

# **Land Degradation in the Cathedral Peak Area of the Natal Drakensberg : 1945 to 1992**

by

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degree of Master of Science (MSc)**

**in the Department of Environmental and Geographical Science  
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**Land Degradation in the Cathedral  
Peak Area of the Natal  
Drakensberg : 1945 to 1992**



## Abstract

This report describes a study of land degradation in adjacent portions of land comprising a section of the Cathedral Peak State Forest (park and private land) and segments of three wards of the former Kwazulu homeland district of Okhahlamba. The study region is known as the Cathedral Peak Area.

The report aims to describe and account for the historical development of land degradation in the Okhahlamba District using the Cathedral Peak Area as a case study. Sequential aerial photographs from 1945, 1964 and 1992 were employed to conduct a temporal comparison of area effected by changes in number of homesteads, area of cultivation, forests, eroded areas or surfaces and gullies and drainage density.

The results show that for number of homesteads and cultivated area in the Cathedral Peak Area, there has been an exponential (geometric) and constant (arithmetic) increase respectively during the period under investigation. These increases in anthropogenic activities in the Cathedral Peak Area have resulted in a consequent increase in pressure on environmental resources of the area.

In terms of variations in the extent of forests in the Cathedral Peak Area, there has been a decrease in the forested area for the park section of the Cathedral Peak Area, and this reduction of forests has been ascribed to the felling of alien trees by conservation organisations in the area. In the surrounding communities, a progressive increase in the extent of forested area has been noted. This increase in afforested land in the community section has been attributed to the people of the communities of the Cathedral Peak Area who unknowingly spread the seeds of alien trees when they transport trees for use as a fuelwood source and building material.

With regards to the eroded areas or surfaces, in the park and private land section of the Cathedral Peak Area, there has been a progressive decrease in the extent of eroded surfaces which is linked to the change in land use from private to park land. In the surrounding community section of the Cathedral Peak Area, eroded surfaces also

decreased over the study period, however an increase in eroded area was recorded during 1964. This result, together with other applicable studies, suggest that the fluctuations in eroded surfaces in the community area are related firstly, to changes in land use activities and secondly, oscillations in the intrinsic variables of the erosion system, mainly rainfall.

Drainage density and gullies have been shown to increase over the study period in the Cathedral Peak Area. The changes in drainage density and gullies has been associated to increased land use activities and the dynamic erosion system of the Drakensberg region including, sub-surface erosion processes.

Overall, the study of land degradation in the park and private land section of the Cathedral Peak Area shows that there have been significant improvements and a decrease in the extent of land degradation. These improvements have been manifested in the decrease of eroded surfaces and afforested areas. In the surrounding community land, a different scenario exists, where land degradation, associated with an increase in alien tree infestation has been found. In terms of erosion in the community land, although there has been an overall increase in land degradation, indications are that these changes are linked primarily, to rainfall and to some degree the rapidly expanding population of the area.

The results obtained in this study in tandem with the changing development objectives of the new government, are used to make recommendations for improvements in environmental conservation and people/park interaction in the Cathedral Peak Area.

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**Acronyms**

ASOP	American Society of Photogrammetry
CCWR	Computing Centre for Water Research
CPSF	Cathedral Peak State Forest
CSS	Central Statistical Services
DCA	Drakensberg Catchment Area
ENGEO	Department of Environmental and Geographical Science, University of Cape Town
GIS	Geographical Information System
GNU	Government of National Unity
MHSV	Moist Highland Sourveld
NGO	Non - Governmental Organisation
NPB	Natal Parks Board
PADS	Photographic Analytic Digitising System
RDP	Reconstruction and Development Programme
SPAM	Single Photo Aerial Mapping
STG	Southern Tall Grassveld
TJSB	Thukela Joint Services Board
UCS	Unconfined Compressive Strength

## Preface

In January 1995, following negotiation, the Natal Parks Board (NPB) requested a group of masters students from the University of Cape Town's Department of Environmental and Geographical Science (hereafter referred to as the Masters Group<sup>1</sup>), to undertake a preliminary environmental assessment for the proposed development of a hutted camp at Cathedral Peak (see Masters Group; Map 1, Vol. 1), within the Natal Drakensberg Park.

The Masters Group undertook a variety of tasks in order to research the project and completed a three volume assessment of the proposed development. The three volumes included a main report (Vol. 1), a public participation report (Vol. 2) and an appendices volume (Vol. 3). Arising from the public participation volume (Vol. 2, 1995) are particular findings that have motivated this researcher to pursue the issue of changes in the environment and land degradation within the study area. The critical findings of the Masters Group were:

- ◆ that pressure from rural settlements neighbouring the park has, for a number of reasons, led to the degradation of many of the resources in the surrounding areas. (Section 3.4.1.8c)
- ◆ that there is a severe lack of job opportunities within the rural settlements surrounding Cathedral Peak, and what was once fertile land is, in many places, highly degraded. (Section 3.4.3)
- ◆ that, at present, NPB owns and controls part of the area which is considered by the community to be fertile. NPB land has abundant vegetation cover and the authorities even sell grass and wood (Section 3.4.3)

The project on land degradation developed out of different circumstances under which students have worked during 1995. Usually on the project section of the M.Phil/M.Sc course, students undertake a three month group baseline study in which they collect baseline information. Subsequently, students undertake a three month individual project in which they analyze, interpret and evaluate information collected during the baseline

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<sup>1</sup> The Masters Group consisted of five students viz. Nina Askeland, Osman Asmal, Andy Spitz, Piet Theron and Penny Urquhart.

section of the project. The Masters Group project of 1995 to Natal undertaken for NPB, has differed from that of their predecessors because of the terms of reference from the NPB. The terms of reference were, very briefly, to complete a Preliminary Environmental Impact Assessment by mid April 1995. In completing the entire environmental impact assessment by mid April, the situation has arisen whereby new projects have had to be chosen by the various members of the Masters Group that have worked in Natal. This particular project on the changing environmental characteristics and land degradation of the study area is based on the original Masters Group study and forms but one of a series of reports on various aspects thereof. In a general sense, all of these reports, like this one, deal with the concept of environmental management.

# Chapter 1

## Introduction

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## 1.1. Introduction

The Drakensberg and its immediate surroundings has long being recognised as an important nature conservation area and more importantly, as a water catchment area. One of the primary management objectives of the Department of Environmental Affairs and Forestry (1986) has been to maintain a sustained high quality yield of water from the Drakensberg. In South Africa, where mean annual precipitation is less than 500mm, the Drakensberg mountain range, together with its foothills and adjacent flatter areas, is of particular significance to the management of water resources, for with annual rains from 700 to 1800 mm, it constitutes the major inland source area of the country's water supply, and large annual and seasonal supplies of water are available to augment deficits elsewhere. (Schulze, 1979). Sections of the Drakensberg were declared State Wilderness Areas under the Forest Act No. 72 of 1968 as amended in 1971, and served the function of preserving indigenous forests, plant communities or natural scenery for scientific, aesthetic and recreational reasons. Considering its ecological and hydrological significance, then one would expect that land degradation in the Drakensberg to have been minimised.

Land degradation in Okhahlamba (See Fig 1.1), a former district of the Kwazulu homeland which borders the Central and Northern Sections of the Natal Drakensberg Park is, however marked. An initial study by the Masters Group (1995) that investigated socio-economic conditions in eMhlwazini, a ward in the Okhahlamba District, briefly outlined the nature, extent and causes of degradation.

NPB areas, then, are relatively undisturbed, while the populated rural areas of Okhahlamba District are apparently degraded. One indication of this is the clarity, or otherwise, of stream water in the different parts of the Thukela River Catchment (See Fig. 1.1). The Thukela<sup>1</sup> Joint Services Board (TJSB) (1994) asserts that water emerging from the high Drakensberg is clear and of excellent quality, its quality rapidly declines as it passes through the densely populated Upper Thukela Location. The TJSB(1994) remarks that of particular concern is

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<sup>1</sup> The word Thukela has been spelt differently by various authors e.g. Tugela or Thukela. Throughout this report, the most recent spelling of Thukela by the Thukela Joint Services Board (TJSB, 1994) has been adopted.

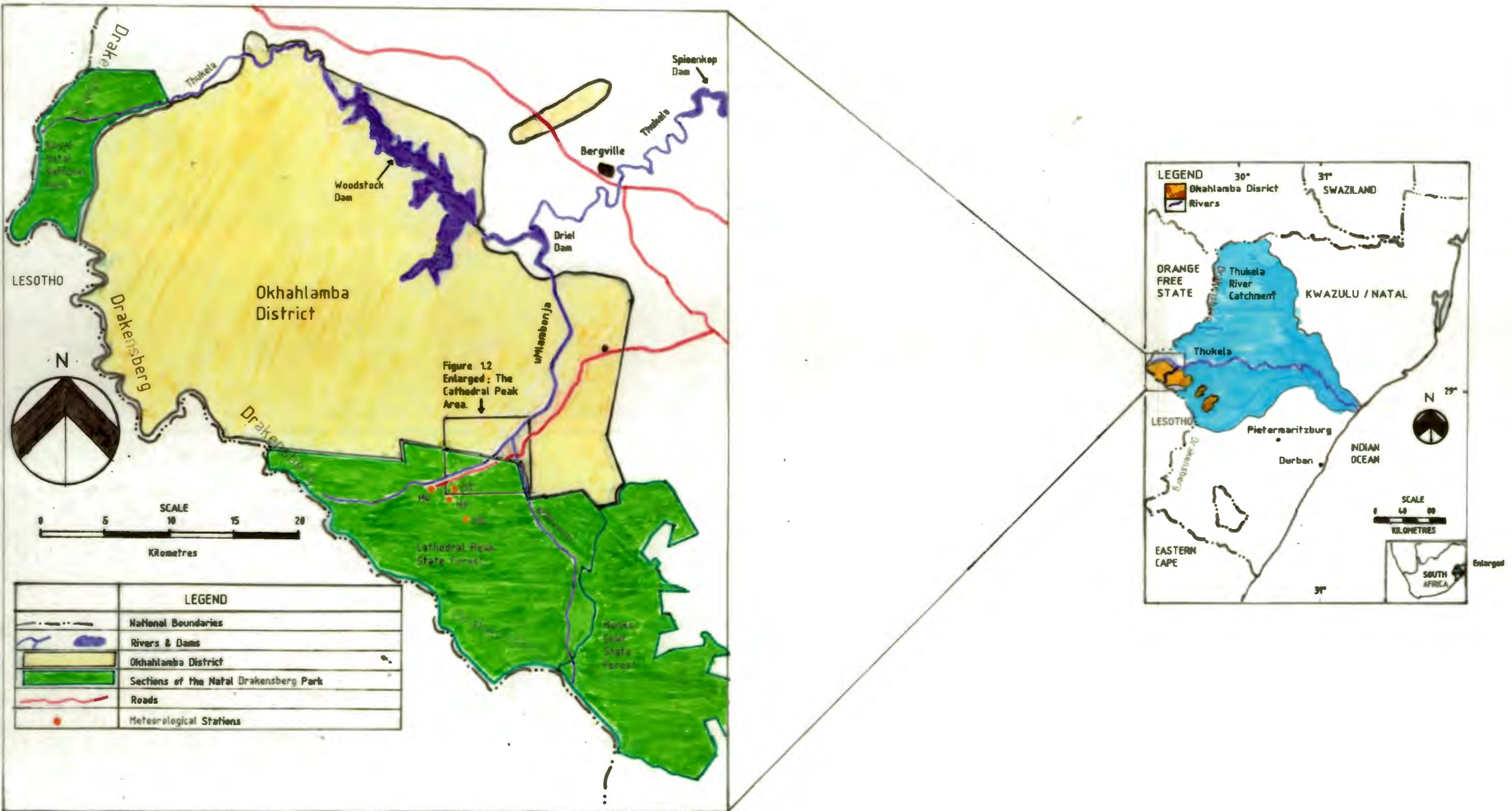


FIGURE 1.1 : NATIONAL, REGIONAL & LOCAL CONTEXT OF THE OKHAHLAMBA DISTRICT & THE CATHEDRAL PEAK AREA

the high sediment load acquired when water flows through areas of the Upper Thukela Location. The perspective that the runoff within the region is highly laden with sediment is quite widely accepted by most individuals and organisations in the region, as can be noted from the comment made by an anonymous member of the Bergville Farmer's Association, who mentioned that the quality of water that is discharged from the hutted camp (Masters Group, 1995) will probably be of a very good quality in terms of its load, compared to what the water accumulates as it passes through sections of the Upper Thukela Location between Bergville and the Drakensberg Mountain.

Thorrington-Smith(1960: 125) discussing the Upper Thukela Location (section of the Okhahlamba District) states:

"... that the mesas of the Little Berg are used for grazing, the cattle tracks to these areas being the incipient cause of erosion...The Balmoral and Avalon soil types, together with good rainfall provide an excellent environment for agricultural pursuits. Under good management and control it is believed that these areas could support a population much greater than at present. In the meantime malpractices are resulting in the erosion of what are in reality stable soils while in the lower valley of the Little Thukela irreparable damage has been done."

The following quotation from Irwin and Irwin(1992: 3.10 - 3.11) appropriately summarises hikers' perceptions of erosion in the Singati, Ifidi, Mnweni and Ntonjelane Valley areas, situated within the Okhahlamba District and approximately 15 km north of Cathedral Peak:

" Despite the extreme poverty in the area, some of the inhabitants have made an effort towards improving farming methods and conserving the environment. Agricultural and environmental education programmes have been received with enthusiasm and conservation measures such as contour ploughing and crop rotation are becoming more widely practiced...The land is however at present being utilized beyond its naturally low carrying capacity, a situation which is aggravated by socio-political conditions, mounting pressure of population and domestic animals and by some of the unsophisticated farming methods that are used. Slopes are often severely overgrazed, animal drawn sledges are still in common use and the grass is burnt every year. Soil erosion is consequently widespread. Protea woodlands, forests and riverine scrub are rapidly being depleted for firewood and with the exception of the unpalatable grey Rhebuck and Baboon, there is little game left owing to hunting and predation by dogs. Overstocking with goats is particularly harmful because they easily penetrate steep, ecologically fragile areas and feed unselectively."

Subsistence agricultural farmers of Kwazulu and Lesotho are forced to occupy these areas owing to socio-economic circumstance (Hudson, 1987). Their practices of cropping in small

fields and livestock grazing have considerable detrimental effects on the sensitive Drakensberg ecosystems and extensive sheet and gully erosion is prevalent (Bainbridge, 1986).

In personal communication with tribal authorities and individuals within the eMhlwazini community, pasture shortage and soil erosion were identified as important environmental problems affecting the eMhlwazini Ward. Little or nothing could be done about soil erosion due to the limited capital that was available in the Okhahlamba District as well as the socio-economic conditions that prevailed (Tribal authorities, pers comm).

Non-Governmental Organisations (NGO's) and conservation bodies that are based in the Okhahlamba District have identified soil erosion, in addition to overstocking as the most obvious environmental problems affecting the Okhahlamba District. Limited capital, coupled with the traditional cultural values, are factors that hinder the improvement of soil erosion in the Okhahlamba District (pers comm, anonymous NGO).

Numerous studies have been conducted within the Natal Drakensberg Park. A very brief review of these studies is necessary in order to establish the intensity of research and importance of the Drakensberg to various state departments, organisations and individuals for diverse reasons. A more detailed discussion of environmental characteristics is presented in Chapter Two.

## **1.2. Studies of environmental characteristics and land degradation undertaken for the Drakensberg: a review**

There has been a long history of environmental studies within the Drakensberg, although studies that investigate land degradation have been confined mainly to the fields of soil erosion and soil conservation, whereas those that concern environmental changes over time are extremely limited or non-existent. Studies in the field of soil erosion and conservation

tend to be concentrated on erosion and conservation as a function of recreational land usage and tend to be geographically limited in space to sections of the Natal Drakensberg Park.

At a meeting of the South African Scientific Community the distinguished South African earth scientist Alex L du Toit (1938) identified land degradation in the form of soil erosion as being problematic in the Drakensberg. He mentioned the seriousness of overgrazing along stretches of the Drakensberg and stated that degrassing had led to large scale gully erosion.

In portions of the Cathedral Peak State Forest (CPSF) important research and experiments in hydrology and veld management were conducted by the Department of Forestry (Irwin et al, 1980) to find appropriate burning regimes and management techniques.

Scott and Humphrey (1985) investigated the need for careful path (vehicular and recreational paths) maintenance and construction in the Drakensberg State Forest Areas. These authors state that many of the paths in the Natal Drakensberg are the cause of accelerated soil erosion. The soil loss is in itself undesirable, and the permanent scars which result detract materially from the beauty of the landscape.

Numerous environmental studies have been entrusted by the Natal Town and Regional Planning Commission to organisations and individuals in order to observe and record relevant environmental criteria in the Drakensberg and to establish appropriate conservation and recreational management schemes. With regards to conservation and soil erosion the following studies have been undertaken, the work of Phelan (1976) and Garland (1987) is paramount.

Phelan (1976) classifies the Drakensberg into four land use zones which run parallel to the escarpment and roughly coincide with the geological formations of the Drakensberg. These zones were identified as: the Wilderness Heart Zone, the Landslide Zone, the Trail Zone and the Drakensberg Threshold Zone. According to this zonation, development in the Drakensberg should be restricted to the Threshold Zone.

Garland (1987) researched erosion risk from footpaths and vegetation burning within the Drakensberg. He noted, firstly, that without remediation of affected areas soil loss in the Drakensberg may well accelerate, even if land treatment causing initial erosion is halted and, secondly, that increasing recreational pressure upon the Drakensberg will create demand for more facilities. He stated that unless new facilities are carefully planned, sited and maintained, the number of erosion degraded sites will steadily become greater.

With regards to the former Kwazulu homeland district of Okhahlamba, little information regarding soil erosion and land degradation exists. The importance that has been ascribed to the Drakensberg as a hydrological catchment, conservation or recreational area is apparently irrelevant in the context of the scenario depicted of the Okhahlamba District in section 1.1.

Despite all the existing statements and perceptions of environment change and degradation in the Okhahlamba District, the paucity of factual information has hindered any meaningful conclusions on the state of the environment.

The paucity of environmental information as well as research programmes and conservation measures for the Okhahlamba District is acute, particularly when one compares the volumes of information that exists for the nearby sections of the Natal Drakensberg Park. Makhanya (1993) states that previous governments neglected subsistence agriculture and areas within the former homelands. One of the consequences of this neglect has been that, whereas a range of land use maps are readily available for the commercial agricultural areas, there is a lack of such maps for subsistence agricultural areas (Makhanya, 1993). The poor state of environmental information that exists for the Okhahlamba District presents an opportunity for initial investigations of the environmental scenario that exists and factors that have effected environmental change in the Okhahlamba District using the Cathedral Peak Area as a case study.

### **1.3. The brief and need for the study : environmental change and land degradation in the Cathedral Peak Area**

Since degradation is a perceptual term, it must be expected that there will be a number of definitions in any situation (Blaikie and Brookfield, 1987). In this project land degradation is defined as alterations to all aspects of the natural environment by human action, to the detriment of vegetation, soils, landforms and water, whereas environmental change refers to the general changes in environmental characteristics that have occurred over time in the Cathedral Peak Area as a result of human activities.

Within the general overview it is evident that the majority of studies in the Drakensberg have focused on soil erosion and conservation within the formally conserved Natal Drakensberg Park whereas the surrounding areas of the Okhahlamba District have had a very limited input in terms of environmental research, a situation which may be regarded as typical of the situation in South Africa which has frequently found environmental research focused in "pristine" areas. There is a need for a more scientifically sound database that would provide reliable information of the state of the environment in subsistence agricultural and former homeland areas (Makhanya, 1993). In order to assess the state of the environment in subsistence agricultural areas in South Africa, more information of an objective nature is required

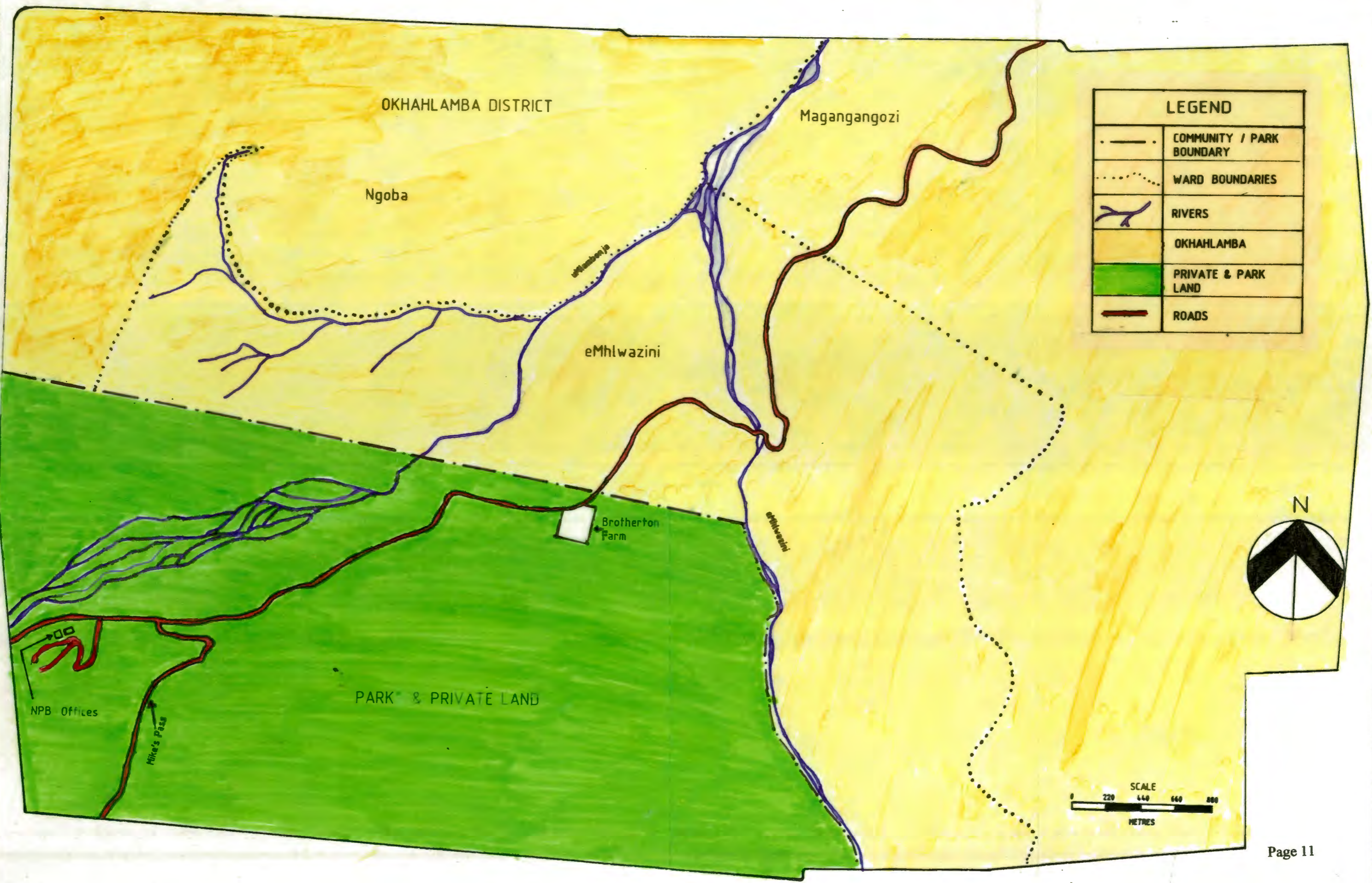
In certain areas of the Okhahlamba District, the general environmental features e.g. climate, geology, geomorphology, soils, vegetation, etc. are similar to those that relate to the features of the Natal Drakensberg Park. Existing literature and research from the Drakensberg, therefore, could easily be reciprocated for the Okhahlamba District. The eMhlwazini and adjacent wards of Ngoba and Magangangozi (See Fig. 1.2), which border the Cathedral Peak Section of the Natal Drakensberg Park represent segments within the Okhahlamba District where the reciprocation of environmental characteristics can easily be identified with those of the Drakensberg as a function of their close proximity to the Drakensberg escarpment.

