1 311 509	7 220 299	211 989	7 432 288	0	7 432 288
GRAND TOTAL	420 854	724 084	1 144 938	5 900 656	7 045 594	1 316 087	8 362 401	1 221 601	9 584 002	237 068	9 821 070

able 5.2: **Schedule of the running cost of the MGR from 1988 to March 1993**

	1988	1989	1990	1991	1992	1993
Ammunition		279	553	1 097	1 455	1 495
Consulting fees	3 146					577
Consumable stores	3 279	5 866	5 920	18 698	7 010	7 186
Depreciation	3 692	39 724	44 849	36 959	35 662	58 520
Educational courses		997	320	8 530	9 920	2 109
Feed, licks & medicines	832	84				
Game capture costs						16 225
Game purchases	159 453	190 149	184 899	172 429	18 128	
Helicopter hire					19 074	
Leasing		8 492	21 188	56 927	27 838	17 044
Licences	1 141				1 277	
Livestock expenses			357	2 579	3 929	20 410
Machine hire	13 638	4 645	997	452	300	3 555
Maintenance:						
Buildings	98	1 733	558	12 077	4 628	5 037
Fences	509	1 876	50	1 742	2 380	1 627
Vehicles	11 827	2 152	3 503	6 202		1 750
Radio			2 048	10 099	5 132	6 931
Roads		1 761	1 762	1 906	1 129	
Large equipment						23 051
Small equipment	217	1 348	12 101	9 562	15 522	7 312
Marketing & entertainment				1 037	34	864
Printing & Stationary	2 707	598	336	1 114	1 349	963
Purchase kiosk			6 312	25 968	31 702	
Rations	11 403	27 616	39 132	56 445	46 874	48 729
Rental radios		1 142	1 641	2 394	2 682	4 208
Running expenses:						
Tractor		4 112	102 319	13 939	1 200	11 032
Truck		36 343	3 993	29 771		
Vehicles		54 113	43 969	137 409	136 778	181 926
Salaries	141 121	255 322	456 409	590 560	718 238	664 233
Stock adjustments					13 705	
Sundry expenses:						
Reserve	1 400	4 058	7 878			
Gate/kiosk			4 592	37	29	69
Telephone	179	562		1 097		
Transport	24 796	3 217	519	1 244	1 053	397
Uniforms		18 724	25 668	21 520		16 666
Veld & wildlife manag.	1 095	2 348	810	1 343	8 197	
Water & electricity			54	565		6 341
TOTAL	380 533	667 261	972 764	1 224 749	1 110 093	1 108 257

A period of 36 months was regarded as sufficient to register the 99 year lease (for the period 1st March 1993 to 28 February 2092) of the Bongani site. On registration of lease an amount of R4 500 000.00 will be paid to the KPC to pay back the loan to the Standard bank that was used to built the lodge. In the interim period while the lease is not registered, the private operator will pay the following to KPC:

Month 1 - 12	R41 667.00/pm + 0
Month 13 - 24	R46 250.00/pm + 50% on interest of R4 500 000.00
Month 25 - 36	R46 250.00/pm + R1 000.00/pm starting with month 25 adding another R1 000.00 each month + Interest (15.25%) on R4 500 000.00

If after 36 months the lease is not registered, the private operator can pull out of the agreement, or

1) Pay R4 500 000.00 into a trust. The interest on this investment will accrue to the KPC. A rental of 4% of monthly turnover with a minimum of R10 000.00/pm will be payable to the KPC, or

2) Pay the interest at 4% over prime rate to the KPC + R46 250.00 + R1 000.00/pm.

If lease is registered after 36 months the R4 500 000 will be paid and a monthly rent of 4% of monthly turnover with a minimum of R10 000.00/pm will be paid to the KPC.

5.4 SOCIAL RESEARCH

The social research was done in association with Afrosearch and was summarised in Chapter 2. From this survey it was evident that a real need for harvesting of renewable natural resources does exist. It was also obvious that the need of these communities go further than just resource harvesting and that issues such as job creation, water provision, health care, etc. need urgent attention.

Although these needs are all real and important, it would require conflicting management actions if one has to provide for all these needs. An important part of this study was therefore to determine which management action will have the biggest financial impact in the community.

The demographic profile of the different villages and the specific problems that were identified for each village, provided a useful starting point to address these needs.

Different actions were taken by the KPC since the sociological study was completed to address these issues. Several boreholes were drilled by the KPC at Mpakeni village. The KPC also facilitated the equipment of these boreholes. A creche was built at Daantjie village where the money in the trust fund was used to partially fund the building. The KPC has also facilitated the negotiations for aid funds to build a workshop for the disabled at Daantjie. Since 1993 a major effort was put in at the Luphisi village to establish individual gardens on the Permaculture method (Mollison 1992). More than 60 gardens and water tanks were established in private gardens as well as a communal garden for the village.