The resources and time constraints of the project preclude a comprehensive study of the Okhahlamba District, consequently a smaller area, encompassing most of the macro-scale

variations of the Okhahlamba District and the Drakensberg has been chosen. The eMhlwazini, Ngoba and Magangangozi Wards of the Okhahlamba District together with a portion of the Cathedral Peak State Forest (CPSF) provide these characteristics and have been adopted in the project as the study area, termed the Cathedral Peak Area (See Fig 1.1, Fig. 1.2 and Plate 2.1)

The availability of aerial photographs for the Cathedral Peak Area dating back to the mid 1940s provides a valuable tool for investigating land degradation. Thwaites (1986), Watson (1990) and Garland and Broderick (1992) used aerial photographs to study soil erosion within sections of the Orange Free State and Kwazulu/Natal Provinces respectively. The availability of aerial photographs since the early 1940's for the Cathedral Peak Area would aid in the interpretation of environmental changes and land degradation in the area as well facilitating comparisons with results of similar studies.

In the Cathedral Peak Area four reasons viz. the paucity of environmental research for the former Kwazulu homeland Ward of eMhlwazini Ward and the District of Okhahlamba, an adequate coverage of aerial photographs, the flexibility with which environmental features and parameters can be substituted with information from the Natal Drakensberg Park and information collected on the baseline study component in the Masters Group (1995) project offer an appropriate opportunity whereby information and research may be combined to give some indication of the state of land degradation for the Okhahlamba District. The close proximity of the eMhlwazini, Ngoba and Magangangozi Wards to the Cathedral Peak Section of the Natal Drakensberg Park also allows for the development of recommendations in order to improve relations between people and parks.



## 1.4. Aims of the study

Land degradation in the Okhahlamba District has been described as severe. The information that exists for environmental change is extremely limited whereas that for land degradation is limited to the fields of soil erosion and conservation. With this in mind, the report aims to:

1. Describe and account for the historical development of land degradation and changes to the environment in the Okhahlamba District using the Cathedral Peak Area as a case study. Describing historical development, would include an assessment of the extent of land degradation in the Cathedral Peak Area.

At an important juncture in South Africa's history when social upliftment and capacity building are important national priorities and when land use changes are likely to occur in rural areas, environmental conservation measures offer an opportunity to improve the interaction between impoverished people and sensitive environments. People/park relationships is defined in the project as being the interaction between communities that border nature and game reserves or parks and administration of parks. A programme launched to improve people/park interaction was reported by TV 1 News (20h00, June 29 1995) where local communities from around the Tsitsikamma Nature Reserve have been recruited as labour to help fell alien trees. The programme has been initiated as a method of improving neighbour relations between national parks and the surrounding communities. Opportunities for improving people/park interaction and social upliftment exist for the Cathedral Peak Section of the Natal Drakensberg Park and the communities of the eMhlwazini Ward. Accordingly, the third and fourth aims of this project respectively are:

2. Identify critical periods when land degradation is liable to expand in the Cathedral Peak Area and the Okhahlamba District.
3. To make recommendations and offer management options for reduction of land degradation and possibilities for increased and improved people/park interaction.

## **1.5. Objectives of the study**

In order to identify and monitor land degradation in the Cathedral Peak Area, three sets of sequential aerial photographs over a time span of approximately four and a half decades, between the years 1945 and 1992 are utilised.

Historical changes that have occurred in the Cathedral Peak Area are assessed by using the principles of photogrammetry and aerial photo interpretation. Photogrammetry and air photo interpretation entail the mapping of environmental components from the aerial photographs.

Occasions when land use changes are likely to occur in the Cathedral Peak Area are assessed by reviewing information that has been collected by the Masters Group (1995) and from the objectives of national, provincial and local government development programmes and people's aspirations.

## **1.6. Assumptions and Limitations**

### **1.6.1. Assumptions:**

- ◆ The eMhlwazini Ward and adjacent surroundings has been taken as a representative of the Okhahlamba District. The justifications for using the eMhlwazini Ward as a representative sample of the Okhahlamba District are: that the eMhlwazini Ward is firstly part of the former Kwazulu homeland's Okhahlamba District and secondly due to its close proximity to the Natal Drakensberg escarpment.
- ◆ Due to the lack of bio-physical information that exists for the eMhlwazini, Ngoba and Magangangozi Wards, per se information from surrounding areas of the Natal Drakensberg Park can be reasonably reciprocated for the eMhlwazini Ward due its location within the Drakensberg foothills.

### **1.6.2. Limitations**

- ◆ Limited time constraints for the project prevents a more thorough examination of land degradation in the Cathedral Peak Area. The mapping of material directly from aerial

photographs onto a Geographical Information System (GIS) may have been more suitable, however due to time constraints, all mapping and area calculations have been undertaken manually.

## **1.7. Structure of report**

Chapter One commences by introducing the reader to the state of the environment as perceived by organisations and individuals in the Okhahlamba District and the need for the study of environmental change and land degradation in the Cathedral Peak Area.

Chapter Two sets out the broad geographical and environmental characteristics that are found in the Cathedral Peak Area as a backdrop to the study. These characteristics include the socio-economic as well as biophysical features.

The principles of photogrammetry and airphoto interpretation as a setting to the methodology that has been adopted in the study are discussed in Chapter Three. An explanation relating to the various categories of environmental changes used in this study viz. changes in homesteads, cultivation, forests, erosion and gullies is discussed. The various techniques that have been employed as methodologies for obtaining results are also elucidated.

The results that have been obtained in the study by using a combination of the principles of airphoto interpretation, photogrammetry and manual mapping are stated in Chapter Four. Results obtained have been divided according to the categories that have been identified in chapter three.

Following the results of the study, Chapter Five leads a discussion regarding the results obtained. Comparisons and interpretations with other studies at a local, regional, national and international level are included. There are some implications that emanate from the

study which include changes in the extent of forests in the community areas and changes in erosion.

In concluding this dissertation Chapter Six draws together all the issues discussed and offers proposals and recommendations for improving neighbour relations between people and parks in the Cathedral Peak Area through environmental conservation measures.

# Chapter 2

## Geographic Description

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This section deals with the description of environmental characteristics of the Cathedral Peak Area. Relevant information on both the socio-economic as well as biophysical factors that influence the area as a background to environmental change and land degradation in the area are identified.

## 2.1. Location

The Cathedral Peak Area is a term coined for use in this project. Fig. 1.2 indicates that the Cathedral Peak Area refers here to a small portion of the Cathedral Peak section of the Natal Drakensberg Park as well as the eMhlwazini Ward and portions of the surrounding wards of Ngoba and Magangangozi (also refer Plate 2.1) The three wards of the Cathedral Peak Area is sometimes also referred to as the community section or community land of the Cathedral Peak Area. The Cathedral Peak Area or "the area" is located at approximately 29° 20" E longitude and the 28°57" S latitude. The total spatial extent of the Cathedral Peak Area, is 30.5 km<sup>2</sup>. The eMhlwazini, Magangangozi and Ngoba Wards form part of the previous self governing homeland of Kwazulu and the District of Okhahlamba (See Fig. 1.1). Another term adopted in this study is the Drakensberg Region or the Drakensberg, which refers to the Drakensberg Mountain Range in its broader geographical context. The Cathedral Peak State Forest (CPSF) is also used extensively in this section and is shown on Fig 1.1.

## 2.2. History

The present environmental situation in the Cathedral Peak Area is a result of past and present interactions of the physical environment with that of the human environment. Pressure upon the land has progressively been increasing in the Cathedral Peak Area. Although settlements may have existed in the Cathedral Peak Area historically, government policies and programmes together with population growth have played a major role in increasing the population in the Cathedral Peak Area. In order to understand the present situation in the Cathedral Peak Area, this section discusses the main historical forces that have caused the increase of population and hence pressure upon the environment in the area.



Plate 2.1: The Cathedral Peak Area (as seen from south of south west in the Cathedral Peak State Forest)



Plate 2.2: Community land use in the Cathedral Peak Area include subsistence agriculture, grazing and residential land use.

When white farmers who had settled in the Drakensberg Region complained of stock theft, the colonial government of Natal responded by removing African communities from the Klipriver area and resettled them in the higher areas as close to the Drakensberg as possible (Mazel, 1981). This resettlement scheme was the first planned government programme of resettlement and produced an immediate increase in the population of the Drakensberg Region. The resettlement scheme was undertaken so as to create a buffer between the white farmers and the San People. The many "locations" of the Okhahlamba District that surround developed nodes of the various section of Natal Drakensberg Park stand as evidence of the Natal Government's "Buffer Policy".

The Land Acts of 1913 and 1936 resulted in the confiscation of land of black farmers and pastoralists (Ramphela, 1991). The reduction of land and survival options due to increasing numbers of settlers (Letsaolo, 1987) together with natural hardships, forced many Africans to exchange their labour for work on European farms or in urban areas. In 1948, the Nationalist government instituted its policy of *apartheid*. Kwazulu, a *bantustan* created in the apartheid era, has been densely populated. Apartheid policies had the effect of severely depriving the communities to a better quality of life and in many cases resulted in a breakdown of family and community life. In terms of the environment, as population and agricultural pressure increase on any particular piece of land, it inevitably increases the rate at which vegetation is removed and soil is destabilised (Nowicki, 1992). Ramphela (1991) describes a range of environmental problems that have arisen in former homelands as a result of the overcrowding instituted by apartheid policies and include accelerated soil erosion, overgrazing and water and air pollution as a consequence of the policies of apartheid.

The population growth rate given for former Kwazulu areas over the last 30 years has been estimated at 2.5% per annum (CSS, 1991). Actual census figures, however, only exist for the Okhahlamba District from 1970's onwards. For the time interval 1970 to 1990, the population of the entire Okhahlamba District increased from 69 599 to 196 963 people (Central Statistical Services {CSS}, 1991). The almost three fold increase in population would imply a resultant increase in the requirement for land and hence increased pressure upon the environment.

### 2.3. Socio-economic environment

Most of the information for this section comes from the Masters Group (1995) study. The community section of the Cathedral Peak Area consists in the main of the eMhlwazini Ward and small portions of surrounding wards of Ngoba and Magangangozi. It is possibly one of the poorest and least developed areas in the country. The population for the eMhlwazini Ward (See Fig 1.2) is estimated at approximately 2700 people (Masters Group, 1995). Only 24% of the population of the eMhlwazini Ward was formally employed, the majority of whom are migrant workers (Masters Group, 1995). Pensioner's income and informal employment activities, such as craft making and vegetable sales, provide a substantial source of income to people of the ward. Due to the nature of the migrant labour system that exists in the ward, there exists a disparity between the numbers of males and females. The only primary health care available to people of the ward is a vehicular clinic that operates on a monthly basis and the nearest hospital to the eMhlwazini Ward is approximately 35 km away. There are no formal supplies of electricity, water, waste disposal or sanitation facilities in any parts of the ward. In terms of education, only 37% of the population have an education to standard 5 level, whereas an even smaller proportion has matric (Standard 10) qualifications. The poor supply of facilities is also manifested within the one primary school that serves the eMhlwazini Ward. Overcrowding is common in schools and the population is clearly in dire need of an increase in facilities.

Poverty poses arguably the greatest threat to the environment in South Africa. People are powerless to address the problem of land degradation and are forced to further degrade their environments largely because of unemployment, poverty and lack of possibilities to improve their lot (Nowicki, 1992; eMhlwazini Resident, pers comm.). In the eMhlwazini Ward as well as other sections of the Okhahlamba District, the opportunities to improve the quality of life are limited, and basic needs have not been met. The extremely poor conditions that exist in these areas have certainly contributed to the degradation of the environmental resource base.

## 2.4. Land use

The land use in the Cathedral Peak Area depends to a large extent upon land ownership. There is a very limited variety of land use activities in the Cathedral Peak Area. These activities are restricted and limited in providing employment opportunities for the people of the eMhlwazini Ward. In the former homelands being, able to practice some kind of agricultural activity may be literally a matter of life or death. There are scarcely any job opportunities, while pensions and the remittances of family members working as migrants elsewhere are meager and uncertain. It is vital to plant some crops and to raise some livestock (Kruger, 1991), thereby leading to an increase in the pressure upon the land. However in direct contrast to the situation in the surrounding community areas, the park section of the Cathedral Peak Area, is well vegetated and is used mainly for the purposes of water conservation and limited recreational activities.

### 2.4.1. Community use of land

The term community in this context refers to the African community which surround the park in the Cathedral Peak Area. The land in the community section of the Cathedral Peak Area is held in trust by the King of the Zulu people, who parcels it out to the district Nkosi or Chief. The eMhlwazini Ward falls under the jurisdiction of Nkosi Hlongwane who is based at Emmaus, a "location" in the vicinity of the Cathedral Peak Area. The community inhabitants of the land have a usufruct right to land, but no power either to dispose of it or negotiate with it. Land in the community that is not allocated for building or for planting purposes, is available to everyone in the community for grazing their livestock. The Masters Group (1995) found similar results to Vilakazi (1962) who stated that, because the traditional Zulu society is based on subsistence, the concept of producing surpluses over and above the needs of the homestead, and exchanging these for money is completely foreign.

The use of the land in the community section of the Cathedral Peak Area has been mainly for communal, subsistence and non-profit purposes which include activities such as grazing and agriculture (See Plate 2.2). More recently however, two commercial activities have been established in the area. Cultivation of cannabis provides a much needed source of income to some of the people of the area and land is also used for residential purposes.

In terms of agricultural activities, the Masters Group (Vol. 2, 1995) found that 93 % of the sample population had grown crops for subsistence. In a rough calculation to determine the stocking rate for the eMhlwazini Ward, the Masters Group (Vol. 2, 1995) suggested that the eMhlwazini Ward was overstocked. Although the livestock population was below the maximum carrying capacity calculated for the eMhlwazini Ward, when all land use types are included into the calculation, the land available for grazing is being utilised beyond its calculated carrying capacity limit (Masters Group, 1995).

#### **2.4.2. Forestry and conservation**

By the turn of the twentieth century, the first forestry reserves were established by the Colonial Natal Government. The Cathedral Peak State Forest (CPSF) was one of the declared forestry reserves (see Fig. 1.2). In the early 1960's the Department of Forestry took over the management of the CPSF. Parts of the CPSF were declared State Wilderness Areas under the Forest Act No. 72 of 1968 as amended in 1971, and served the function of preserving indigenous forests, plant communities or natural scenery for scientific, aesthetic and recreational reasons. The Department of Forestry established The Cathedral Peak Research Area within the CPSF. Important hydrological and veld management research were and are still conducted in the area. The government as part of its rationalisation programme in the 1980's devolved the management of the CPSF, together with other forests areas in the Drakensberg on to NPB. At present most of the land in park area is used for conservation and forestry purposes, with a small percentage for recreational, administration and residential purposes. The previous Department of Environment Affairs and Forestry as well as the NPB who presently manage the Cathedral Peak Section of the Natal Drakensberg Park, provided and still provide a vital employment opportunity and a much needed source income to the communities of the Cathedral Peak Area.

#### **2.4.3. Private land history**

By the 1930's the first and only privately owned resort in the in close proximity to the Cathedral Peak Area i.e. the Cathedral Peak Hotel was established (1939) (Located at site M4 on Fig. 1.1). Several commercial white farmers had also acquired property in the area. Apart from the Brotherton and Hotel properties which still operate presently, all other white private property owners sold their properties to the Department of Forestry

and was incorporated into the CPSF. Today, private land is used for recreational, residential, commercial and forestry purposes.

## 2.5. Climate

The Cathedral Peak Area is located within the summer rainfall region of South Africa which characteristically experiences hot, wet summers and cool to occasionally cold and very dry winters. The climate of the Cathedral Peak Area results from the interaction of several major factors. Tyson et al (1976) and Irwin and Irwin (1992) identify distance from the escarpment, altitude, topography, influence of the warm Agulhas current and the pattern of the atmospheric pressure systems over and adjacent to South Africa. Due to the diverse nature of the landscape in the Cathedral Peak Area and its proximity to the escarpment, microclimate is greatly affected. Temperatures and evaporation are generally higher on north facing slopes than south facing slopes due to incoming radiation.

Mean maximum daily temperatures over 25°C occur for seven months of the year in the CPSF (Granger, 1976). The mean daily maximum temperature in the Drakensberg, for January (the hottest month), ranges from 23°C at 800m altitude to 21°C at 2400m altitude. Equivalent values for July, the coldest month in the Drakensberg, are 15°C and 12°C respectively (Tyson et al 1976). July and August are the coldest months having mean air temperatures of between 0°C and -1°C respectively (Hudson, 1987). For five months of the year, the mean daily minimum is below zero and frost is a common occurrence (Garland, 1987).

Most of the Drakensberg Region experiences over 200 rain days (Irwin and Irwin, 1992). Schulze (1979), researching in the CPSF, described two rainfall seasons common to the Natal Drakensberg. Firstly the "frontal rainfall season" which occurs in the winter and spring months with low intensity rainfall. The second season is called the "thunderstorm season" which occurs in the summer and autumn months. Hudson (1987) says that 80% of the rainfall in the CPSF falls within the months of October to March. The rainfall in the thunderstorm season occurs in the form of short, intense storms, with a high erosive potential. Rainfall that falls in the full frontal season embodies much lower kinetic energy

per unit of rainfall and is thus of lower erosional significance (Hudson, 1987). Schulze(1979) has found that the CPSF has markedly higher frequencies of relatively high intensity rains for durations exceeding one hour compared with other selected stations in Natal.

The proximity of the eMhlwazini, Ngoba and Magangangozi Wards to the Drakensberg escarpment and varied topography of the region are primary factors that influence their rainfall. The mean annual rainfall recorded at four meteorological stations within the Cathedral Peak Section of the Natal Drakensberg Park and within two to six kilometers of the eMhlwazini Ward are shown in Table 2.1 and Fig. 1.1. respectively, and illustrate the variability of rainfall on a local scale.

Station	Station Number (Fig. 1.1)	Rainfall (mm)
CP. Boos	M1	1356
Gewaaght	M2	1470
C.P. Forest	M3	1241
C.P. Hotel	M4	1307

**Table 2.1:** Rainfall data for stations in close proximity of the eMhlwazini Ward (AE and CCWR\*<sup>1</sup>, Pers Comm.).

## 2.6. Geology

The rocks of the Cathedral Peak Area comprise geological formations entirely of the Karoo Sequence. Fig. 2.1 shows the various geological formations that make up the rocks of the Karoo Sequence in the Drakensberg.

At the base of the geological succession in the Cathedral Peak Area are rocks of the Tarkastad Formation. These form the uppermost unit of the Beaufort Group. The rocks of the Tarkastad formation are composed of fine to medium grained, red and blue shales, mudstones and sandstones.