Although the needs addressed by the KPC did not always correspond with the priority as determined by the Odendal (1991) report, it was prioritised by the reserve management committee. The establishment of vegetable gardens for example, was second to last on the list of developments identified by Odendal (Table 2.7). However, since the development of vegetable gardens based on the Permaculture method was introduced in the Luphisi village, it was met with great enthusiasm by the local people and the gardens have expanded since. The Mpakeni community has also approached the KPC to assist with the establishment of vegetable gardens in their village.

The low priority for vegetable gardens, as indicated in the Odendal report, could be as a result of attempts in the past by the Department of Agriculture to establish similar vegetable gardens, which have failed because of lack of water, bad planning etc. or because of initial ignorance on the side the local communities of the potential of these developments.

5.5 RESOURCE UTILISATION

This study was aimed at quantifying the resource base of which the sustainable harvesting is so often a topic of controversy. As discussed in Chapter 1, conservation areas must become more relevant to the people for these areas to assure their survival. The MGR was used as a case study because it is a recently established Game Reserve and the natural resource harvesting was well documented since 1988, good relations exists between the KPC and the Mpakeni tribal authority. During the sociological survey real needs were expressed by the community in terms of natural resource harvesting, job creation and education.

5.5.1 Plant resource

5.5.1.1 Fuelwood

A detailed survey was done on fuel wood production in the MGR (Chapter 3). The pilot study showed that there was a definite preference for certain fuelwood species and that only certain areas of the reserve is accessible for fuelwood collection. The baseline study determined the annual wood biomass production on 392,25 tonnes. With the average family using 4 tonnes of fuel wood per annum, the harvestable production in the MGR can provide in the needs of 98 households. The average family in urban areas spend R60.00 to R80.00 on paraffin or coal for cooking and heating per month (Ramphele and McDowel 1991). Therefore the fuelwood is worth R70 000.00 to R90 000.00 annually to these people.

Although people are allowed to collect dry wood in the MGR, it is not a very desirable practice. It is difficult to control because people are scattered over a large area. With the presence of dangerous animals people are at risk of injury in the future.

Since 1991 local people were involved on a voluntary basis to clear certain areas of all vegetation with a diameter of less than 15 cm. The stumps were cut level with the ground to prevent damage to tyres during off road driving. The stumps were not treated with a herbicide to allow coppicing and in a couple of years the process would have to be repeated. The objective of this action was to create clearings that will favour grazers and will enhance game viewing. It also proved to be much easier to control people on these limited clearings during fuelwood collection. This arrangement is to the mutual benefit of both parties, the people get firewood for their labour and the MGR obtains a management objective at no cost.

It is obvious that sustainable utilisation of the firewood resource from the MGR can not make a significant contribution towards the fuel problem in this densely populated rural area. Conservation agencies that promote resource harvesting by local communities has been accused of suffering from a firewood and thatch syndrome (Mulder *pers.comm.*). What these people do not realise is, that it does not matter how insignificant this contribution seems to the overall wood shortage in the region as a whole, the mere fact that there is access to the reserve with some benefit to the people, has a major influence on the attitudes of the people bordering on the reserve.

The energy crisis in rural areas forms part of a socio-economic problem. Therefore, it is not a problem with a single solution but it is inextricably woven into the social, demographic, cultural and land use patterns (Gandar 1984). The provision of alternative fuel sources, the utilization of more fuel efficient stoves, the establishment of woodlots and a tree planting strategy, is among other options, proposed as solutions to the problem. However, the fuelwood problem can not be solved in isolation, but must form part of an integrated strategy to uplift the socio-economic condition of rural communities.

5.5.1.2 Thatch grass

The harvesting of thatch grass was encouraged since the inception of the MGR and is well documented (Table 3.11). Many factors have an influence on the annual thatch harvest eg: rainfall, management burns, accidental fires, grazing pressure and market prize. The annual thatch harvest can vary from nothing in a year with little rainfall, to 47 726 bundles in a good year. When the thatch grass is ready to be cut, women are allowed to cut as many as they can, free of charge. The cutting of thatch grass is restricted to a specific area at a time and the women are always accompanied by game scouts to ensure safety and control. They can then sell the thatch to a thatching contractor (1993 price at R0.30/bundle) or use it for themselves. This is a direct benefit for the people and the MGR act only as facilitator.