<sup>1</sup> Source : Department of Agricultural Engineering (AE) and Computing Centre for Water Research (CCWR) at the University of Natal, Pietermaritzburg

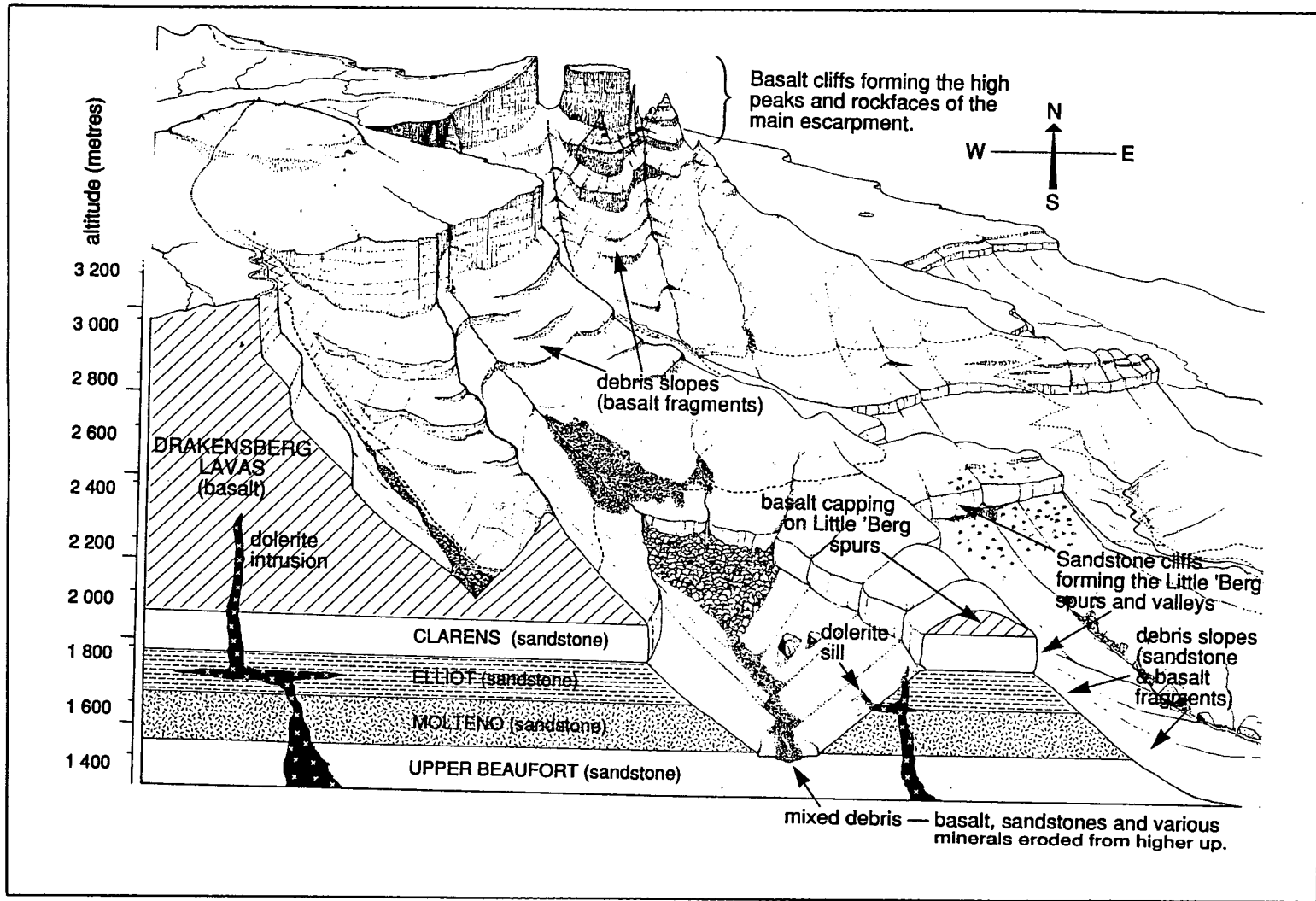


Figure 2.1: Geological features of the Natal Drakensberg (adopted from Irwin and Irwin, 1992)

Following the Tarkastad Formation are the alluvial deposits of the Molteno Formation which are composed of blue grey sandstones thought to have accumulated in a vast inland delta (Irwin and Irwin, 1992). The Elliot Formation, which overlies the Tarkastad Formation is composed of fine grained red and purple shales and mudstones. The aeolian deposits of the Clarens Formation overlie the rocks of the Elliot Formation. These rocks are characterised by massive, yellow to pale red coloured, fine to medium grained sandstones. The Drakensberg Formation, which caps the Karoo Sequence is composed almost entirely of basaltic lavas. Dolerite, which has the same chemical composition as basalt, occurs as dykes or sills within the Cathedral Peak Area and has intruded into the older geological formations of the Karoo Sequence.

In terms of erosivity, the dolerite intrusives and the basaltic lavas are the hardest geological formations in the Drakensberg. Unconfined compressive strength (UCS) is the maximum stress which a laterally unsupported specimen of material (rock) can sustain before breaking up (Brink et al, 1982). In terms of UCS, the dolerite and the basalt have UCS values of 400 Mpa and 190 Mpa respectively (Brink, 1983 cited in Garland 1987). The Clarens formation has a UCS between 21 and 102 Mpa. The basalts and dolerites, hence are much more resistant to erosion than the rocks of the Clarens Formation.

## 2.7. Geomorphology

In detail, as well as in large scale features, the form of the Drakensberg is governed by the action of running water (King, 1944). The volcanic lavas of the Drakensberg Formation are resistant to erosion and today form not only the high peaks and escarpment, but also the protective capping of the Little Berg (Irwin and Irwin, 1992). Dolerite dykes are the hardest rock type in the Cathedral Peak Area and they often promote the formation of waterfalls where rivers cross sills (Irwin and Irwin, 1992). The distinctive sandstone cliffs of the Clarens Formation (See Plate 2.3) form the capping and plateau of the Little Berg in the Drakensberg Region. The Drakensberg foothills generally project perpendicularly to the main escarpment of the Drakensberg. The slopes and valleys of the Little Berg are composed of the Tarkastad, Molteno and Elliot Formations. Due to the ruggedness of the terrain in the Cathedral Peak Area, there are



Plate 2.3: The distinctive cliffs of the Clarens Formation and the effect of aspect evident on south facing forested slopes in valley (bottom centre)



Plate 2.4: The eMhlwazini and uMlambonja Rivers, and their confluence point which marks the boundary between the three wards of the Okhahlamba District (See Fig. 1.2)

major altitude and steep slope differences which exist and promote the process of erosion.

Aspect has a major influence on soils, vegetation, moisture and temperature at a micro-slope scale. In general north facing slopes receive much more radiation than south facing slopes, resulting in increased temperatures and decreased soil moisture content for north facing slopes. A further attribute of the radiation difference results in north facing slopes supporting drier grassland or protea savannah, with encroachment by scrub being prevented by frequent fires (Irwin and Irwin, 1992). South facing slopes in contrast are moister and support montane forests (See Plate 2.4).

## 2.8. Soils

Because soils have not been mapped either by the author or any other study within all the portions of the Cathedral Peak Area identified for this study, soil information for the Drakensberg Region by Van der Eyk et al (1969) and Phillips (1973) provide most of the detail for the study.

Van der Eyk et al (1969) categorised the soils of the Drakensberg into the Highland Zone of the Thukela Basin. Phillips (1973) argues that, because of the more rugged terrain and the steeper topography of the highlands, the problem of erosion is complex. Following cultivation for some years and, where the terrain is especially steep, the accelerated gully and sheet erosion on the soils being disturbed either in the course of producing annual crops or by close grazing and trampling of the indigenous pasturage has been identified by Phillips (1973) as a special problem affecting soils in the highlands.

Soil-landscape association for the foothills of the Drakensberg Mountains identified by Van der Eyk et al (1969) is shown in Fig. 2.2. Additional soil types that occur, mainly on basalt, which were identified by Bainbridge (1979) cited in Garland (1987), have very limited occurrences in the Cathedral Peak Area identified for this study

Van der Eyk et al (1969) categorised the soils of the Highlands to which the Drakensberg is part of, into three groups viz. i) red apedal soils ii) yellow apedal soils and iii) acid gley soils.

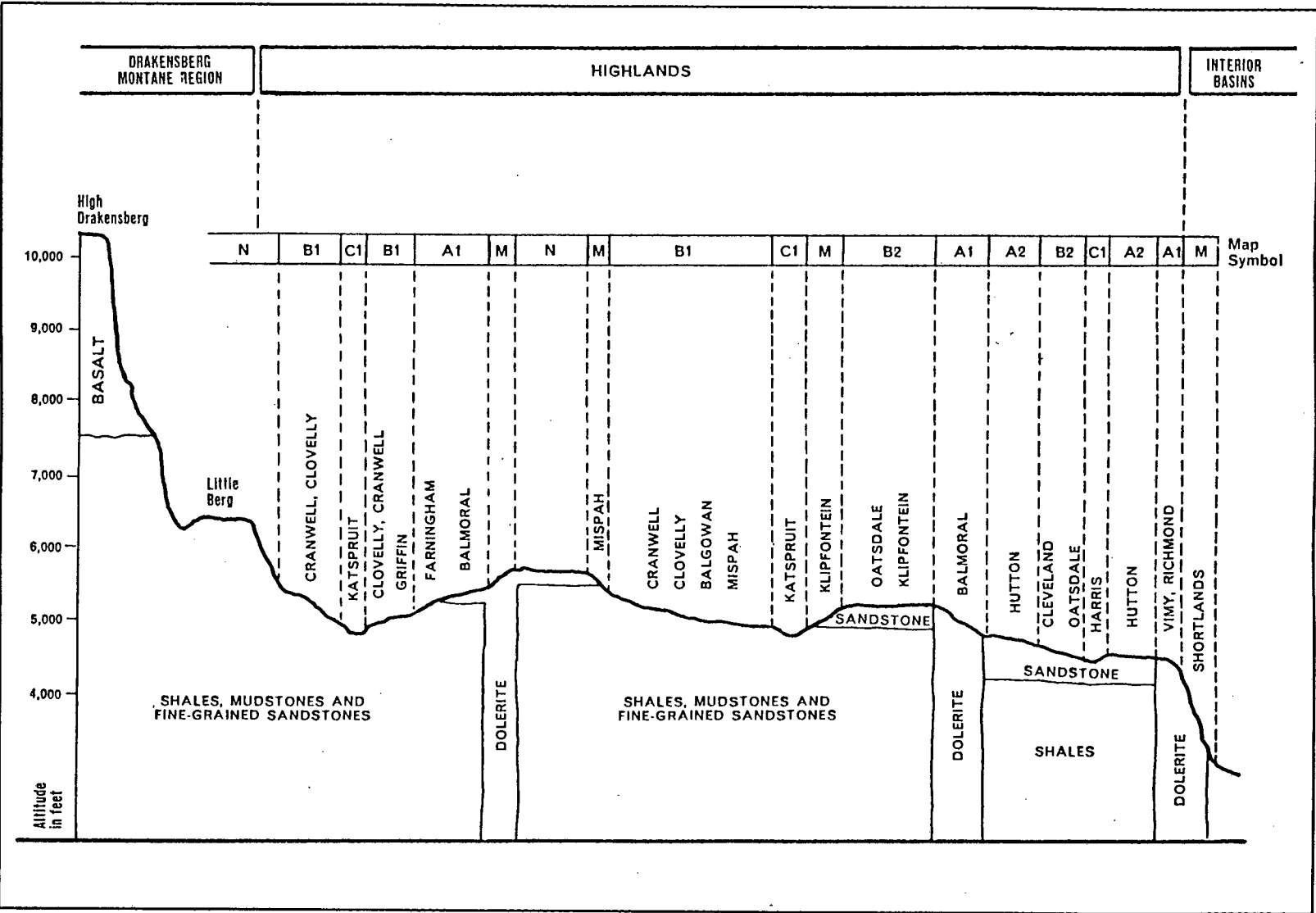


Figure 2.2: Soil-landscape relationship in the Natal Drakensberg (Van der Eyk et al, 1969)

## **2.8.1. Red apedal soils**

### **2.8.1.1. Clayey soils**

These soils have been identified as being deep permeable and well aggregated soils which are stable under cultivation. From the standpoint of their excellent physical characteristics and favourable moisture regime, they are prime arable soils with a very low erosion hazard (Van der Eyk et al, 1969).

### **2.8.1.2. Loamy soils**

This series is dominated by the Hutton Series, a very strongly acid, sandy clay loam, with high infiltration rate and rapid subsoil permeability. These soils are somewhat susceptible to erosion by wind under continuous cultivation which results in rapid loss of organic matter and degradation of soil structure. The Hutton Series also shows some tendency to surface crust formation under raindrop impact on bare soil depleted of organic matter with the attendant danger of water erosion (Van der Eyk et al, 1969).

## **2.8.2. Yellow apedal soils**

### **2.8.2.1. Clayey Soils**

These include soils of the Clovelly; Griffin; Cranwell; Mispah; Balgowan; Farmhill and Newport series. This soil series occurs most extensively in the Drakensberg Region. With the exception of the Mispah, which is a soil susceptible to erosion, all other soil series are permeable, deep or moderately deep and have a high plant available moisture capacity. Erosion hazard is low, provided the well aggregated conditions of the topsoil is preserved. Severe sheet erosion is, however, common on mismanaged Mispah and Clovelly soils (Van der Eyk et al, 1969).

## **2.8.3. Acid gley soils**

### **2.8.3.1. Clayey and loamy soils**

These are the wet soils of the bottomland sites, the vleis in which the Thukela river system rises (Van der Eyk et al, 1969). Vleis are seen as a vital part of the anatomy of the landscape for they stabilise stream and riverflow and largely govern the hydrological regime of the surrounding landscape. Their destruction by erosion must be avoided at all costs since this would cause sporadic riverflow and lowering of drainage base-levels leading to desiccation of the surrounding catchments and accelerated erosion. (Van der

Eyk et al, 1969) Breaching of highland vleis is accompanied by devegetation of their catchments and sheet and pipe erosion (Van der Eyk et al, 1969).

A good deal of information exists on erosion within the CPSF suggesting that the soils in this area are sensitive to change. For example, soils in the CPSF have been identified as being highly susceptible to compaction by vehicles (Beckedahl, 1993; Everson, 1995 in Masters Group, Vol. 3). Roads and paths in sections of the Cathedral Peak State Forest have been responsible for the formation of soil erosion gully systems (Beckedahl, 1993).

Hudson (1987) states that there has been concentration of erodible soil materials such as montmorillonite in soil profiles below the depth of 70 cm in the Drakensberg Region. The implications of the concentration of montmorillonite at this level is significant should the top layers of the soil be removed through, for example a change in land use. Should this layer be exposed, the erodibility status of the area would be altered to one supporting accelerated soil erosion (Hudson, 1987). The comparison of erosion between adjacent parcels of land in the Okhahlamba District where overgrazing has removed this layer and resulted in accelerated erosion and the protected CPSF is used as an example by Hudson (1987) to highlight the impact of the removal of this soil layer.

In the Drakensberg, mass soil movements in the form of landslides and slumps are common (Bosch and Hewlett, 1980). Mass movements contribute large amounts of sediment to stream channels and leave unsightly scars. Natural conditions govern mass soil movements, although disturbance of delicately balanced conditions by anthropogenic activities such as road building, channel erosion and tree cutting can enhance the process of mass soil movements and hasten damage (Bosch and Hewlett, 1980).

Phillips (1973) states that, where farming is attempted on slopes greater than 15 percent, the more readily erodible soils require careful conservation.

Overall, it appears that soils in the Cathedral Peak Area which is similar to that of the Drakensberg Region are stable under natural conditions, although once disturbed by anthropogenic activities, they become sensitive and if significantly affected this may lead to soil degradation .

## 2.9. Vegetation

Vegetation protects soil from wind and water erosion as well as pressure from human activities and grazing animals. The two dominant factors influencing vegetation in the Drakensberg are altitude and the long history of regular and frequent burning (Garland, 1987). The Cathedral Peak Area chosen for this study is dominated by vegetation of the Southern Tall Grassveld (STG) (No 65 Acocks, 1988) (Everson, pers comm). The effect of altitude is illustrated by the gradual change to Moist Highland Sourveld (MHSV) generally above the Clarens Formation rock level (Everson, pers comm). This may change on some warmer north facing slopes, where the gradation occurs below the level of the Clarens Formation rocks.

The STG is dominated by *Themeda* and *Hyparrhenia* grasses. Acocks (1988) states that erosion is severe in this veld type. Other plant communities that occur in the region include protea savanna and scrub which occur on the warm dry grassy slopes above and below the sandstone cliffs and forests which occur mainly on the cooler south facing slopes. They occur in limited numbers in the Cathedral Peak Area. The reason for their limited extent in the Cathedral Peak Area chosen for the study is unknown but in former Kwazulu areas, approximately 10 to 15 km north of the Cathedral Peak Area, Irwin and Irwin (1992) attribute the restricted area of protea, scrub and forest vegetation to their use as building material and fuel by people of the surrounding African communities.

Indigenous vegetation in the Cathedral Peak Area is generally slow growing and removal of vegetation by development could result in serious erosion (Everson, 1995, in Masters Group, Vol. 3), hence new land uses and developments in the region should be carefully managed. In a subjective estimation (Hardy, pers comm) commented that much of the Cathedral Peak Area already under pastoral use is in moderate to poor condition.

Stands of invasive alien plants exist within the Cathedral Peak Area both within the eMhlwazini Ward as well as the park area. Their presence within the park has been limited as a result of the conservation measures, although within the eMhlwazini Ward their numbers have been limited as a result of their use as fuel and building material (eMhlwazini resident, pers comm).

Within the eMhlwazini Ward, the most common alien invasive is the black wattle (*Acacia mearnsii*). The origins of alien invasives in the Drakensberg Region has been traced back to sometimes in the 1870's by Henderson and Wells (1986), and were brought by early colonial farmers that settled in the region. Irwin and Irwin (1992) note that the dryness and dense shade beneath *Acacia mearnsii* prevents undergrowth from developing, which in turn increases erosion and stream sedimentation. Two factors that promote the spread of *Acacia mearnsii* are firstly, that the seeds of *Acacia mearnsii* remain viable for time intervals between 50 and 100 years (Maloney, pers comm), and secondly, that up to 20000 seeds may be found in the leaf litter beneath a single mature tree (Irwin and Irwin, 1992).

In the Cathedral Peak Area in general *Acacia mearnsii* is found in areas where habitat has been removed e.g. homesteads, road verges, gullies, cattle tracks and overgrazed lands (Nichols et al 1985). In spring, soil beneath stands *Acacia mearnsii* is resistant to wetting hence runoff is increased and erosion regimes are likely to be affected (Henderson and Wells, 1986).

### 2.9.1. Burning

Vegetal cover in the Drakensberg has been regularly burnt off, certainly since people first entered the area, and probably long before by naturally occurring fire (Garland, 1987). More recently, fire has been used extensively as a management tool in the CPSF to maintain grasslands and to modify water yields from catchments. The most favourable burning frequency for the Drakensberg has been found to be short rotational burns every two to three years done alternatively in the late autumn, winter and spring (Irwin and Irwin, 1992)

Removing vegetation by burning leaves the soil bare of a protective cover. Although erosion may increase after burning due to the removal a soil cover, Watson (1983) researching in the Cathedral Peak State Forest has reported no significant increase in sediment yield and soil loss after burning. Nevertheless when the frequency and intensity of fires are changed the consequences may be devastating. Irwin and Irwin (1992) report that after a wildfire in the Cathedral Peak State Forest a stream that

transported 10 mg\litre of sediment in the winter season increased its sediment load to 4000 mg\litre. The difference between the two results is that Watson's study was over a regular interval whereas the incident described by Irwin and Irwin (1992) is more of an extreme event.

It would seem that the effect of burning on soil loss is inconclusive, although Garland (1987) states that soils that have developed with a regular burning interval will be in long term equilibrium with the burning regime, whereas areas within which burning is introduced as a new concept may experience dramatic effects upon soil characteristics. In the Cathedral Peak Area, where invasions of alien vegetation occur in grasslands, the fire regime is effected because of the increased fuel loads associated with the greater biomass of alien trees (Henderson and Wells, 1986).

Increasing stands of alien vegetation are known to exacerbate the erosion problem. A fire in a *Pinus patula* plantation in the Natal Drakensberg killed the trees and removed the litter layer (Versfeld and Van Wilgen, 1986). Sediment loss after the fire in the adjacent grasslands was 000.4 tons km<sup>2</sup> yr<sup>-1</sup> compared to about 0.25 tons km<sup>2</sup> yr<sup>-1</sup> from the afforested catchments for two years after the fire (Van Wyk, 1985 cited in Versfeld and Van Wilgen, 1986).

## 2.10. Hydrology

A primary objective of conservation of the Drakensberg is to supply high quality water to various downstream users. The Thukela and Orange Rivers have their sources within the Drakensberg Mountains. Water from the Upper Thukela catchment (Appendix 1) is often made available to the Orange Free State and Gauteng Provinces via the Thukela-Vaal Hydro-electric scheme to supplement deficits in those regions. The CPSF which is approximately 300 km<sup>2</sup> in extent and borders the Okhahlamba District is part of the Drakensberg Catchment Area (DCA). The DCA is South Africa's greatest inland source of water (Schulze, 1979).

There are two prominent rivers that flow through the Cathedral Peak Area viz. the uMlambonja and eMhlwazini Rivers (Refer to Plate 2.4 ). All water from the Cathedral

Peak Area flows via these two rivers. The confluence of the uMlambonja and the eMhlwazini Rivers delineates the boundary of the eMhlwazini and Magangangozi Wards whereafter the river is known as the uMlambonja. The uMlambonja flows eastwards and intersects further downstream with the Thukela River. The uMlambonja River has a catchment area of 497 km<sup>2</sup> (Middleton, 1953).

The magnitude and frequencies of occurrences of peak discharges of streams are of particular significance because it is to the peak discharge that most adverse geomorphological, structural and erosive effects are frequently related (Schulze, 1979). If all first order streams, including small ephemeral streams, as well as those of higher orders are taken into account, the Drakensberg Region has a very high drainage density. Garland (1987). Garland (1987) also points out that the discharge pattern of the fluvial system in the Drakensberg is very flashy and hydrographs can reach high peaks in response to intense rainstorms, although Schulze (1979) noted that with heavy and reliable rainfalls, coupled with high water holding capacities of the basalts derived soils the co-efficient of variability of streamflow within three catchments of the CPSF was substantially lower than those of other catchments in the Drakensberg Region. Nevertheless the variations in altitude in the Cathedral Peak Area together with the research by Schulze (1979) who noted that the CPSF has markedly higher frequencies of relatively high intensity rains for durations exceeding one hour compared with other stations in Kwazulu/Natal suggest that erosion potential of the hydrological system is high.

## 2.11. Erosion

Murgatroyd (1979) calculated geologically normal and accelerated soil erosion rates in Natal using the Upper Thukela Catchment as a research area and found that erosion was twenty eight times greater than the geologically normal rate of erosion. Smitten (1981), cited in Beckedahl et al (1988), identifies the Northern Natal region as having some of the highest erosion indices in South Africa (see Fig. 2. 3).