5.5.2 Animal resource

The optimisation of the wildlife resource was investigated by using the goal programming method. The objective of this study was to manage the resource to the best benefit of the people and therefore, the utilization values of game were determined. The carcass -, trophy hunting -, live sale - and tourism values were alternatively used as priority in the goal programming model that was developed. By including the ecological and management constraints and assumptions, several solutions were obtained. The solutions to satisfy trophy hunting and live sale of animals provided the same species composition. This species composition will provide the best game viewing opportunities for guests visiting the Bongani lodge but will also produce the most trophy animals for hunting to optimise the income from this resource. An agreement will have to be reached with the tourist operator to strike a balance between income from hunting to finance management costs in such a way as not to influence their tourist operation. Table 4.14 gives the present number of animals stocked in the MGR in comparison to the number of animals determined by GP as the best option. This optimum solution can not instantly be attained. However, animal numbers must be managed towards this goal.

The tourism potential must be fully developed in order to create the jobs and to ensure the success of the project. To compete with other tourist operators in the eastern Transvaal, the product to be sold must include excellent game viewing and, of course, the "Big Five". Because of the broken terrain and mountainous nature of the MGR, roads are difficult to make and game viewing is more difficult than in classic lowveld conditions. Game numbers are of course determined by CC and other ways must be investigated to enhance game viewing.

Measures have already been taken to enhance the visibility of predators by implanting abdominal transmitters and tracking of these animals.

The possibility of creating focal points in the landscape to enhance the possibility of seeing animals is also investigated. This implies the artificial fertilisation of areas, the provision of game and salt licks, the mowing of grass, etc.

5.6 BENEFIT TO THE TRIBE

Presently the KaNgwane Parks Corporation is a parastatal body with a Managing Director who reports to a Board of Directors. The Board is responsible to the Minister of Agriculture and Forestry in KaNgwane. The management of the MGR is a joint venture between the KPC, the tribe and private enterprise. A Reserve Management Committee has been formed with representatives from the KPC, the tourist operator and the tribal authority. This committee is responsible for management decisions eg. culling quotas, bush clearing programmes, game introductions etc. Income from the MGR is split three ways.

The share that accrues to the tribe is made up as follows:

1) Direct benefit to tribal authority via reserve management committee

(a) The Tribe will earn R5 000.00/pm for the first 12 months, there after 108% of R5 000 for the following 12 months. This amount will then increase each year by 10%. With the planned share block development by the operator the tribe will receive 25% of the sales of these facilities.

(b) Fifty percent of the income of trophy buffalo hunted in the MGR accrue to the tribe as well as all the carcasses of these animals. Income for 1993 financial year = R39 000.00.

2) Indirect benefit via the community

a)	Fire wood harvesting	=	R 9 617.00 (1993)
b)	Thatch grass harvesting	=	R 6 364.00 (1993)
c)	Salaries Bongani lodge	=	R519 200.00 (Financial statement for 1993 KPC)
d)	Salaries MGR	=	R531 386.00 (Financial statements for 1993 KPC)

In Table 5.3 the benefit to the tribe, be it direct in the form of a lease payment or indirect in the form of salaries, are illustrated since 1988. It is interesting to note that the income from the harvesting of natural resources, especially in the earlier years has been significantly lower in relation to income from salaries. However, the impact that the harvesting of these resources has on the attitude of the people is invaluable.

The low incidence of poaching in the MGR is an indication of the peoples attitude towards the reserves. Poaching incidents for example has diminished over time and no poaching incident was recorded during 1993.

Table 5.3 Direct and indirect benefits to the tribe derived from the MGR since 1988

Year	Thatchgrass (R)	Meat (R)	Firewood (R)	Hunting (R)	Lease of land (R)	Salaries (R)
1988	,0	1 737	0	-	-	112 896
1989	13 500	2 736	2 879	-	-	204 257
1990	5 588	11 133	3 492	-	-	495 608
1991	14 317	8 178	5 871	-	-	1 014 978
1992	0	12 564	7 259	-	-	1 198 722
1993	6 364	10 818	9 617	39 000	60 000	1 051 305
Total	39 770	47 166	29 120	39 000	60 000	4 077 768

5.7 CONCLUSION

In conclusion the following major issues must be addressed for a future in which Game Reserves and Parks are closely integrated with surrounding land use practices and people.

5.7.1 Ecological

There is no doubt that the old apartheid policy where 80% of the people were forced to live on 13% of the land had devastating consequences on the land. In almost all the "homelands" the "land is breaking under the burden that has been laid upon it" (Ramphele & McDowel 1991). One very negative effect created by the apartheid policy was the concentration of people on the boundaries of parks, which resulted in the increased human pressure on these areas. However, if we consider the destruction of rhino and forests in other poverty stricken countries we have to realise that the removal of apartheid will not by itself ensure ecological wholeness.