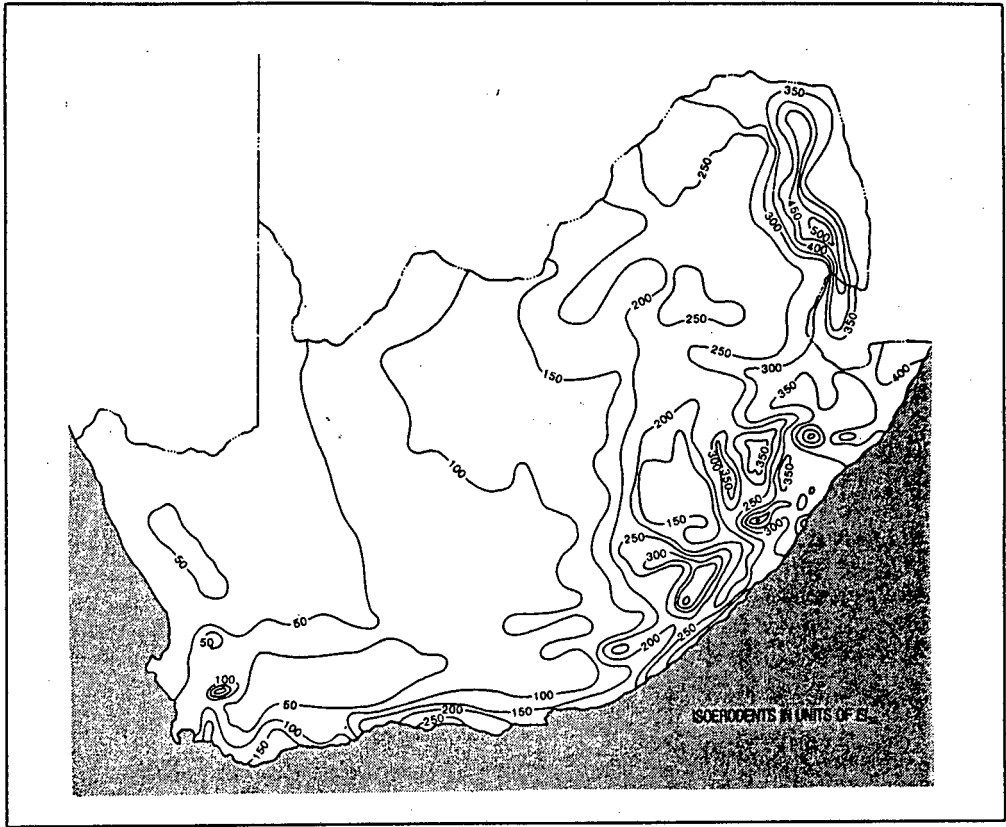


Figure 2.3: Erosion indices for Southern Africa (Smithen cited in Beckedahl et al, 1988)

In the Drakensberg, rainfall erosivity is extremely high because of two factors (Scott and Humphrey, 1985), viz. high absolute rainfall and the preponderance of high intensity storms. Scott and Humphrey (1985) point out that although nothing can be done about rainfall erosivity, its significance should be noted and management practices aimed at ameliorating its effects. The TJSB (1994) state that areas of the Drakensberg and surrounds are prone to erosion because of the strong correlation between erosion hazard to both slope and rainfall.

Due to the interaction of many factors, both biophysical and social, several types of erosion can be identified in the Cathedral Peak Area.

**2.11.1. Types of erosion**

Sheet erosion or sheetwash occurs when rain or overland flow of water removes soil particles (Barrow, 1991). Hogg (1982), cited in Beckedahl (1988), defines sheetwash as being the removal of easily transported material from the soil surface by runoff on a

relatively homogeneous surface. In the Cathedral Peak Area, sheetwash is the most common of the types of erosion and occurs mainly on surfaces with no vegetation cover.

Wild (1993) defines rill and gully erosion in the context of cultivation, stating that rill erosion occurs when channels are sufficiently shallow to be covered by cultivation, whereas gullies are defined as channels too deep to be covered by cultivation. Beckedahl et al (1988) add to the definitions of rill and gully the time concept, rills being temporary features whereas gullies tend to be more permanent features of the landscape. In the Cathedral Peak Area rills are also present but are localised in extent.

Gullies are more conspicuous than sheetwash and rills and in some cases are quite spectacular landscape features in Cathedral Peak Area and are concentrated along roads and footpaths (See Plates 2.5 and 2.6.) Thorrington-Smith (1953) noted that subterranean erosion was the main cause of donga (gully) erosion in the Drakensberg. He further pointed out that the deterioration and removal of vegetation through mismanagement had been the main cause of gully erosion. Beckedahl (1977) who researched subsurface erosion in the Drakensberg, found that the dispersion and suspension characteristics of the soil material, its grain size, the cohesion of the surface soil and the presence of a layer of highly permeable material, are critical in the development of piping. The high permeability of soils of the Drakensberg region (See section 2.8) suggest that piping is likely to be a feature of the Cathedral Peak Area

Beckedahl et al (1988), noted that the incidence of gully erosion is greatly increased along cattle tracks and footpaths. In the Cathedral Peak Area gully erosion is common along cattle tracks and footpaths.

Scott and Humphrey (1985) and Beckedahl (1993) state that many of the roads and paths in the Natal Drakensberg are the cause of accelerated soil erosion.

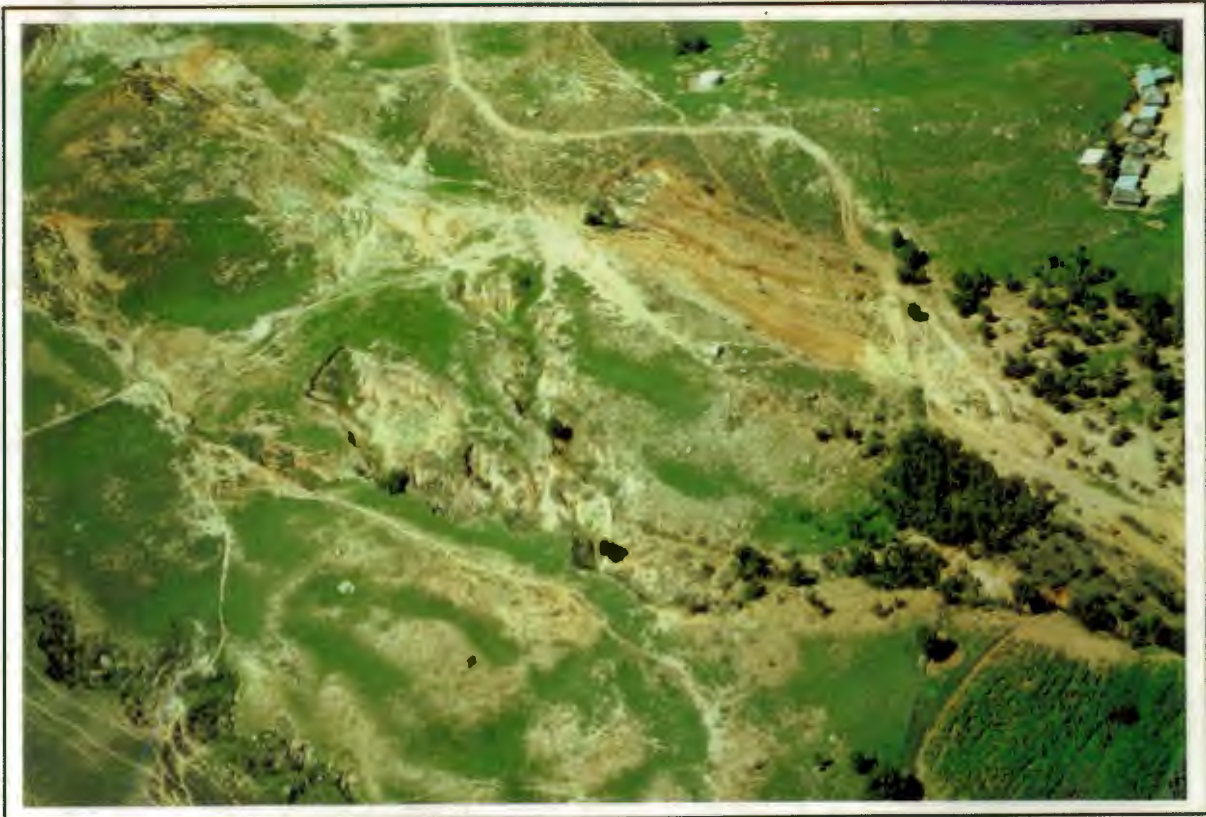


Plate 2.5: Sheet erosion, rills and gullies in the Cathedral Peak Area. Note the footpaths and roads in the upper right and middle of the plate.



Plate 2.6: Severe gully and rill erosion along footpaths. Also note the alien tree infestation in the vicinity of the eroded areas.

Garland's (1987) study of erosion risk from footpaths and vegetation burning within the Central Drakensberg Region noted two points. Firstly, that without remediation of affected areas, soil loss in the Drakensberg may well accelerate, even if land treatment causing initial erosion is halted and secondly, that increasing recreational pressure upon the Drakensberg will create demand for more facilities. He stated that unless facilities are carefully planned, sited and maintained, the number of erosion degraded sites will become steadily greater.

### **2.12. Conclusion**

The combination of the physical, historical and socio-economic factors together with land use that affect the Cathedral Peak Area is unique. These factors describe an area that has been in constant change since the early nineteenth century and is still very much in the process of changing. The interplay of these factors has led to a unique situation with respect to the broader environmental situation in general, and with respect to land degradation in particular.

In the following chapter the methodology adopted for use in this project and which includes air photo interpretation and photogrammetry is discussed in detail.

# Chapter 3

## Methodology

3.1. Introduction	39
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3.3. Methodology adapted for use in the project	45
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### 3.1. Introduction

The methodology adopted herein provides a tool in acquiring an understanding of the environmental situation that exists in the Cathedral Peak Area as a result of the changes that have occurred over the past half century. The methodology pertaining to this project is outlined in detail and discussed in this chapter.

The selection of the methodology for this project has been influenced by several factors viz. i) aims of the study (See section 1.4); ii) the available data sources and iii) the limited duration and financial constraints for completing this project.

A remote sensing medium, together with information accumulated during the Masters Group field trip to the Cathedral Peak Area, have provided the main data sources for this project. Numerous research reports of government departments, conservation organisations and individuals (discussed in Chapter Two) undertaken in the surrounding areas of the Natal Drakensberg Park provide additional sources of information for investigating environmental change and degradation in the Okhahlamba District using the Cathedral Peak Area as a case study.

Remote sensing is defined as the technique of obtaining information about objects through the analysis of data collected by special instruments that are not in physical contact with the objects of investigation (Avery and Berlin, 1992). Panchromatic aerial photography is one of the oldest and most commonly used varieties of remote sensing. A panchromatic aerial photograph is an ordinary black and white photograph of which the film has the same sensitivity as the human eye (de Montille, 1989). For the aims of this project (See section 1.4) panchromatic aerial photographs have been adopted for two reasons. Firstly, most areas in South Africa have aerial photographs that date back to the mid 1930's (Liebenberg et al, 1976). The availability of sequential aerial photographs since the mid 1930's facilitates comparative and historical studies thereby probably fulfilling the aim of recording environmental modifications, transformations and fluctuations in the Cathedral Peak Area. The second reason for using aerial photographs in this project is because they are a relatively cheap and easily accessible medium of remote sensing. In the following

section a review of the principles of airphoto interpretation is presented as a brief guide to the use of aerial photographs in this project.

### 3.2. Principles of airphoto interpretation and photogrammetry

Photographic interpretation is the act of examining photographic images for the purposes of identifying objects and judging their significance (American Society of Photogrammetry (ASOP), 1960). The interpreter of airphotos must know how to use scientific tools and methodology to arrive at objective findings, these in turn must often be supplemented with deductive reasoning (Avery and Berlin, 1992).

There are a two types of aerial photographs. Firstly, there is the oblique aerial photograph (refer to Plate 3.1 and Fig. 3.1) in which the camera's optical axis is tilted away from the vertical by an angular of more than  $20^{\circ}$ . For the purposes of this project, vertical aerial photographs, the second type of aerial photograph, has been employed. Vertical aerial photographs (Plate 3.2) are those taken with the camera's optical axis orientated in a vertical or nearly vertical angle to the local ground surface (Fig. 3.1) (approximately  $90^{\circ}$  with an error margin of between  $0^{\circ}$  and  $3^{\circ}$ ).

ASOP, (1960) and Avery and Berlin, (1992) identify a number of characteristics of what are referred to as "recognition elements" in airphoto interpretation that aid the interpreter in identifying various aspects on aerial photographs. These characteristics include aspects such as shape, size, pattern, shadow, tone or colour, texture, association or site. In this study, the main aspects that have been used to identify categories are shape, size, pattern and tone. The exact identification details that are used to map various categories for this project are discussed in section 3.3.

Spurr (1960) defines photogrammetry as the science or art of obtaining reliable measurements by means of photography. There are a number of photogrammetric factors that have to be considered in analysing aerial photographs. Firstly the scale of aerial



Plate 3.1: Oblique airphoto showing the park/community boundary in the Cathedral Peak Area



Plate 3.2: Vertical aerial photograph showing areas of the Okhahlamba District. Note the tone and shape recognition elements of the subsistence cultivated areas, Scale is 1 : 50000.

photographs may be different. In the case of this project all the aerial photographs were of a varying scale (refer to Table 3.1). When purchasing vertical aerial photographs for this project, the author requested the Aerial Photographs and Map Section at the Department of Land Affairs to magnify the scale of the 1964 and 1992 aerial photographs to match the scale of the 1945 set. The adjustment of the 1964 and 1992 aerial photographs to a similar scale to that of the 1945 aerial photograph set enabled direct comparison between the various time sequences without the setting up a of scale adjusted grid framework to make the necessary adjustments.

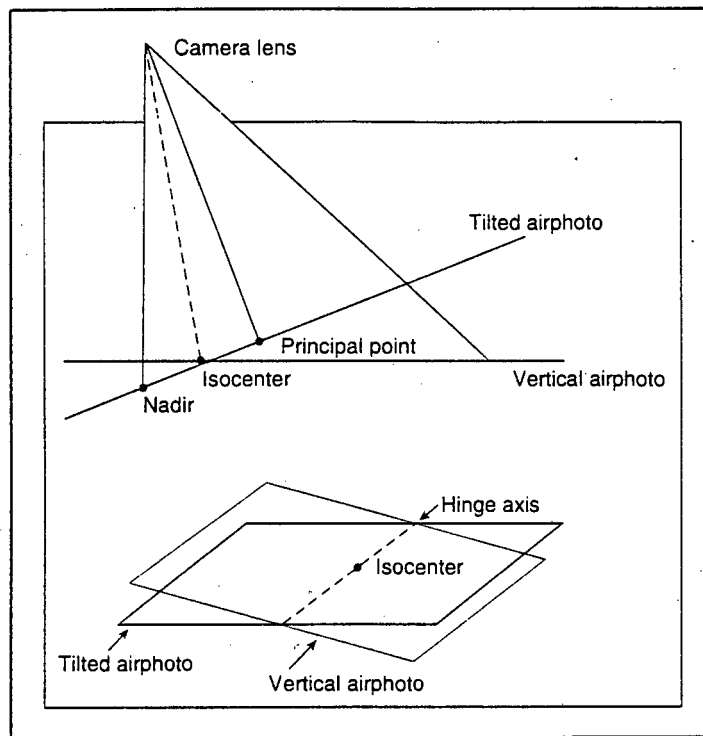


Figure 3.1: Generalised diagram showing features of oblique aerial photo and photographic tilt or tilt distortion. (from Avery and Berlin, 1992)

According to Barnes (1982) and Avery and Berlin (1992) other factors that have to be considered when working with aerial photographs include height distortion, tilt distortion and paper distortion.

Height distortion or image displacement is caused by variations in ground relief. In the case of the Cathedral Peak Area, which is situated in the foothills of the Drakensberg,

ground relief is a major factor due to the vast changes in topography over short distances. The effect of ground relief can best be checked by viewing two homesteads one situated in a valley bottom and the other located on or near the top of a hill. On the aerial photo the object on the hill will appear larger than the homestead in the valley bottom (See Fig. 3.2) owing to their difference in elevation. This is an expected result of aerial photography as the higher point is closer to the camera.

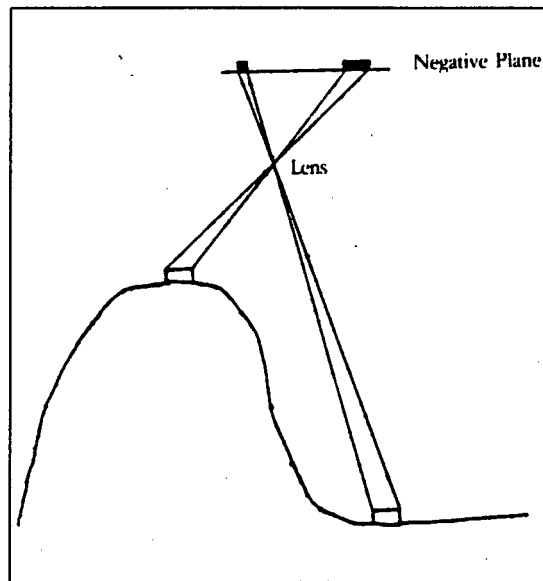


Figure 3.2: Effect of height distortion on aerial photographs (from Barnes, 1982)

Tilt distortion or displacement occurs when the camera is tilted, causing pictured objects to be displaced by a small amount from the positions that they would occupy (See Fig. 3.1) in a precise aerial photograph. Avery and Berlin (1992) state that the presence of small amounts of tilt often go undetected in aerial photos. Attempting to solve the tilt distortion is a tedious task (Avery and Berlin, 1992). Usually tilt angles of  $2^{\circ}$  to  $3^{\circ}$  can be ignored without serious consequences to calculations. Barnes (1982) states that if contact prints are stretched or distorted in any way, measurement on it will be erroneous. In scaling the aerial photographs used in this study to a common scale of 1 : 22000, there have been some distortions. The 1964 and 1992 aerial photographs are single airphotos of the Cathedral Peak Area, hence distortions on them have been kept to a minimum of between 5 % and 10 %. However in the case of the 1945 aerial photographs, a mosaic of six aerial photographs had to be set together. Due to the distortion of each photograph of the

1945 set, the error is the greatest on this set and varies up to 30 % (GIS Lab., Surveyor Generals Office, pers comm).

There have been several methods developed to overcome these photogrammetric errors and the problems arising from them so as to ensure that research results are as accurate as possible. In this research project, two systems of corrections and calculations that relate to studies on land degradation are reviewed and discussed.

Schwabe and Martin (1992) used the Photographic Analytic Digitising System (PADS) to incorporate aerial photograph results in their study of the rate and extent of deforestation and denudation. This was a relatively new system offered by the Aircraft Operating Company which was specifically designed to digitize distortion-free map data directly from aerial photographs. However it was not used in this project as it is a computer based system with time specifications and would have not been feasible with the time and financial constraints imposed by the requirements of this Masters course project date specifications.

Single Photo Aerial Mapping (SPAM) was developed by Barnes (1982) to map and monitor features of land use, ecological and other related studies and was used by Thwaites (1986), Watson (1990,1995 - in press) and Garland and Broderick(1992) in historical studies of soil erosion. SPAM is a programme which corrects systematic measurement errors attributable to camera characteristics as well as tilt and relief distortion inherent in single air photos, and therefore facilitates accurate measurements of distance and area. However similar to the PADS system, the SPAM system was precluded in this project by virtue of its requirement for the use of a desk top computer system with a digitiser and plotting table and time to familiarise with the system.

Without using these systems in the study, the error margin has been limited between 5 % to 10 % for the 1964 and 1992 aerial photographs, whereas with the 1945 set, a larger margin of error, up to 30 % could be expected (GIS Lab, Surveyor Generals Office, pers comm).

### 3.3. Methodology adapted for use in the project

Three sets of aerial photographs were used as part of the study. The details of aerial photographs employed in the study are shown in Table 3.1. The photographs taken in the years 1945 and 1992 respectively were chosen as the earliest and most recent editions available for the Cathedral Peak Area. The aerial photograph taken in 1964, was chosen as a time interval intermediate to the initially identified aerial photograph dates.

Job Number	Scale	Year	Month	Supplier
79	1:22000	1945	April/May	Aerial Photograph and Map Section Department of Land Affairs Mowbray, Cape Town
488W	1:22000*	1964	June	
965	1:22000*	1992	July 15	

Table 3.1: Details of aerial photographs used in this study (\*<sup>1</sup>)

Data collected by any remote sensing method must be analyzed by interpretive and quantitative techniques in order to provide useful information about any subjects of investigation.

The method applied to identify environmental changes in the eMhlwazini Ward and surrounds used in this study involved identifying various categories of environmental features that could be observed and, therefore, mapped. The various categories were identified using different recognition elements such as shape, size, pattern, shadow, tone or colour, texture, association or site. The following categories appear over the forty seven year time span of the aerial photographs and have been identified as parameters indicative of environmental changes and land degradation:

1. Homestead population:
2. Cultivation
3. Forests
4. Eroded surfaces
5. Gullies

<sup>1</sup> \* Aerial photographs for the years 1964 and 1992 have been increased to a 1:22000 scale by the Directorate of Survey from 1:41000 and 1:50000 scales respectively.

The main recognition elements used in this study are shape, size, pattern and tone of the various categories that appear. All these recognition elements apply to aerial photographs used in this study.

A homestead is defined in the study as being a number of homes and/or traditional huts clustered together on the same piece of land to form a single stand of buildings, see Plate 3.1. for an oblique view and visual concept of a homestead. Homesteads were identified mainly by the roughly circular to ellipsoidal shapes that they portray, although tone of the land also help in the differentiation of homesteads from individual trees. The tone of land around homesteads compared to individual trees is usually lighter due to the clearance of vegetation around homesteads by the local community people.

Cultivation in the Cathedral Peak Area was identified mainly by pattern and shape. Cultivated fields usually display an interlocking mosaic of roughly rectangular shapes (See Plate 3.2). The identification of cultivated areas was aided by the fact that the aerial photographs were taken during the winter months when little is grown in the Cathedral Peak Area. Maize was found to be the main crop grown in the Cathedral Peak Area (Masters Group, Vol. 2, 1995) and it can be reasonably assumed that by the time that the aerial photographs were taken, the growing and harvesting stages of the season was over.

Forests were identified mainly by the tones that they display on the aerial photographs. In certain cases indigenous forests could be differentiated from introduced alien plantations by the latter group having regular patterns. Within the 1992 aerial photograph identification of forests was more difficult than the 1945 and 1964 aerial photographs as a result of many burnt patches which displayed similar tones to forests. Particular forests that occur in the 1992 aerial photographs were confirmed as being alien or indigenous by Masters Group field trip to the Cathedral Peak Area and by personal communications with individuals and organisations in the Cathedral Peak Area. Forests on the 1945 and 1964 aerial photographs were distinguished by the shape of the forest plantations and by the general rule that indigenous montane vegetation had occurred on moist south facing slopes as well as by personal communications.

Eroded surfaces and areas included land affected by sheetwash, but smaller rills, terracettes or small slumps could not be recognised with any degree of confidence. Areas devoid of vegetation or with poor vegetation cover has been included into this category. Eroded areas was identified mainly by tonal differences on the aerial photographs.

Photographic scale was suitable for the identification of gullies approximately 5 meters and greater in size. Gullies were identified by shape and tone. Active gullies usually show steep unvegetated banks with slumping such that the channel walls often display very light tones on the photograph (Thwaites, 1986). Streambank erosion can be recognised by similar criteria to gullies and has been included into the section of gullies.

The mapping of these categories was based as close as possible upon the principles of photogrammetry (refer to Section 3.2). For the purposes of this project it would have been ideal to map the identified categories by computer using a GIS system, however the time constraints for this project have precluded the use of any type of computer based system. Consequently the mapping of the various identified categories was completed manually.

The method used for calculations of area is adapted from Spurr (1960), Paine (1981), de Montille (1989) and Avery and Berlin (1992) and is discussed in further detail below. Each category was traced onto firm transparent plastic sheets (Appendix 2a), by using fine tipped permanent markers. Categories 1,2 and 3 were mapped on A4 size plastic transparencies so as to allow for comparative analysis with information collected by the Masters Group (1995). Categories 4 and 5 were mapped on A3 sized plastic transparencies to allow for a more representative calculation of erosion in the Cathedral Peak Area. This method differed slightly from Spurr (1960), Paine (1981), de Montille (1989) and Avery and Berlin (1992) method in that a three phased approach was adopted compared to just measuring directly off the aerial photographs or by just tracing outlines onto a tracing paper. By using transparent plastic, the difficulty of lifting partially transparent tracing paper with every trace was avoided. This also allows for increased accuracy in tracing areas of the aerial photographs.

The categories of homesteads, agriculture and forestry were mapped only for the eMhlwazini Ward in the community section of the Cathedral Peak Area and for a small portion of the Park and private lands (See Fig. 1.2 and 4.2). The reason for limiting these categories to the eMhlwazini Ward relates to the Master's Group approach in limiting their field work and research mainly to the eMhlwazini Ward and sections of Cathedral Peak Park (See Masters Group, Vol. 2, Section 3.2.1). An ideal for this project would have been to identify the categories before going to the Cathedral Peak Area, although this was not to be the case. The study has been limited in extent to the Cathedral Peak Area in order to allow for verification of details such as types of forests, erosion etc. with results from the Masters Group (1995) research as well as by personal communication with contacts of individuals and organisations set up in Kwazulu/Natal during the Masters Group research.

For the categories of erosion and gullies, the study area was extended to include an additional two wards viz. Magangangozi and Ngobas.

After homesteads were drawn, tallying of the numbers of homesteads for the respective years of the aerial photographs was undertaken.

Following the mapping of categories 2, 3 and 4 onto transparent plastic, the area boundaries were redrawn onto appropriately sized see through tracing paper (Appendix 2b) for the different categories. Retracing was done to enable a 2 mm grid-blocked sheet (Appendix 2c) of A4 graph paper to be placed below the tracing paper in order to facilitate the calculations of area of the various categories. Areas for the various categories were calculated by counting and totaling the number of 2 mm blocks that occur within a single traced category. Spurr (1960), Paine (1981), de Montille (1989) and Avery and Berlin (1992) suggest a similar method as the one used in this study to calculate area and call it a dot grid calculation. Their approach involves using a transparent overlay with dots uniformly spaced on imaginary squares to calculate area.

After gullies were mapped, their total length was measured using a mile-o-graph<sup>2</sup> or pantometer. Thereafter the total area affected by gullies was calculated by the same method used for calculation of area described for categories 2, 3 and 4. By calculating total length of gullies and streambank erosion together with the area drained by gullies, the drainage density could be calculated by dividing the total length (km) of gullies and streambank erosion by the total area (km<sup>2</sup>). Drainage density is an indication of rainfall and infiltration capacity (Paine, 1981).

Mapping and calculating aspects of the various categories for the years chosen in this study, assisted the quantification and interpretation of environmental changes and degradation that has occurred in the Cathedral Peak Area.

### **3.4. Problems with methodology employed in the study**

The problems associated with distortions, have been discussed under section 3.2. The study has been conducted using aerial photographs. However due to time constraints, computer based mapping was precluded. Without using these systems in the study, the error margin has been limited between 5 % to 10 % for the 1964 and 1992 aerial photographs, whereas with the 1945 set, a larger margin of error, up to 30 % could be expected (GIS Lab, Surveyor Generals Office, pers comm).

Given time, a larger area encompassing larger tracts of the Okhahlamba District and more aerial photographs could have been used to estimate the changes in land degradation. A greater duration of time would allow for more parameters to be included into the survey, better ground verification and inclusion of more data.

Any future study of land degradation in the Okhahlamba District should at least include a computer generated survey to limit or compensate for errors in methodology and should include a minimum time interval to allow for the inclusion of a computer based system.

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<sup>2</sup> Pen like instrument with various scale measurements and a rotating wheel that allows for the calculation of distance and length of objects or features on maps and aerial photographs.

### 3.5. Conclusion

It is clear that any study using aerial photographs is time consuming. Given the time constraints of this project, the use of a GIS computer based systems for calculating environmental changes which Walsh (1988) in Watson (1990) asserts is the best technique, has been precluded. In undertaking this study, the principles of airphoto interpretation and photogrammetry have been used in order to attempt completing a proper study, given the various limitations and assumptions of this project.

Garland and Broderick (1992) note that air photo interpretation is a tried and a tested method for erosion survey. They further mention that the reliability of the results although subject to photographic; scale and quality; the ability and experience of the interpreter and the density of vegetation cover, has been shown to be very good.

In the ensuing chapter i.e. Chapter Four, the results obtained by the methodology employed in this study are recorded.

# Chapter 4

## Results

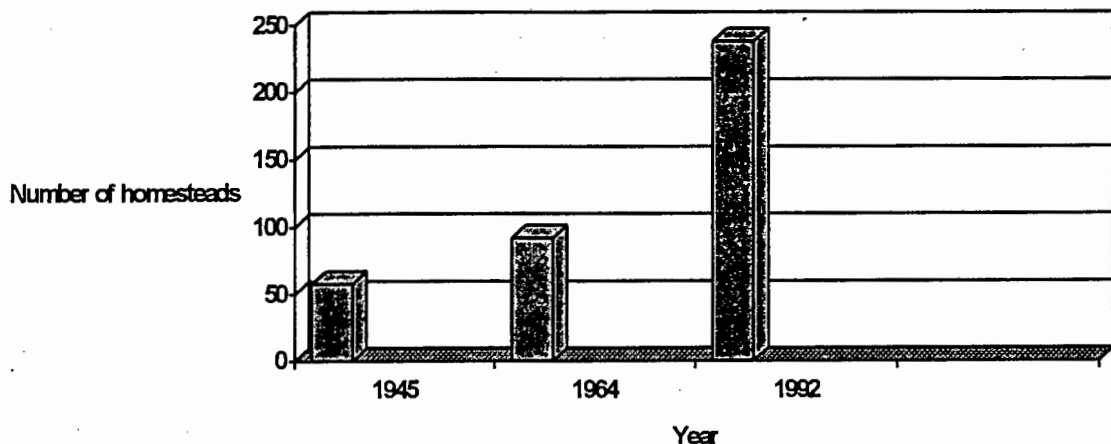
4.1. Homestead population	51
4.2. Cultivation	55
4.3. Forestry	59
4.4. Eroded surfaces	60
4.5. Gullies and drainage density	64

The results of this study are presented according to the categories that have been identified in Chapter Three, homesteads, forests, cultivation, eroded surfaces/areas and gullies. Each category is presented in relation to a specific geographical area e.g. eMhlwazini Ward, Cathedral Peak Area or the surrounding community land. The details of each category researched are outlined under the respective headings.

### 4.1. Homestead population

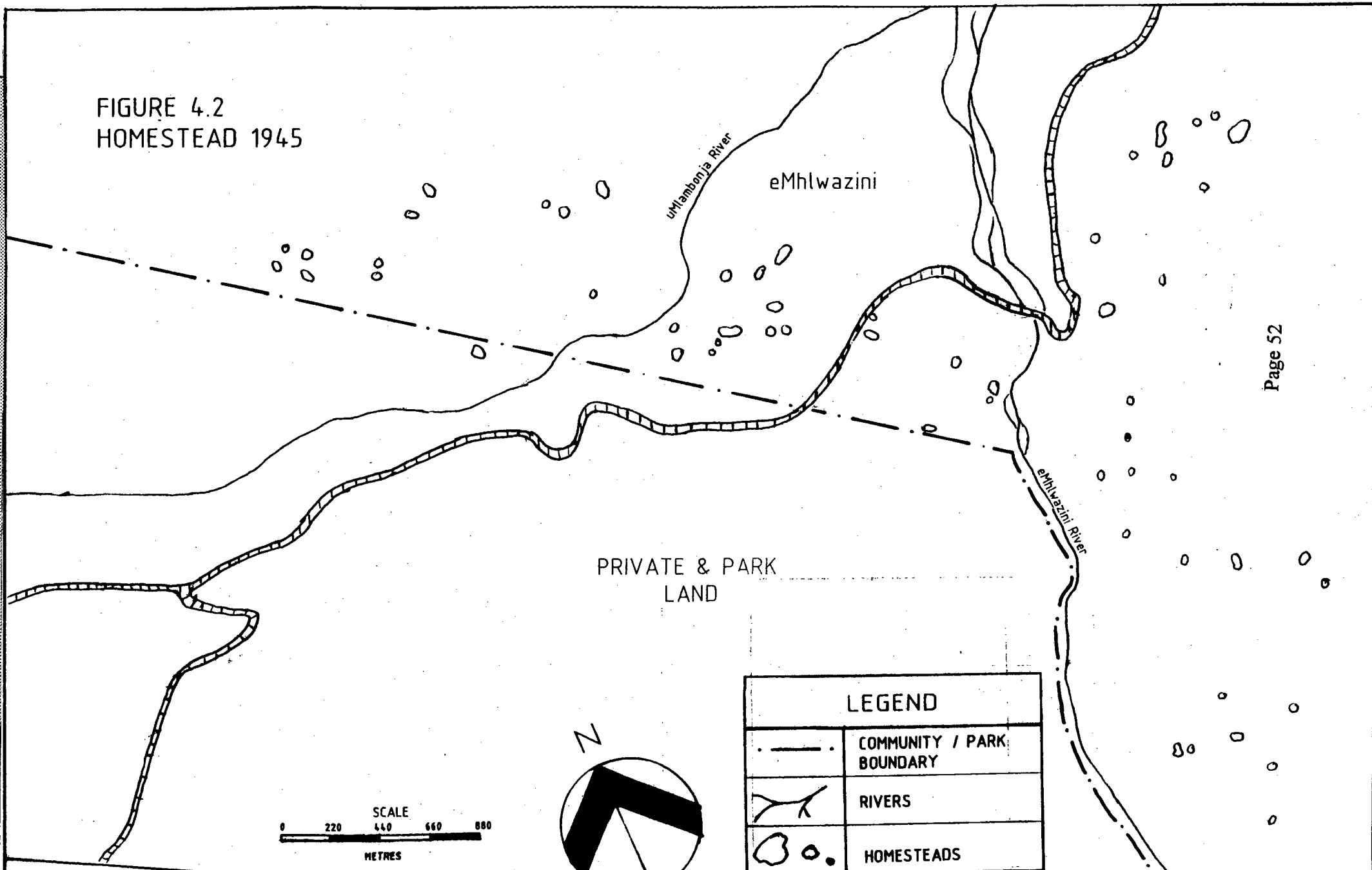
The change in the number of homesteads in the eMhlwazini Ward has been dramatic over the forty seven year interval chosen for this study. The enumerations of homesteads in the ward for the chosen aerial photographs are shown in Fig. 4.1. The mapped areas of homesteads are shown in Fig. 4.2.

**Figure 4.1: Change in the Number of Homesteads between 1945 - 1992 in the eMhlwazini Ward**

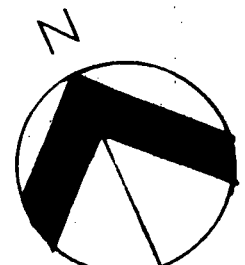


Using the year 1945 as a baseline for calculations of change, the following results have been obtained. Between 1945 and 1964, 38 new homesteads were founded. This represented a 59% increase over nineteen years. During the years 1964 and 1992, the population of homesteads increased from 92 to 263 representing a 186% increase. Between 1945 and 1992 there was an overall 354% increase in the number of homesteads within the

FIGURE 4.2  
HOMESTEAD 1945

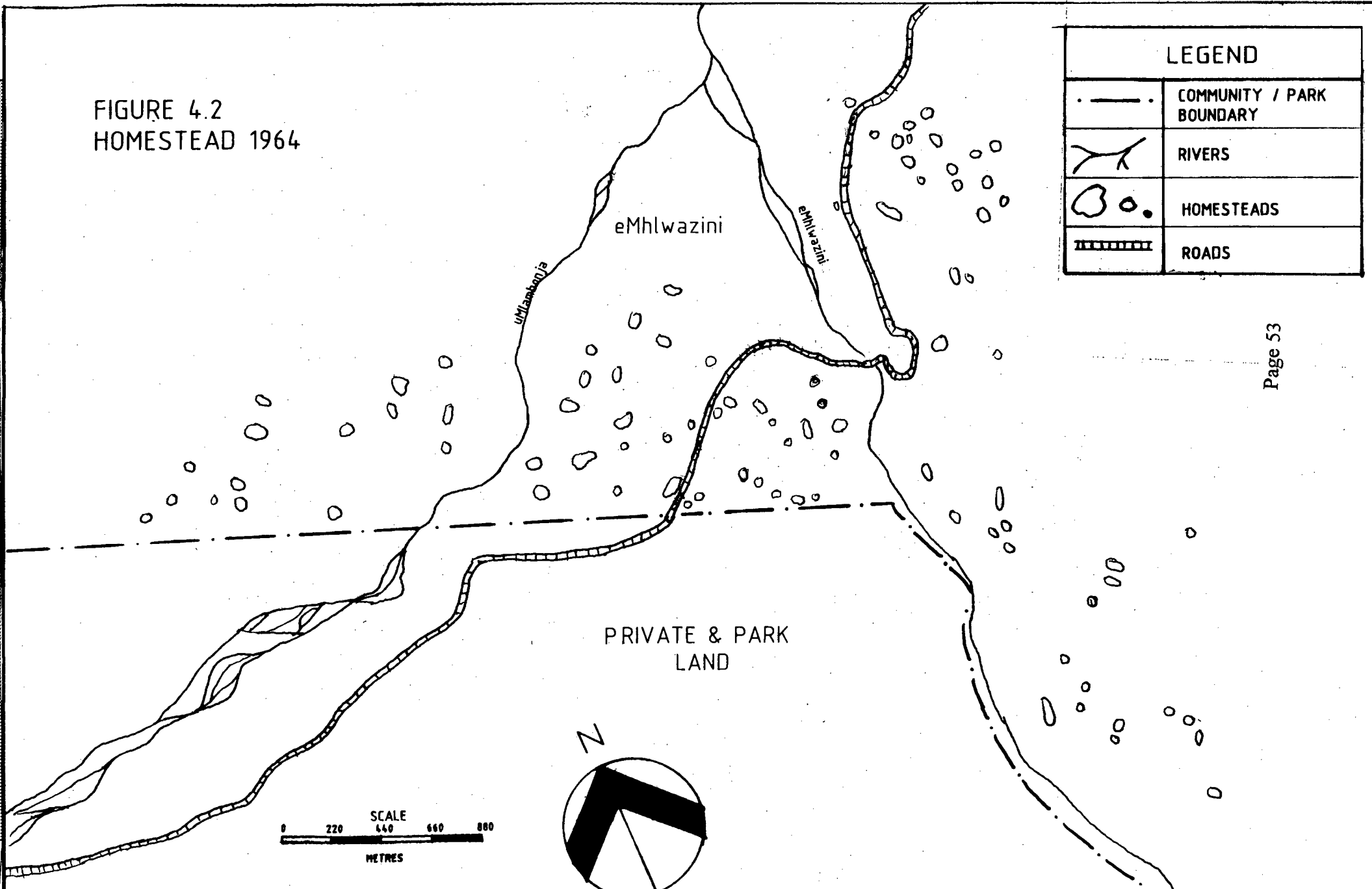


PRIVATE & PARK  
LAND



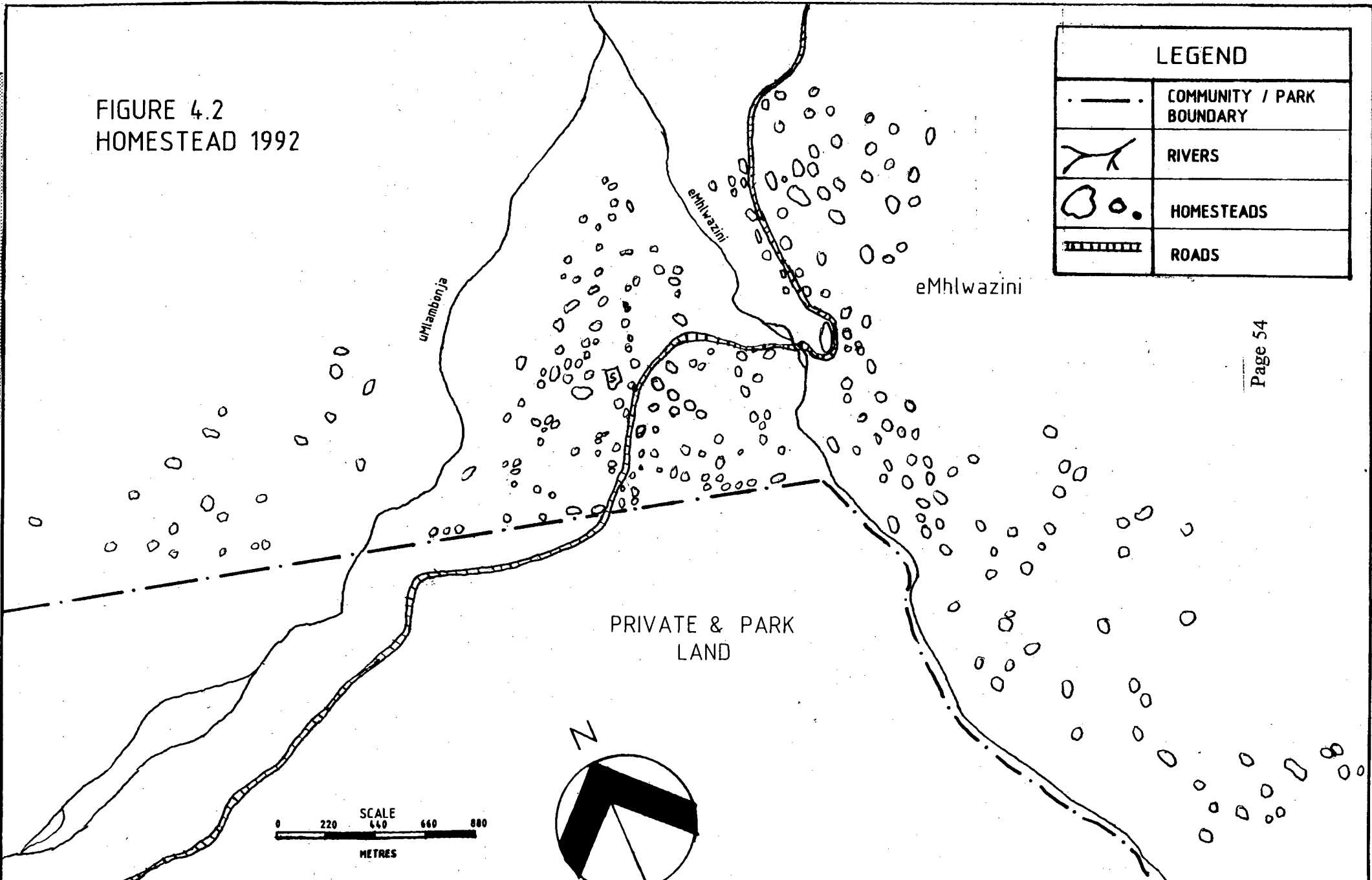
LEGEND	
— · — ·	COMMUNITY / PARK BOUNDARY
~	RIVERS
○	HOMESTEADS

FIGURE 4.2  
HOMESTEAD 1964



LEGEND	
---	COMMUNITY / PARK BOUNDARY
~	RIVERS
○	HOMESTEADS
	ROADS

FIGURE 4.2  
HOMESTEAD 1992



eMhlwazini Ward. The homestead category is not applicable to the park and private land areas.