The sustainable utilisation of the african savanna is important for the survival of people, livestock and wildlife. In many rural areas with low rainfall, poor soils, no industries or mining, the african savanna is the only resource available to sustain large communities and their livestock. This usually leads to the over utilization and the eventual degradation of the resource. Although african rangelands are very resilient and recover quickly given a chance, it will lead inevitably to the degradation of the environment on a grand scale if subsistence agriculture continues to be the dominant form of land use with expanding populations.

Cattle play an important role culturally and economically in the life of rural people and it is nearly impossible to get rid of or even reduce cattle numbers on the communal lands. This phenomenon is generally referred to as "The Tragedy of the Commons" after Hardin's (1968) paper with the same name. The KPC is investigating ways to create more sustainable development with the introduction of game into the rangelands that will stimulate tourism and hunting and therefore broaden the income from the resource base. (Stalmans, Van Wyk & Mentis 1993).

5.7.2 Economically

Ramphele & McDowel (1991) stated that there is a direct and symbiotic relationship between human poverty and ecological destruction. The exploitation of resources is economically driven and the socio-economic upliftment of rural communities is therefore the only way to reduce the pressure on the resource base.

During the last decade the development of community based wildlife utilisation programmes have made a promising start. The CAMPFIRE programme in Zimbabwe, the Richtersveld National Park in the Northern Cape and the Pilanesberg National Park in Bophuthatswana, as well as the MGR in KaNgwane, to mention only a few. These still fragile initiatives face enormous hurdles, not the least of which include a failure on the part of western environmental groups on the one hand, and the agricultural development establishment on the other, to appreciate their promise for both conservation and development (Cumming 1990).

The development of tourism is the most profitable way in which Conservation areas can generate income. Barnes (1990) suggests that Southern Africa's better quality protected areas might support 133-980 hectares per lodge bed, with an average of 700 hectares. These figures support the high-price low quantity approach. This more commercial route was also taken by the highly commercialised lodges in the Sabie-Sand Private Game Reserve which generates an annual income of R600 000.00 to R1 000 000.00 per 1 000 ha in foreign exchange (Ratray *pers.comm.*). Although it could be argued that the high-price approach limits the "wildlife experience" to the relative well off and that the local people could be alienated in the process, the opposite seems to be true. This approach creates more jobs and stimulates the establishment of entrepreneurs within the local communities.

It is clear from examples in other african countries that budgets for conservation in the future will be reduced in favour of more pressing and immediate needs such as housing, education and health services. Only if conservation areas can become economically viable could it be sure of its survival.

5.7.3 Institutional

By involving the local people in decision making the reserve became more relevant to the people. A number of people, however, feel that they are not represented by the traditional leaders eg. tribal authority or local government. A committee or forum representing all the people must therefore be elected by the community from a broad representation base, including tribal authorities, civic action groups, woman groups, cattle owners, teachers, etc.

Where money is accrued by the community from a game reserve, it is better to establish a legal structure in the form of a Section 21 company or Trust. The elected committee should be the directorate of the structure (Mountain *pers. comm.*). This committee will then be accountable to the whole community on how the income was spend.

With the CAMPFIRE programme in Zimbabwe, individuals get a cash benefit from resource harvesting. This option is impractical in densely populated areas and income from resource harvesting should rather be used for community projects which will create job opportunities or will provide in a need that will benefit most people.

5.7.4 Community development

Conservation agencies will have to change their traditional role where responsibilities used to end at the game reserve boundary. Although the allocation of resources to neighbouring communities are important, management will also have to get actively involved in community upliftment programmes. Although Conservation Agencies are often not able to assist financially, it can act as facilitator to stimulate development and training in these areas. An important first step is the establishment of community development committees and the training of these committee members to build the capacity to enable people to take control of their lives and to improve their decision making abilities.

In today's changing society the needs and aspirations of people must be considered. Nature conservationists therefore have to be aware and involved in what is going on outside the game reserve, to be able to fulfil their management task inside the game reserve.