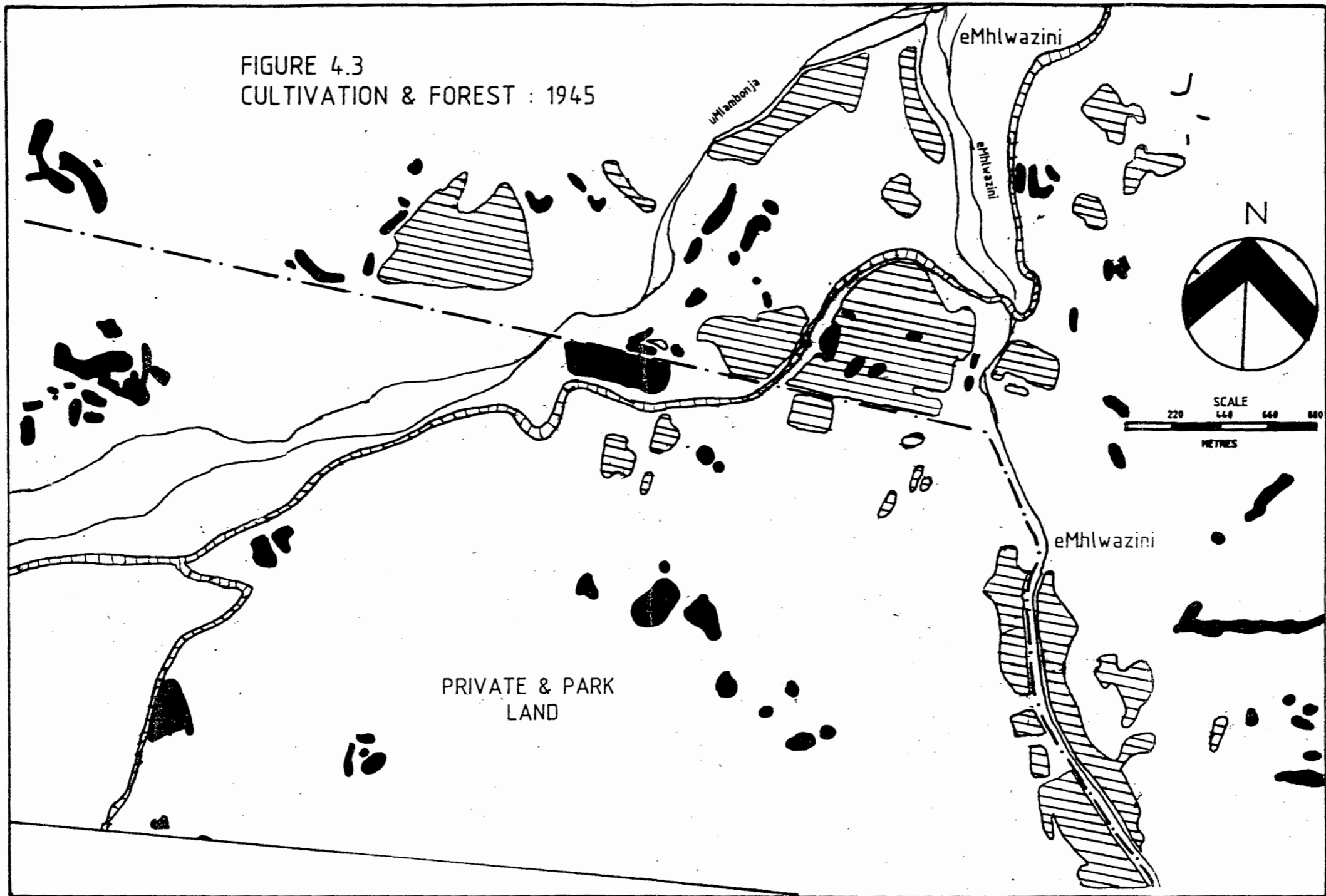
## 4.2. Cultivation

The section on cultivation is divided into two land ownership categories viz. i) park and private land and ii) the eMhlwazini Ward. This is a smaller portion of area than that defined for the Cathedral Peak Area in Chapters One and Two, but reference is still made to both the park and private land and the eMhlwazini Ward as being the Cathedral Peak Area. This definition and extent of the Cathedral Peak Area, should be retained for this section of cultivation as well as for the subsequent discussion on forested area in section 4.3.

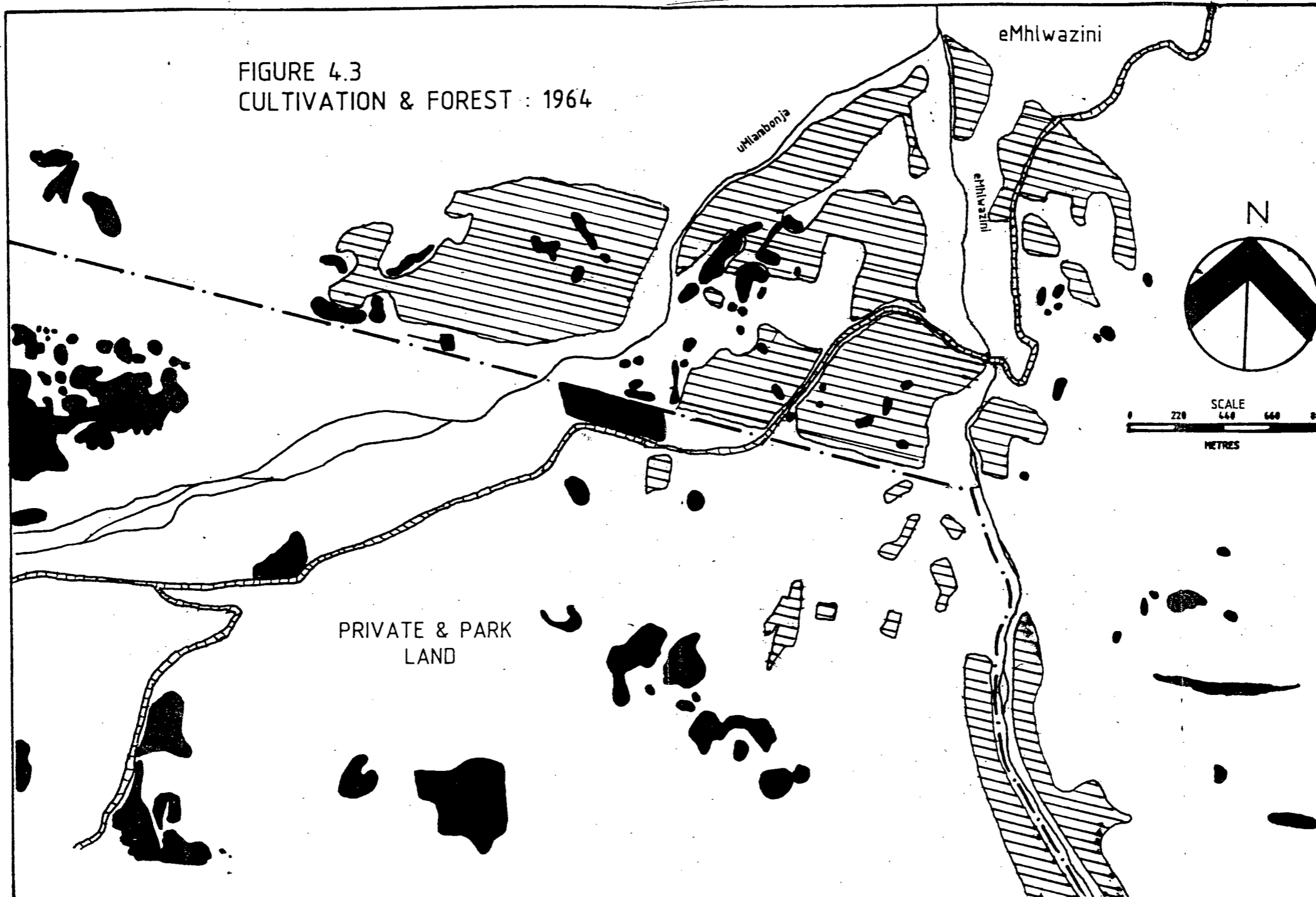
The cultivation changes that have occurred during the time span of the study are shown in Table 4.1. and the mapped changes for the respective years are shown in Fig. 4.3. Between 1945 - 1964 cultivation in the Cathedral Peak Area increased from 1.62km<sup>2</sup> to 2.39km<sup>2</sup> representing a 18 % increase. Later, between the years 1964 and 1992, cultivated areas increased by 50 % from 2.39km<sup>2</sup> to 3.58km<sup>2</sup>. In its entirety, cultivated lands increased by 121 % in the Cathedral Peak Area.

Year	Park and Private Land		eMhlwazini Ward		Total	
	Area (km <sup>2</sup> )	% Change	Area (km <sup>2</sup> )	% Change	Area (km <sup>2</sup> )	% Change
1945	0.37		1.25		1.62	
1964	0.30	- 19	2.09	+ 67	2.39	+ 48
1992	0	-100	3.58	+ 71	3.58	+ 50
1945 - 1992		-100		+ 186		+ 121

Table 4.1: Changes in the area ( in square kilometres) of cultivation for private, park and community land.



LEGEND	
	COMMUNITY / PARK BOUNDARY
	RIVERS
	FORESTS
	CULTIVATED AREAS
	ROADS



LEGEND	
— · — ·	COMMUNITY / PARK BOUNDARY
~ ~ ~	RIVERS
■	FORESTS
▨	CULTIVATED AREAS
====	ROADS

The overall increase in cultivated area for the Cathedral Peak Area is misleading as there are two distinct trends, one for the park and private land and the other the eMhlwazini Ward. There has been a 19 % decrease in cultivated area within park and private lands between 1944 and 1964 followed by a 100% decrease in cultivation from 0.30km<sup>2</sup> to 0km<sup>2</sup> during the subsequent years 1964 to 1992.

Within the eMhlwazini community land, on the other hand, there has been a constant increase in the area of cultivated land. The time span between 1945 to 1964 shows a 67 % increase in cultivated area, whereas the time interval between 1964 and 1992 shows a further 71 % increase in cultivated area. Overall, between the 1945 and 1992 there has been a general increase of 186 % in cultivated areas in the eMhlwazini ward, from 1.25km<sup>2</sup> to 3.58km<sup>2</sup>.

### 4.3. Forestry

The changes in the extent of forestry are categorised in the same fashion as cultivation, viz. private and park land are considered separately from eMhlwazini community land, see Table 4.2 for a breakdown of the changes in the area of forestry over the study period. Fig. 4.3 displays a visual assessment of the change in forestry patterns over this time span.

Year	Park and Private Lands		eMhlwazini Ward		Total	
	Area(km <sup>2</sup> )	% Change	Area(km <sup>2</sup> )	% Change	Area(km <sup>2</sup> )	% Change
1945	0.35		0.31		0.66	
1964	0.84	+ 140	0.34	+ 10	1.18	+ 79
1992	0.67	- 20	0.49	+ 44	1.16	- 2
1945 -1992		+ 91		+ 58		+ 76

Table 4.2: Changes in the extent of forests between 1945 and 1992 for the park and private lands as well as the eMhlwazini Ward.

There has been a 79 % increase in the forested area in the Cathedral Peak Area between the years 1945 and 1964, followed by a 2 % decrease during the ensuing years of 1964 to 1992. Collectively, in the 47 year time interval between 1945 to 1992, forested areas in the Cathedral Peak Area increased by 76 % from 0.66km<sup>2</sup> to 116km<sup>2</sup>.

On park and private lands, during the years 1945 to 1964, there has been a 140 % increase in forest area. Subsequently during the years 1964 to 1992 there was a 20 % decrease in forest areas, from 2.77km<sup>2</sup> to 2.21km<sup>2</sup>. The overall increase in forested areas over the 47 year time span has amounted to 91%.

In the surrounding eMhlwazini Ward, the situation is somewhat different to that of park and private lands. There has been a 10 % increase in forested area within the years 1945 to 1964, whereas the time interval between 1964 and 1992 shows a 44 % increase in the forested areas of the ward, overall this represents an increase in forested areas of 58 % in the community lands of the eMhlwazini Ward.

#### 4.4. Eroded surfaces

Table 4.3. shows that the change in the extent of eroded area in the Cathedral Peak Area has been sub-divided according to park and private lands as one unit and the erosion in the community areas as a second and separate unit. Eroded areas are mapped in Fig 4.4. In total, erosion surfaces in the Cathedral Peak Area has shown a decrease of 16 % from 1945 to 1992. This figure is somewhat simplistic, as eroded surfaces between the years 1945 and 1964 increased from 0.45km<sup>2</sup> to 0.73km<sup>2</sup> representing a 62 % increase of eroded area. Between 1964 and 1992 eroded surfaces decreased by 48 % from 0.73km<sup>2</sup> to 0.38km<sup>2</sup>.

Between the years 1945 and 1964, erosion within park and private areas decreased by approximately 11 % from 0.18km<sup>2</sup> to 16km<sup>2</sup>. The time interval from 1964 to 1992 shows a decrease from 0.16km<sup>2</sup> to 0.3km<sup>2</sup>. This represents a 81 % decrease in eroded areas. The overall erosion for the 47 year time interval shows a decrease from 0.18km<sup>2</sup> to 0.3km<sup>2</sup>

FIGURE 4.4  
ERODED AREAS : 1945

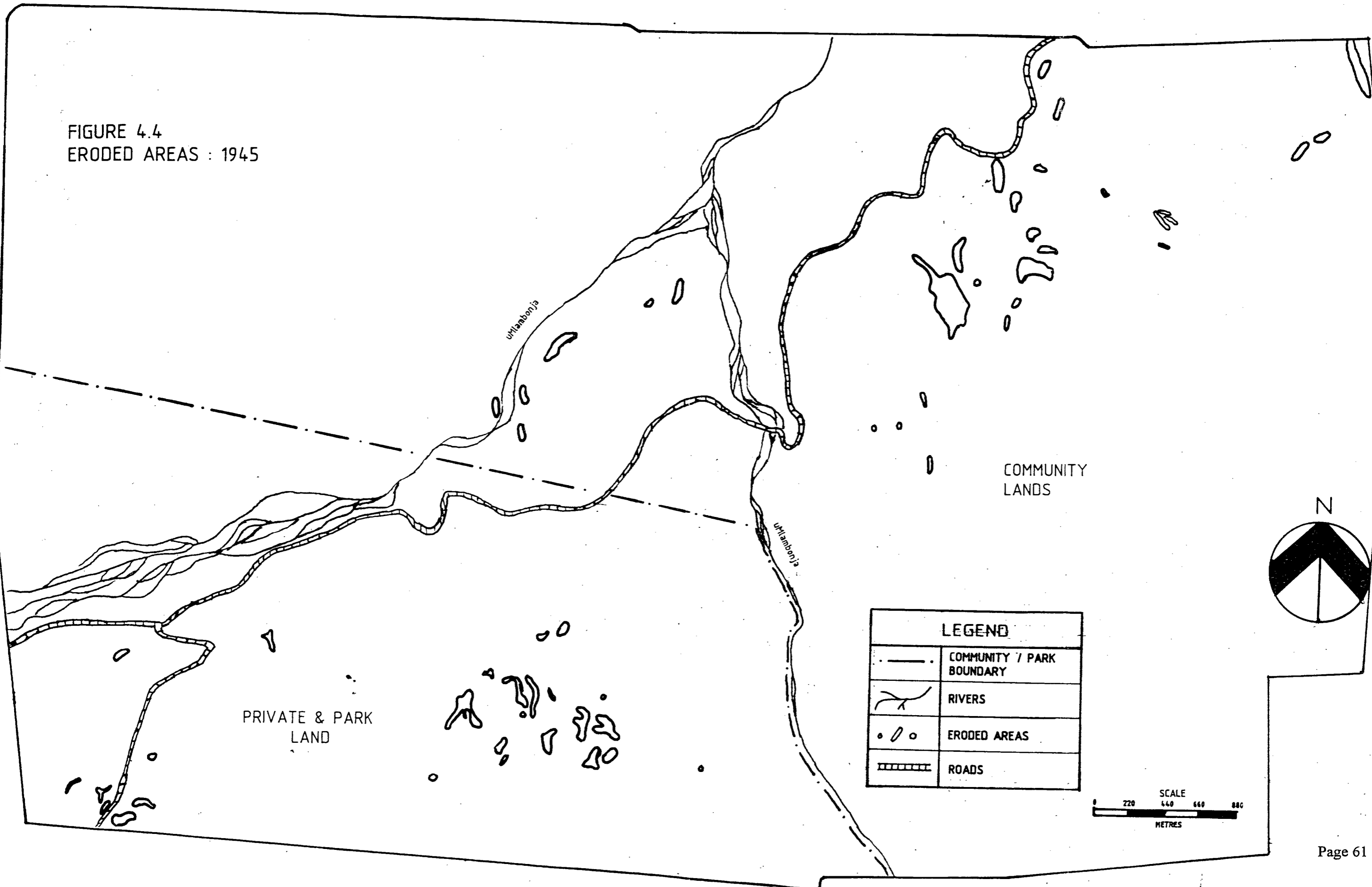
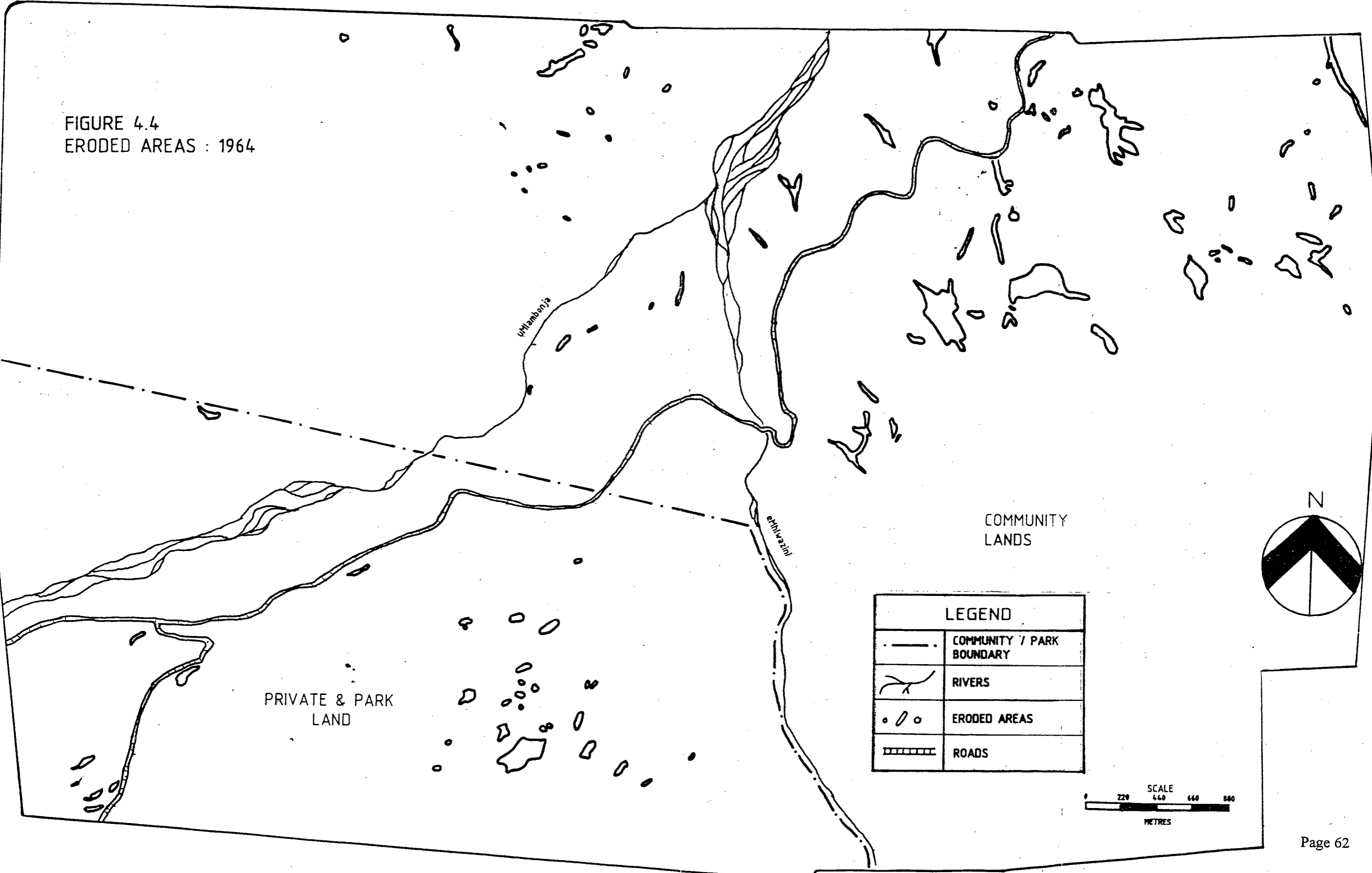


FIGURE 4.4  
ERODED AREAS : 1964



LEGEND	
---	COMMUNITY / PARK BOUNDARY
~~~~~	RIVERS
o / o	ERODED AREAS
	ROADS

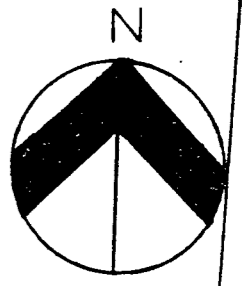
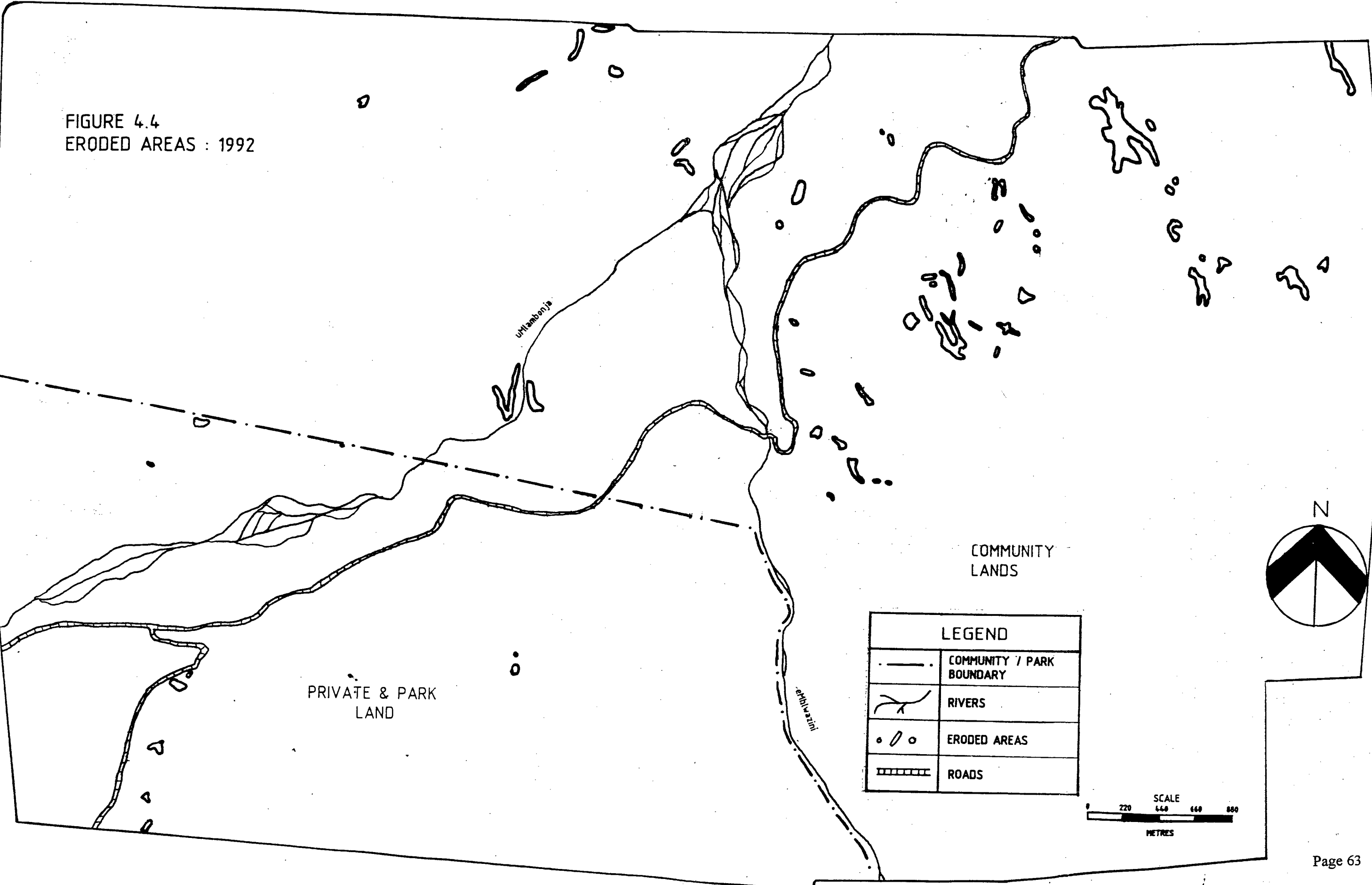
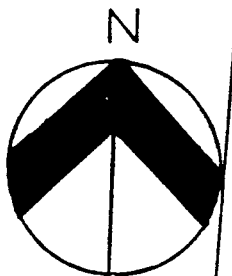


FIGURE 4.4  
ERODED AREAS : 1992



LEGEND	
---	COMMUNITY / PARK BOUNDARY
~	RIVERS
o / o	ERODED AREAS
	ROADS

SCALE  
0 220 440 660 880  
METRES



representing a 83 % decrease in the eroded surface areas within private and park owned land.

Year	Park and Private Land		Community Land		Total	
	Area(km <sup>2</sup> )	% Change	Area(km <sup>2</sup> )	% Change	Area(km <sup>2</sup> )	% Change
1945	0.18		0.27		0.45	
1964	0.16	- 11	0.57	111	0.73	+ 62
1992	0.3	- 81	0.35	- 39	0.38	- 48
1945 - 1992		- 83		30		- 16

Table 4.3: Changes in the extent of erosion over the 47 year time span of the study

In contrast, within the surrounding community areas, eroded areas show a 111 % increase between the 1945 to 1964 time interval. From 1964 to 1992, there is an 39 % decrease in the eroded areas of the eMhlabuzini Ward and surroundings. Overall, between for the years 1945 and 1992, erosion within the study area has increased by 30 %.

#### 4.5. Gullies and drainage density

Gully mapping and evaluation has been undertaken as one group for the entire Cathedral Peak Area. Streambank erosion has also been added to the section of gullies hence representing total gullies and streams. Table 4.4 and Fig. 4.5 show the drainage density and the mapped gullies respectively.

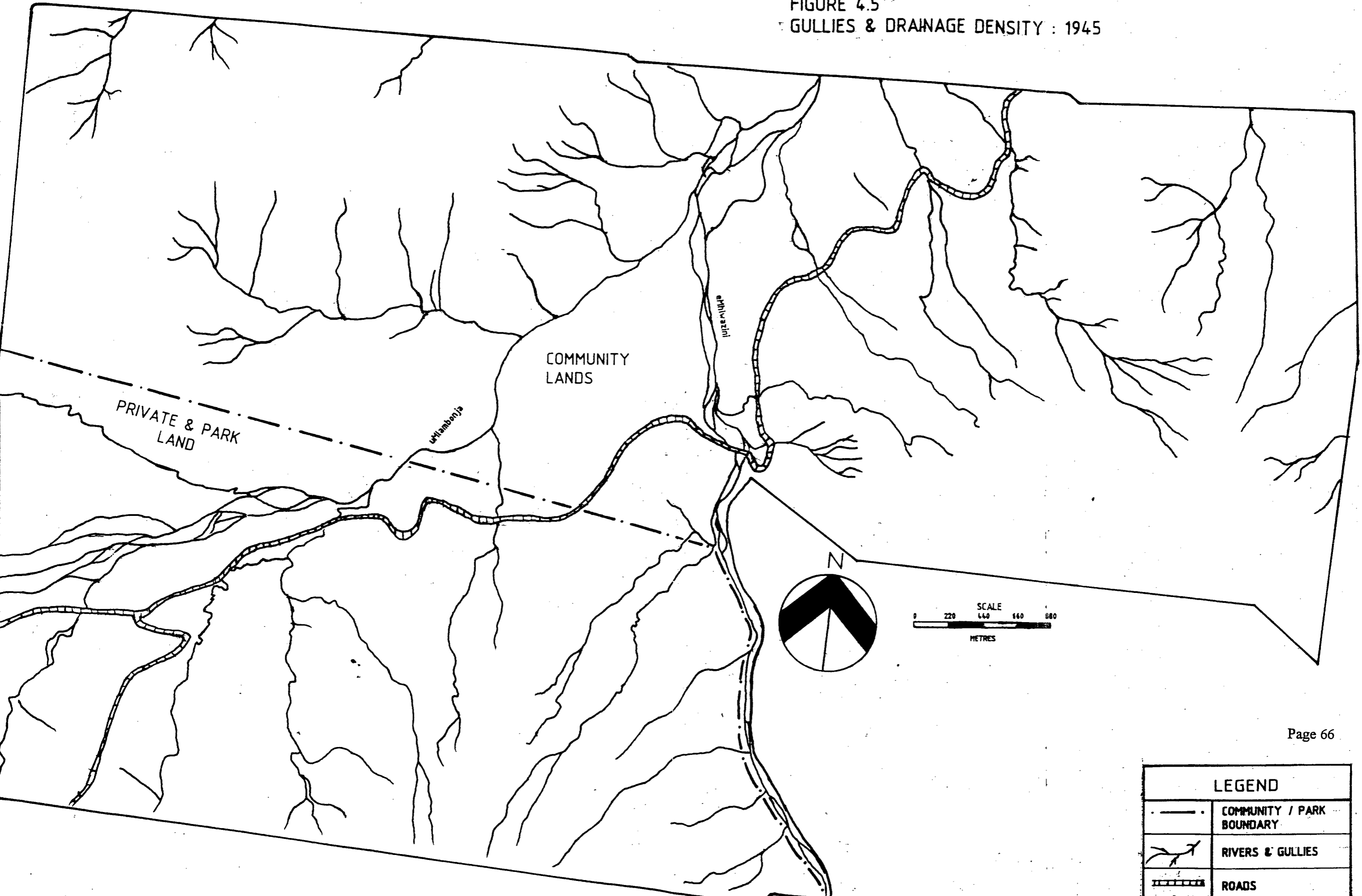
Year	Drainage density (km\km <sup>2</sup> )	% Change
1945	2.88	
1964	3.14	+ 9
1992	3.30	+ 5
1945 - 1992		+ 15

Table 4.4: Changes in the drainage density in the Cathedral Peak Area between 1945 and 1992.

Drainage density in the Cathedral Peak Area changed by an overall 15 % from  $2.88\text{km}\backslash\text{km}^2$  to  $3.30\text{km}\backslash\text{km}^2$  between 1945 and 1992. During the time interval from 1945 to 1964 drainage density changed from  $2.88\text{km}\backslash\text{km}^2$  to  $3.14\text{km}\backslash\text{km}^2$ , representing a change of 9 %. Subsequently, between the years 1964 and 1992, drainage density changed by 5 % from  $3.14\text{km}\backslash\text{km}^2$  to  $3.30\text{km}\backslash\text{km}^2$ .

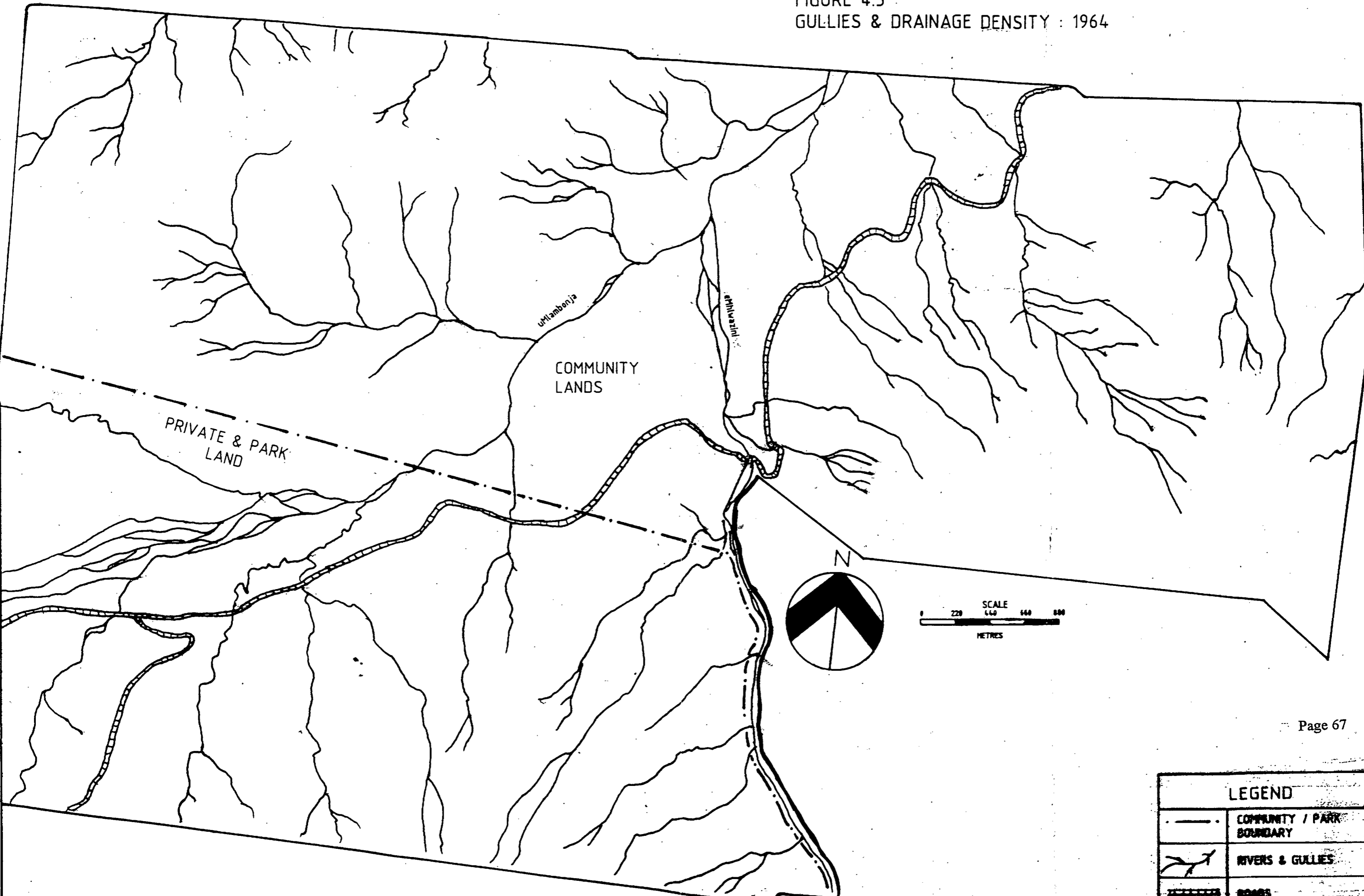
In Chapter Five, further elaboration and discussions relating to the various categories are undertaken. This discussion also includes comparisons with other studies and the findings of this study.

FIGURE 4.5  
GULLIES & DRAINAGE DENSITY : 1945



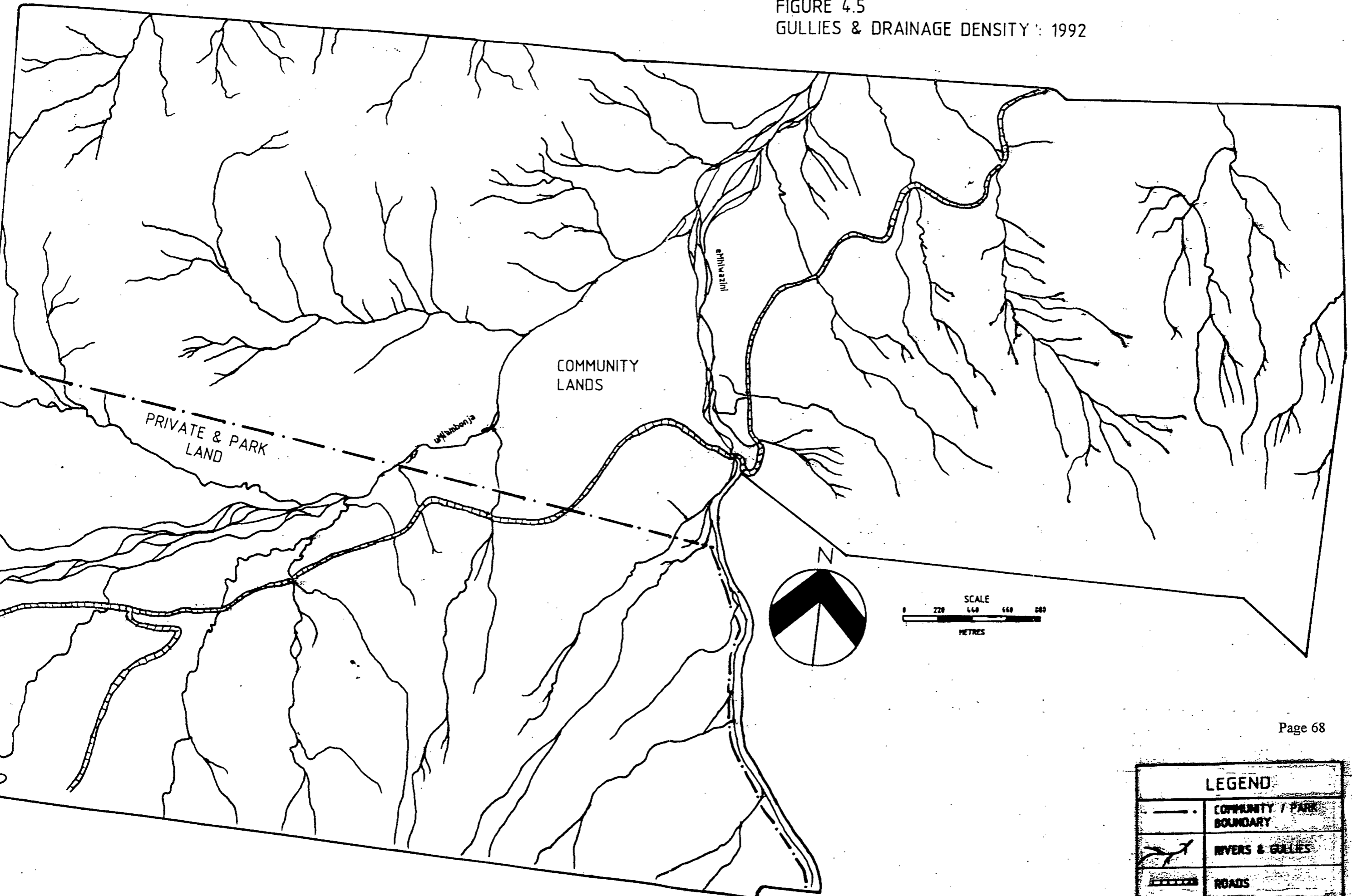
LEGEND	
--- · ---	COMMUNITY / PARK BOUNDARY
~	RIVERS & GULLIES
— · — · — · —	ROADS

FIGURE 4.5  
GULLIES & DRAINAGE DENSITY : 1964



LEGEND	
---	COMMUNITY / PARK BOUNDARY
~	RIVERS & GULLIES
	ROADS

FIGURE 4.5  
GULLIES & DRAINAGE DENSITY : 1992



LEGEND	
	COMMUNITY / PARK BOUNDARY
	RIVERS & GULLIES
	ROADS

# Chapter 5

## Discussion

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The results obtained in the study (Chapter Four) are discussed in further detail in this chapter. The environmental changes in the Cathedral Peak Area are discussed according to the categories identified in Chapter Three i.e. homesteads, cultivation, forestry, eroded surfaces or areas and gullies and drainage density. The situation for each category is described and accounted for. Where possible, analogous situations of other studies are reviewed and, finally, suggestions are made regarding the environmental changes, favourable or problematic.

### 5.1. Homesteads

Population census data for the Okhahlamba District only exists for the post 1970 time interval. The population increase for the period 1970 to 1991 for the Okhahlamba District is shown in Table 5.1. The percentage change in the population for the Okhahlamba District for the period 1970 to 1991 is 183% whereas that of the increase in the number of homesteads for eMhlwazini Ward is 160% for the period 1964 to 1992.

The comparable increase between the number of homesteads in the eMhlwazini Ward and the human population increase for the Okhahlamba District reflects a directly proportional relationship between number of people and that of the number of homesteads for the Okhahlamba District.

Year	Population
1970	69 599
1980	123 448
1991	196 963

Table 5.1: Human population numbers for the Okhahlamba District (Data from Central Statistical Services (CSS), 1991)

In terms of increased pressure on land in the Cathedral Peak Area in general, the 354 % increase in the number of homesteads, and hence population, between the years 1945 and 1992 certainly represents a substantial increase in pressure upon environmental resources of the eMhlwazini Ward. This increased population points to the situation of land

becoming a progressively limited resource in the Cathedral Peak Area. This observation is substantiated by the fact that there has been a land claim from the local African community for portions of land within the Cathedral Peak Section of the Natal Drakensberg Park (See Masters Group, Vol. 1, section 3.5.3. and Vol. 2, section 3.4.1.12b, 1995) as well as the procurement of a segment of park land that immediately borders the eMhlwazini Ward in May 1995 (Spitz, pers comm).

Population increase in the Cathedral Peak Area can be attributed to two factors. Firstly, resettlement schemes under the colonial government of Natal and later by apartheid governments have been responsible for increasing population in the Okhahlamba District. Okhahlamba is a district of the former Kwazulu government. Kwazulu which was a bantustan created in the apartheid era has been densely populated because of the coercive policy of resettlement (Wilson, 1991). It has been estimated that more than three and a half million people were uprooted and resettled into unsuitable areas due to the policy of apartheid (Ramphela, 1991). Nowicki (1992), working in the Herschel District and Makhanya (1993), carrying out research in the former Kangwane homeland found, accelerated soil erosion to be a major environmental problem affecting their respective study areas. They attributed accelerated soil erosion to the fact that their respective study areas were put under pressure as a result of the crowding of people and animal stock into limited amounts of land under the apartheid policy. Subsequently, natural population growth in those areas led to further pressure upon lands. Ramphela (1991) describes a range of environmental problems that have arisen in former homelands as a result of the overcrowding instituted by apartheid policies that include accelerated soil erosion, overgrazing and water and air pollution.

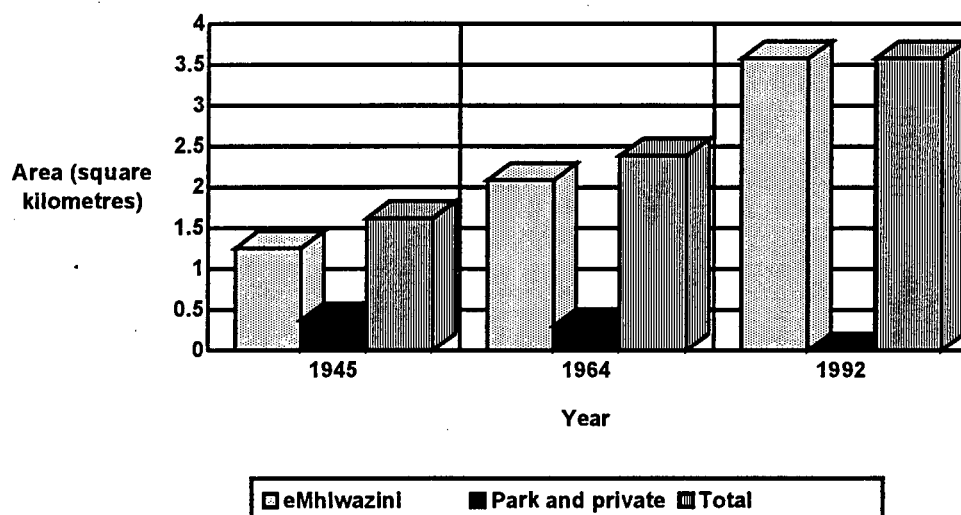
The second factor responsible for increased population in the Cathedral Peak Area is population growth. A population growth rate of 2.5% per annum is given for former Kwazulu areas over the last 30 years (CSS, 1991). Census figures exist for the Okhahlamba District only from 1970 onwards. For the period 1970 to 1990, the population of the entire Okhahlamba District increased from 69 599 to 196 963 (See Table 5.1). The environmental consequences of increased population and agricultural pressures on any particular piece of land, are inevitably increased rates of vegetation removal and soil destabilisation (Nowicki,

1992). In the eMhlwazini Ward, rapid population growth, agricultural modernisation, and historical inequalities of apartheid in land tenure are creating increasingly large populations with little or no access to agricultural land. Without jobs and productive land, poor people are forced onto marginal lands in search of subsistence food production and fuelwood, while those who stay on the land are forced to graze livestock herds on hillsides and areas where vegetation is sparse or where soils are easily damaged (World Resources Institute (W.R.I), 1992). As more people exploit open-access resources in an often desperate struggle to provide for themselves and their families, they further degrade their environment (Cruz and Gibbs, 1990)

## 5.2. Cultivation

The decrease in area of cultivated land (See Fig. 5.1) and consequent increase in natural vegetation within park and private lands reflects the changing nature of land ownership from private property to conservation and research lands during the 1964 to 1992 time span (See section 2.9.2 on conservation and private use of land).

**Figure 5.1: Change in the extent of cultivated area for the eMhlwazini ward and park and private land**



The change in area under cultivation for the eMhlwazini Ward partly mirrors the trend evident in the increase in number of homesteads. Fig. 5.2 shows a clear geometric

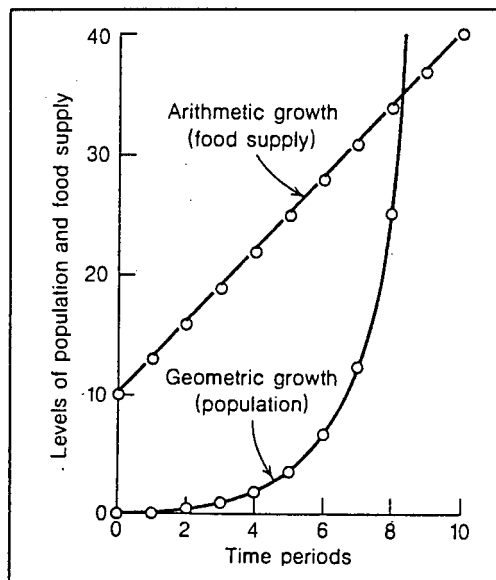
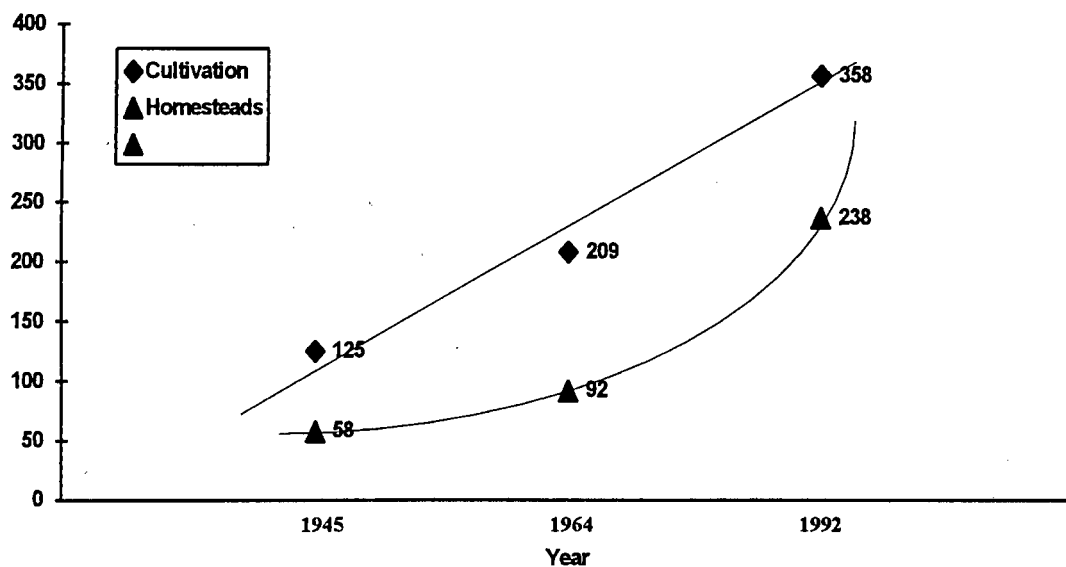
increase in the number of homestead over the 47 year time interval of this study. The gradual increase in the total area used for cultivation in the eMhlwazini Ward shows an arithmetic increase in food and crop production (See Fig. 5.2.). The arithmetic increase in cultivated area for the eMhlwazini Ward is similar to trends found by Dearing et al (1990) for cultivated area in the Bussjosjon catchment of Southern Sweden. Their results showed that cultivated areas had increased arithmetically over the time period 1700 to 1900.

The arithmetic rate of increase of food and crop production together with the geometric rate of increase in the population (See section 5.1) for the eMhlwazini community are similar to the basic theory of the English demographer and economist Thomas Malthus reported by Norris et al (1982). Malthus noted that human population increases geometrically or exponentially (1,2,4,6,8,16....) (See Fig. 5.3) whereas food supply increases arithmetically (1,2,3,4,5,6.....) (Norris, et al 1982). Malthus concluded that population will tend to outstrip food supply, causing famine war and disease (Norris et al, 1982).

Malthus's theory (discussed above) was not accepted by most of his critics as his study was undertaken as a closed system and was very simplistic. Factors such as migration, technology, import and export of goods into and out of the system were not taken into account in his study. In the case of the eMhlwazini Ward Malthus's theory would distinctly fall short as the Masters Group (1995) found that 75 % of people formally employed in the eMhlwazini Ward were migrant workers (Section 3.4.1.1, Vol. 2). The situation in the eMhlwazini Ward has been artificially created by the social engineering programmes of apartheid and are entirely different from Malthus's study, hence the only similarity between this study and Malthus's is the coincidental similarity in trends.

The pressure to produce food caused by a growing population in the eMhlwazini Ward has been the primary reason for the major change in land use. Norris et al (1982) mention that population numbers are increasing so rapidly in some areas that the demand for food causes producers to adopt pastoral and cropping practices that damage

**Figure 5.2: Arithmetic increase in the cultivated area and geometric increase in homestead numbers in the eMhlwazini Ward between 1945 - 1992**



**Fig. 5.3. Malthus's theory of human population and food supply (Haggett, 1975)**

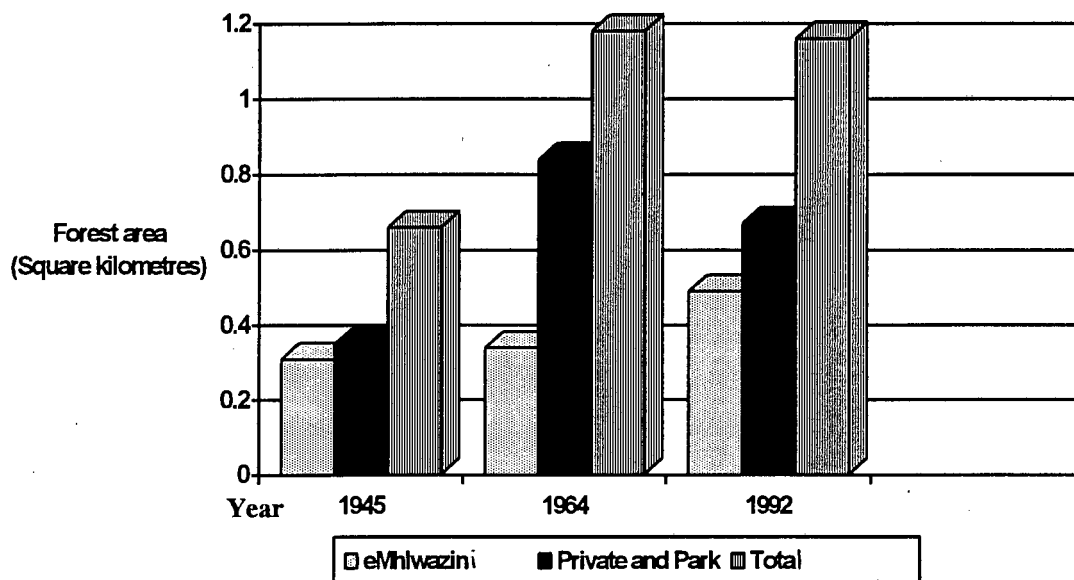
soils and other aspects of the natural environment. The most dramatic change in the physical landscape that has occurred in the eMhlwazini Ward, where people rely mainly on subsistence agriculture as a form of survival, is definitely the increase in population

numbers and the accompanying requirement of increasing food production to feed an increasing population.

### 5.3. Forestry

Forests in the Cathedral Peak Area have increased in extent. The trends that have occurred within forests of the Cathedral Peak Area are shown in Fig. 5.4. Within the park and private lands there has been a doubling of forests between the years 1945 to 1964. This could be attributed to the afforestation programmes that were initiated in the first half of the twentieth century by the private landowners in this region.

**Figure 5.4: Changes in area of forests between 1945 and 1992**



Between the years 1964 and 1992, the park and private areas included in the study show a decrease in the extent of forested areas. The decrease in forest area within the park

section of the Cathedral Peak Area is a result of a conscious effort to limit the spread of alien vegetation. Alien plant infestations in Natal Parks Board Reserves have been a cause of a concern for decades (Porter, 1985). The invasion of alien plants into NPB areas is considered to be a serious problem (Porter, 1985). The NPB believe that the impacts of the afforestation programmes using alien invasive trees, have been detrimental to the environment.