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APPENDIX 1 LIST OF TREES FOR THE MGR AND THEIR MEDICINAL USES

Family	Genus and Species	English Name	Part	Treatment
Liliaceae				
	Aloe marlothi Berger	Mountain Aloe	Leaves Roots	Insect repellent roundworm Stomach disorders
	Dracaena hookerana C. Koch	Large-leaved Dragon tree		
Ulmaceae				
	Celtis africana Burm. f.	White Stinkwood		
Moraceae				
	Ficus abutilifolia (Miq.) Miq.	Large-leaved Rock Fig		
	Ficus glumosa (Miq.) Del.	Mountain Fig		
	Ficus ingens (Miq.) Miq.	Red-leaved Fig	Latex	Disinfectant
	Ficus sur Forssk.	Broom Cluster Fig		
	Ficus sycomorus L. ssp. sycomorus	Common Cluster Fig		
	Ficus thonningii Bl.	Common Wild Fig		
Utricaceae				
	Pouzolzia mixta Solms	Soap-nettle	Bark	Fibre
Proteaceae				
	Faurea saligna Harv.	Transvaal Beech	Bark	Red dye
	Faurea speciosa (Welw.) Welw.	Broad-leaved Beech	Roots	Diarrhoea, ear infections

Family	Genus and Species	English Name	Part	Treatment
Olacaceae				
	Olax dissitiflora Oliv.	Small Sourplum		
	Ximenia caffra Sond. var. caffra	Sourplum	Seeds Leaves	Body ointment Inflamed eyes
Annonaceae				
	Annona senegalensis Pers.	Wild Custard-apple	Roots	Dizziness, emetic
Capparaceae				
	Maerua angolensis DC.	Read-bean Tree		
Pittosporaceae				
	Pittosporum viridiflorum Sims	Cheesewood	Bark	Stomach complaints, black gal-sickness
Rosaceae				
	Parinari curatellifolia Planch. ex Benth.	Mobola Plum	Bark	Pneumonia
Fabaceae				
	Acacia ataxacantha DC.	Flame Thorn		
	Acacia caffra (Thunb.) Willd.	Common Hook-thorn	Bark Leaves	Emetic Abdominal troubles
	Acacia davyli N.E. Br.	Corky Thorn		
	Acacia karroo Hayne	Sweet Thorn	Bark Mould	Antidote for poisoning, gargle Abscesses
	Acacia nigrescens Oliv.	Knob Thorn		

Family	Genus and Species	English Name	Part	Treatment
	Acacia nilotica (L.) Willd. ex Del. ssp. kraussiana (Benth.)	Scented Thorn	Bark	Coughs
	Acacia robusta Burch. subsp. clavigera (E. Mey.) Brenan	Brack Thorn		
	Acacia swazica Burtt Davy	Swazi Thorn		
	Acacia tortilis (Forssk.) Hayne subsp. heteracantha (Burch.)	Umbrella Thorn		
	Albizia versicolor Welw. ex Oliv.	Large-leaved False-thorn	Bark Roots	Fibre Purgative, enema
	Bauhinia galpinii N.E. Br.	Pride-of-De Kaap		
	Bolusanthes speciosus (H. Bol.) Harms	Tree Wistaria	Bark	Stomach disorders
	Cassia petersiana Bolle	Monkey Pod	Various parts	Purgative, fevers
	Crotalaria capensis Jacq.	Cape Rattle-pod		
	Dalbergia armata E. Mey.	Thorny Rope		
	Dichrostachys cinerea (L.) Wight & Arn. ssp. nyassana (Taub.) Brenan	Large-leaved Sickle Bush	Roots	Snakebite, scorpion
	Erythrina latissima E. Mey	Broad-leaved Coral Tree	Bark	Dressing for sores
	Erythrina lysistemon Hutch.	Common Coral Tree	Bark Leaves	Childbirth Sores and wounds
	Lonchocarpus capassa Rolfe	Apple-leaf	Roots	Relieves colds, snakebites

Family	Genus and Species	English Name	Part	Treatment
	Mundulea sericea (Willd.) A. Chev.	Cork Bush	Bark	Emetic, poisoning
	Ormocarpum trichocarpum (Taub.) Engl.	Caterpillar Bush	Bark	Emetic for poison
	Peltophorum africanum Sond.	Weeping Wattle	Bark	Colic, stomach disorder
	Pseudarthria hookeri Wight & Arn. var. hookeri			
	Pterocarpus angolensis DC.	Wild Teak	Bark	Lactation, nettle rush
	Pterocarpus rotundifolius (Sond.) Druce	Round-leaved Teak		
	Schotia brachypetala Sond.	Weeping Boer-bean	Bark Roots	Heartburn Emetic, tonic
Balanitaceae				
	Balanites maughamii Sprague	Green Thorn	Bark	Emetic
Rutaceae				
	Vepris reflexa Verdoorn	Bushveld White Ironwood		
	Zanthoxylum capense (Thunb.) Harv.	Small Knobwood	Fruit Leaves	Colic, flatulence, palsy Gastric disorders
Anacardiaceae				
	Lannea discolor (Sond.) Engl.	Live-long	Bark & Roots	Fever, constipation
	Ozoroa sphaerocarpa R. & A. Fernandes	Currant Resin Tree		
	Rhus chirindensis Bak. f.	Red Currant	Leaves	Heart
	Rhus leptodictya Diels	Mountain Karree		

Family	Genus and Species	English Name	Part	Treatment
	Rhus pentheri Zahibir	Common Crow-berry		
	Rhus pyroides Burch. var. pyroides	Common Wild Currant		
	Rhus rehmanniana Engl.	Blunt-leaved Currant		
	Sclerocarya birrea (A. Rich.) Hochst. ssp. caffra (Sond.) Kokwaro	Marula	Bark	Dysentery, diarrohoea
Celastraceae				
	Cassine aethiopica Thunb.	Kooboo-berry	Bark	Worms
	Cassine transvaalensis (Burtt Davy) Codd	Transvaal Saffron	Bark	Stomach disorders
	Maytenus heterophylla (Eckl. & Zeyh.) N.K.B. Robson	Common Spike-thorn	Bark Thorns	Dysentery Colds & coughs
	Maytenus undata (Thunb.) Blakelock	Koko Tree		
Icacinaceae				
	Apodytes dimidiata E. Mey. ex Arn. ssp. dimidiata	White Pear	Root Bark	Intestinal parasites Splenic pain
Sapindaceae				
	Dodonea angustifolia L.f.	Sand Olive	Leaves	Purgative, rheumatism
	Hippobromus pauciflorus (L.f.) Radlk.	False Horsewood	Leaves	Headaches, eyes
	Pappea capensis Eckl. & Zeyh.	Jacket-plum	Fruit Leaves	Ringworm Sore eyes
	Kirkia wilmsii Engl.	Mountain Seringa		

Family	Genus and Species	English Name	Part	Treatment
Burseraceae				
	Commiphora mollis (Oliv.) Engl.	Velvet Corkwood		
	Commiphora neglecta Verdoorn	Green-stem Corkwood		
Maliaceae				
	Trichilia emetica Vahl.	Natal Mahogany	Bark Seeds	Emetica, enema Cuts, rheumatism
Euphorbiaceae				
	Acalypha glabrata Thunb.	Forest False-nettle	Leaves & roots	Purgative
	Antidesma venosum E. Mey. ex Tul.	Tassel Berry	Roots	Pain, fertility
	Bridelia cathartica Bertol. f.	Blue Sweetberry		
	Euphorbia cooperi N.E. Br. ex Berger	Transvaal Candelabra Tree	Latex	Warts
	Euphorbia evansii Pax	Lowveld Euphorbia		
	Phyllanthus reticulatus Poir.	Potato Bush	Leaves & fruits	Sores and burns
	Securinega virosa (Willd.) Pax & K. Hoffm.	White-berry Bush	Root Bark	Malaria Diarrhoea
Euphorbiaceae				
	Spirostachys africana Sond.	Tamboti	Latex	Toothache
	Synadenium cupulare (Boiss.) L.C. Wheeler	Dead-man's Tree	Leaves	Toothache and headache

Family	Genus and Species	English Name	Part	Treatment
Rhamnaceae				
	Berchemia zeyheri (Sond.) Grubox	Red Ivory	Root Bark	Headache Enema
	Ziziphus mucronata Willd. ssp. mucronata	Buffalo-thorn	Roots Leaves	Pain, lumbago Tubercular glands
Vitaceae				
	Rhoicissus digitata (L.f.) Gilg. & Brandt	Baboon Grape		
	Rhoicissus tomentosa (Lam.) Wild & Drummond	Common Forest Grape	Roots	Anthelmintic
	Rhoicissus tridentata (L.f.) Wild & Drummond	Bushman's Grape	Root	Menstruation, induce labour
Tiliaceae				
	Grewia bicolor Juss.	White Raisin	Root	Chest complaints
	Grewia flavescens Juss. var. flavescens	Sandpaper Raisin	Parts	Nosebleeding
	Grewia hexamita Burret	Giant Raisin		
	Grewia monticola Sond.	Silver Raisin		
	Grewia occidentalis L.	Cross-berry	Bark	Bruises, impotence
Sterculiaceae				
	Dombeya rotundifolia (Hochst.) Planch.	Common Wild Pear	Bark	Intestinal ulcers, induce labour
	Sterculia murex Hemsl.	Lowveld Chestnut		

Family	Genus and Species	English Name	Part	Treatment
Ochnaceae				
	Ochna natalitia (Meisn.) Walp.		Roots	Barrenness
Combretaceae				
	Combretum apiculatum Sond. ssp. apiculatum	Red Bushwillow	Leaves Stem	Stomach disorders Conjunctivitus
	Combretum collinum Fresen ssp. suluense (Engl. & Diels) Okafor	Weeping Bushwillow		
	Combretum hereroense Schinz	Russet Bushwillow	Roots	Enema and stomach disorders
	Combretum imberbe Wawra	Leadwood	Leaves	Coughs and colds
	Combretum molle R. Br. ex G. Don	Velvet Bushwillow	Leaves Roots	Wounds Snakebite, abortio
	Combretum zeyheri Sond.	Large-fruited Bushwillow	Leaves	Backache, eyes
	Terminalia phanerophlebia Engl. & Diels	Lebombo Cluster-leaf		
	Terminalia sericea Burch. ex DC.	Silver Cluster-leaf	Roots	Diarrhoea, colic, eyewash
Myrtaceae				
	Heteropyxis natalensis Oliv.	Lavender Tree	Roots Leaves	Nosebleeds Intestinal worms
	Syzygium cordatum Hochst.	Water Berry	Bark	Medicinal purposes
Araliaceae				
	Cussonia natalensis Sond.	Rock Cabbage Tree		
	Cussonia spicata Thunb. var. spicata	Common Cabbage Tree	Roots	Malaria, venereal disease

Family	Genus and Species	English Name	Part	Treatment
Apiaceae				
	Steganotaenia araliacea Hochst.	Carrot Tree	Roots Bark	Sore throats Asthma
Sapotaceae				
	Bequaertiodendron magalismontanum (Sond.) Heine & Hemsl.	Transvaal Milkplum	Fruit Roots	Epilepsy Epilepsy and headache
	Mimusops zeyheri Sond.	Transvaal Red Milkwood		
Ebenaceae				
	Diopyros natalensis (Harv.) Brenan ssp. natalensis	Small-leaved Jackal-berry		
	Diospyros mespiliformis Hochst. ex A. DC.	Jackal-berry	Leaves, twigs & bark	Ringworm, leprosy and fever
	Euclea divinorum Hiern	Magic Guarri	Roots	Toothache
	Euclea natalensis A. DC. ssp. angustifolia F. White	Natal Guarri	Roots	Purgative, leprosy and headache
Oleaceae				
	Olea europea L. ssp. africana (Mill.) P.S. Green	Wild Olive	Bark	Malaria, constipation and emetic
	Schrebera alata (Hochst.) Welw.	Wild Jasmine	Roots	Diarrhoea, allergy
Loganiaceae				
	Strychnos madagascariensis Poir.	Black Monkey Orange		
	Strychnos spinosa Lam.	Green Monkey Orange	Roots	Snakebite, emetic and fevers

Family	Genus and Species	English Name	Part	Treatment
Apocynaceae				
	Acokanthera oppositifolia (Lam.) Codd	Common Poison-bush	Various parts	Snakebite
	Diplorhynchus condylocarpon (Muell. Arg.) Pichon	Horn-pod Tree	Roots, leaves	Blackwater fever, diarrhoea
Boraginaceae				
	Ehretia amoena Klotzsch	Sandpaper Bush		
Verbenaceae				
	Holmskioldia speciosa Hutch. & Corb.	Wild Parasol Flower		
	Lippia javanica (Burm. f.) Spreng.		Roots	Body weakness
Verbenaceae				
	Vitex harveyana H.H.W. Pearson	Three-fingerleaf		
	Vitex wilmsii Guerke var. wilmsii	Hairy Fingerleaf	Leaf	Prophylactic
Lamiaceae				
	Tetradenia riparia (Hochst.) Codd.			
Bignoniaceae				
	Tecomoria capensis (Thunb.) Spach	Cape Honeysuckle	Bark	Fever, pain, induce sleep
Acanthaceae				
	Ruttya ovata Harv.			
Rubiaceae				
	Breonadia salicina (Vahl) Hepper & Wood	Matumi		

Family	Genus and Species	English Name	Part	Treatment
	Canthium inerme (L.f.) Kuntze	Common Turkey-berry	Leaves	Stomach disorders
	Cantunaregam spinosa (Thunb.) Tirvengadum ssp. spinosa	Thorny Bone-apple		
	Hyperacanthus amoenus (Sims) Bridson	Thorny Gardenia		
	Kraussia floribunda Harv.	Rhino-coffee		
	Pavetta edentula Sond.	Gland-leaf Tree		
Rubiaceae				
	Psychotria capensis (Eckl.) Vatke var. capensis	Black Bird-berry	Roots	Emetic
	Tarenna supra-axillaris (Hemsl.) Bremek. ssp. barbertonensis (Brem.) Bridson	Narrow-leaved False Bride's Bush		
	Tricalysia lanceolata (Sond.) Burtt Davy	Jackal-coffee		
	Vangueria infausta Burch. ssp. infausta	Wild Medlar	Roots	Malaria, pneumonia
Asteraceae				
	Brachylaena discolor DC. ssp. transvaalensis (Phill.) & Schweick	Forest Silver Oak	Leaves Roots	Diabetes, tonic Haemorrhage of stomach
	Tarchonanthus trilobus DC. var. galpinii (Hutch. & Phill.) J. Paiva	Broad-leaved Camphor Bush		

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Van Wyk, P. 1984. Veldgids tot die Bome van die Nasionale Krugerwildtuin. C. Struik Publishers, Cape Town

OC4

ear Visitor

APPENDIX 2

is survey forms part of a research project to optimise the species mix of game in the Reserve to provide you as a visitor e best possible experience in terms of game viewing.

Nationality:	ITALIAN
Age:	30
Sex:	FEMALE

For office use only
(1 - 2)
(3 - 4)
(5)

JESTION 1 Please mark your preference for the following species:-

1 = Most Important 5 = Least Important

ample

Species	1	2	3	4	5
Blesbok	√				
Springbok		√			
Bushbuck					√

	1	2	3	4	5	For office use only
lon selective grazer	1	2	3	4	5	
ebra		√				(6)
/hite rhino	√					(7)
uffalo		√				(8)
elective grazer	1	2	3	4	5	
lue wildebeest			√			(9)
lountain reedbuck		√				(10)
able antelope	√					(11)
'aterbuck			√			(12)
'arthog			√			(13)
ixed feeders	1	2	3	4	5	
ıpala				√		(14)
/ala	√					(15)
ephant	√					(16)
owsers	1	2	3	4	5	
ıdu		√				(17)
'affe		√				(18)
ınd	√					(19)
shbuck		√				(20)
edators	1	2	3	4	5	
opard	√					(21)
n	√					(22)
d dog	√					(23)

QUESTION 2 What is the minimum number of individuals of a species you would like to see as representative of the species? Mark with √.

Example

Species	1	5	10	20	50	100	150	200
Blesbok		√						
Springbok			√					
Bushbuck	√							

Non selective grazer	1	5	10	20	50	100	150	200	Office only
Zebra				√					(24 - 326
White rhino			√						(27 - 29)
Buffalo					√				(30 - 32)
Selective grazer	1	5	10	20	50	100	150	200	
Blue wildebeest					√				(33 - 35)
Mountain reedbuck			√						(36 - 38)
Sable antelope			√						(39 - 41)
Waterbuck			√						(42 - 44)
Warthog		√							(45 - 47)
Mixed feeders	1	5	10	20	50	100	150	200	
Impala	√								(48 - 50)
Nyala			√						(51 - 53)
Elephant				√					(54 - 56)
Browsers	1	5	10	20	50	100	150	200	
Kudu				√					(57 - 59)
Giraffe				√					(60 - 62)
Eland			√						(63 - 65)
Bushbuck			√						(66 - 68)

QUESTION 3: At what size of the herd will it not matter if the herd is any bigger? Mark with √.

Example

Species	1	5	10	20	50	100	150	200
Blesbok					√			
Springbok							√	
Bushbuck		√						

Non selective grazer	1	5	10	20	50	100	150	200	Office only
Zebra				√					(2 - 4)
White rhino		√							(5 - 7)
Buffalo					√				(8 - 10)
Selective grazer	1	5	10	20	50	100	150	200	
Blue wildebeest			√						(11 - 13)
Mountain reedbuck			√						(14 - 16)
Sable antelope		√							(17 - 19)
Waterbuck		√							(20 - 22)
Warthog		√							(23 - 25)
Mixed feeders	1	5	10	20	50	100	150	200	
Impala		√							(26 - 28)
Nyala			√						(29 - 31)
Elephant				√					(32 - 34)
Browsers	1	5	10	20	50	100	150	200	
Kudu			√						(35 - 37)
Giraffe			√						(38 - 40)
Eland		√							(41 - 43)
Bushbuck		√							(44 - 46)

APPENDIX 3

List of abbreviations

AU	Animal Unit
BU	Browser Unit
CC	Carrying Capacity
DM	Decision Maker
GIS	Geographic Information System
GP	Goal Programming
GU	Grazer Unit
IUCN	International Union of Conservation of Nature and Natural Resources
KPC	KaNgwane Parks Corporation
LP	Linear Programming
LSU	Livestock Unit
MCDM	Multi Criteria Decision Making
MGR	Mthethomusha Game Reserve
WCS	World Conservation Strategy