Alien invasives become a problem because populations grow and spread from the initial introduction to the extent that these cause some direct or indirect cost to society. (Kruger et al, 1986). Alien invasive trees cause considerable changes within the community structure of indigenous vegetation. In the Fynbos Biome, for example, alien invasive trees cause considerable changes in community structure of vegetation. By providing a canopy, alien trees cut out light and heat, which are essential elements of indigenous vegetation and change the soil moisture conditions by providing shade and litterfall (Versfeld and van Wilgen, 1986). Increases in the litter and biomass on sites invaded by alien trees substantially alter biogeochemical cycles (Versfeld and Van Wilgen, 1986; Macdonald et al, 1989). Irwin and Irwin (1992) state that the dryness and dense shade beneath *Acacia mearnsii* in the Drakensberg, prevents undergrowth from developing. This in turn increases erosion as a result of the decreased ground cover and thereby increases stream sedimentation.

The geomorphological processes that shape the long term destiny of ecosystems within the Drakensberg is also affected. Alien species that have invaded riparian zones and valleys as well as mountains will affect their riverbank configuration by diverting water towards riverbanks causing undercutting and increased soil erosion rates. Irwin and Irwin, (1992) report that research in the CPSF has shown that an alien plantation of *Pinus Patula* reduced streamflow by 25 % compared to grasslands and has significantly increased erosion and stream sedimentation.

In the Cathedral Peak Area most of the natural vegetation is grasslands (See Plates 2.1, 2.4 and 3.1). When alien tree invasions occur, the hydrological cycles are altered by the greater quantity of water that is transpired by alien trees. A case in the research catchment areas of CPSF by Schulze (1979) clearly demonstrates the impact of alien invasions.

Schulze (1979) found that streamflow had been decreased during the dry season in an afforested catchment compared to a grassland catchment by an amount between 25% to 33%. The streamflow had decreased, despite the fact that the afforested catchment had a higher mean annual rainfall of 1598mm compared to the grassland catchment which had a mean annual rainfall of 1515mm (Schulze, 1979). Fig. 5.5 shows that the coefficient of variability of streamflow for the two catchments. The higher variability of streamflow during the summer (wet) season suggests that there is an increased erosion risk from the afforested catchments and support the hypothesis that alien trees increase erosion.

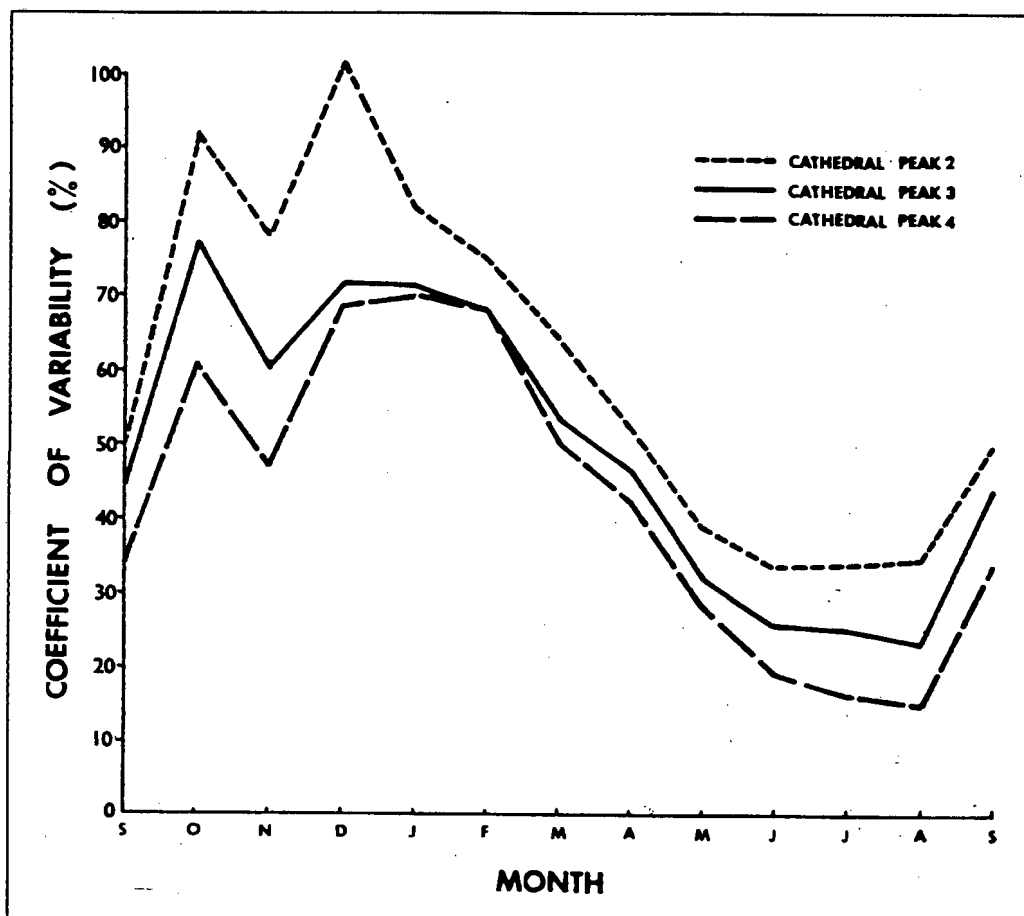


Figure 5.5: Comparison of mean monthly streamflow and coefficient of variability (Schulze, 1979) (Cathedral Peak 2 and 3 are afforested research catchment while Cathedral Peak 4 is grassland catchment)

A large number of the invasives are trees and pose a potential fire hazard when they die or are felled (Versfeld and Van Wilgen, 1986). The fire regime which is a critical component

of the Drakensberg ecosystem, is modified by increased fuel loads caused by increased biomass of alien trees. Scott et al (1991) cited in Van Wilgen et al (in press) provide a case study on the slopes of Table Mountain, where increased fire intensities have induced severe soil erosion. Irwin and Irwin (1992) report that, after a high intensity fire in the CPSF a stream that transported  $10 \text{ mg l}^{-1}$  of sediment increased its sediment load to  $4000 \text{ mg l}^{-1}$  in the winter season.

To mitigate against the negative environmental impacts of alien invasive species, the NPB has implemented an alien organism control programme. Felling of problem tree species that were introduced during earlier times in the CPSF is represented in the decrease of the extent of forested areas in the park and private land section of the Cathedral Peak Area.

The most notable changes in forests of the park and private lands section of the Cathedral Peak Area, are the growth of major stands of indigenous riparian vegetation communities and the felling of stands of alien vegetation during the period of 1964 to 1992. Additions to the indigenous riparian shrub and forests include the spread of for example the *Buddleia salviconia*, *Leucosidea sericea* and *Hilaria lucidus* species.

Within the eMhlwazini Ward, on the other hand, the results of the study suggest a totally different situation. There has been a gradual increase in area under trees over the study period. This is unlike the situation described by Irwin and Irwin (1992) for the Singati Valley some 10 km north of the Cathedral Peak Area, where significant deforestation was reported

According to T. Everson (pers comm), *Acacia mearnsii* is a common alien invader tree species within the eMhlwazini community areas. During field trips into the eMhlwazini Ward, infestations of the black wattle were also noted by the author as common. Possible reasons for the increase in the extent of forests could be attributed to the introduction of alien trees by people from the eMhlwazini community, who use black wattle and other alien trees as fuel and building material. The suggestion that alien trees are spread by people in the surrounding community is supported by the work of Wilson and Ramphele (1989) who report that the average distance to collect one headload of wood has been

estimated at 8.3 km in Kwazulu/Natal. In transporting alien trees, the seeds are often, also transported. The problem with the transport of these seeds, is that their seeds are spread to new areas and once new plants are established, their large reproductive ability, supports their invasion into larger new territories. Irwin and Irwin (1992), report that up to 20000 seeds may be found in the leaf litter beneath a single mature tree of *Acacia mearnsii*.

The consumption of the seeds of plant species is known to limit plant population size. In the case of alien invasive species, there are no or few indigenous or alien organisms that consume entirely the seeds of alien invasive species, hence their spread into new territories is generally uncontrolled. Richardson et al. (1992) cite a case study by Weiss and Milton (1984) who found an average of 5 to 6 viable seeds in the soil under *Acacia longifolia* canopies in Australia (country of origin) compared with the 7370 seeds per square metre in the Western Cape. Overall, it appears that the transport of alien trees would promote their spread into new territories of the Cathedral Peak Area.

Irwin and Irwin (1992) mention that the common habitat of *Acacia mearnsii* is along streambanks. *Acacia mearnsii* is identified by Nichols et al (1986) as being one of the most important water dispersed alien invasive species in Kwazulu/Natal. Conveyance of seeds of *Acacia mearnsii* by water results in their spread along water courses, and may account for their increase in the eMhlwazini Ward over the study period. During field visits to the eMhlwazini Ward, *Acacia mearnsii* was indeed noted to be a common tree species in riparian zones.

The problem with alien vegetation in the former Kwazulu has reached serious proportions and over most areas the presence and spread of invasive plants continues unchecked (Ward, 1985). The problem of alien tree infestation in eMhlwazini Ward may become more intense in the future for two reasons. Firstly, the most crucial factor that could see the extensive spread of alien trees in the eMhlwazini Ward is that the seeds of *Acacia mearnsii* may remain dormant for anything between fifty and a hundred years (see section 2.6) and there is clearly a substantial residual seedbank in the area, particularly along water courses.

The second reason for alien infestation becoming problematic in future is related to factors that may increase the residual seedbank of alien invasives in the in the ward, and is associated with socio-economic conditions. There are three factors that are likely to increase the spread of alien trees seeds. Firstly, the electrification of the eMhlwazini Ward is unlikely to occur in the next two years (tribal authority, pers comm). This would allow for the continued use of alien trees as a fuel source. Secondly, even if the ward is electrified, the acute poverty of people in the ward may preclude many eMhlwazini residents from using electricity. This would also extend the use of alien trees as a fuel source. The third factor that may increase the residual seedbank in the eMhlwazini Ward is related to alien trees being used as a building material by many residents. Related to all three factors is the transport of trees, which also results in the simultaneous transport of alien tree seed over larger and uninfested areas.

If the alien tree infestation in the eMhlwazini Ward intensifies, there are some important repercussions for the general environment and human activities. The eMhlwazini Ward is part of the Drakensberg mountain catchment. According to Rabie et al (1992) one of the most important properties of mountains in South Africa is their function as a natural drainage area. The delivery of water from catchment areas, or watersheds, in South Africa, represents a significant contribution from natural ecosystems to human well-being (Van Wilgen et al, in press). The impact of alien forests on water in Kwazulu/Natal was estimated in 1980 to have decreased streamflow by some 413 million  $\text{m}^3 \text{yr}^{-1}$  (van der Zel, 1995). The figure for water reduction by alien forests is predicted to increase to some 605 million  $\text{m}^3 \text{yr}^{-1}$  by the 2000 (van der Zel, 1995). These figures take account only of the commercial forestry sector and do not include the alien tree infestations in communal and other non commercial lands such as the eMhlwazini Ward. In the Western Cape Province, Le Maitre et al (in press) cited in (Van Wilgen et al, in press) state that the impact of alien invasions, if uncontrolled, would result in average loss of water of  $347 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$  representing an equivalent loss of more than 30 % of the water supply to the city of Cape Town. Van Wilgen et al (in press) have calculated that with management of alien plants in the Fynbos Biome, water yield from a catchment would be 62.7 million  $\text{m}^3 \text{yr}^{-1}$  compared to 48.6 million  $\text{m}^3 \text{yr}^{-1}$  without management of alien plants.

The Thukela-Vaal hydroelectric scheme located in the Upper Thukela Catchment provides water to both, the Orange Free State and the Gauteng Provinces. The Drakensberg provides water for the entire Kwazulu/Natal and Eastern Cape Provinces. The increase in the number of alien forests in the eMhlwazini Ward and Drakensberg region either in the surrounding communities or in the Natal Drakensberg Park, could jeopardize the water supply in other regions of South Africa which depend on water from the Drakensberg and the Thukela River catchment. This problem is highlighted at present by the fact that the Gauteng Province is experiencing one of the worst drought in living memory (TV 1 news, 12/7/95). Water from the Thukela-Vaal Scheme is used to supplement fast declining water levels in dams of the OFS and Gauteng Provinces. The continued existence and growth of industries central to the South African economy and which are necessary to support the growing population of these regions, is limited by water (Van Wilgen et al, in press). Industries in these regions that benefit from water originating in the Drakensberg, include mining, agriculture and manufacturing. Together they constitute the backbone of the South African economy. At a time when water supply is becoming a more critical issue and the consideration of construction of new water supply structures to meet these demands a priority, alternative means of supplying water should be explored. Van Wilgen et al (in press) found that the optimal catchment management system for the supply of water by controlling alien plant populations was 1.8 and 6.7 times cheaper than re-use of sewage and desalination projects respectively.

The risk of water shortage to these regions is likely to be more severe during the dry spells that are associated with South Africa's fluctuating climate patterns (See Fig. 5.6) and with the increasing variability of weather patterns associated with global warming thereby placing people and their activities at risk. The case by Schulze (1979) discussed in section 5.3, clearly demonstrates that water supply in an afforested catchment of the CPSF had been decreased in the dry season by between 25 % and 33 %.

Increasing stands of alien vegetation could in addition, exacerbate the erosion problem. Fires in a *Pinus patula* plantations in the Natal Drakensberg kill trees and remove the litter layer Versfeld and Van Wilgen (1986). Sediment loss after one such fire in the adjacent grasslands was  $0.004 \text{ tons km}^{-1} \text{ yr}^{-1}$  compared to about  $0.25 \text{ tons km}^{-1} \text{ yr}^{-1}$  from the afforested catchments for two years after the fire (Van Wyk, 1985 cited in Versfeld and Van Wilgen, 1986).

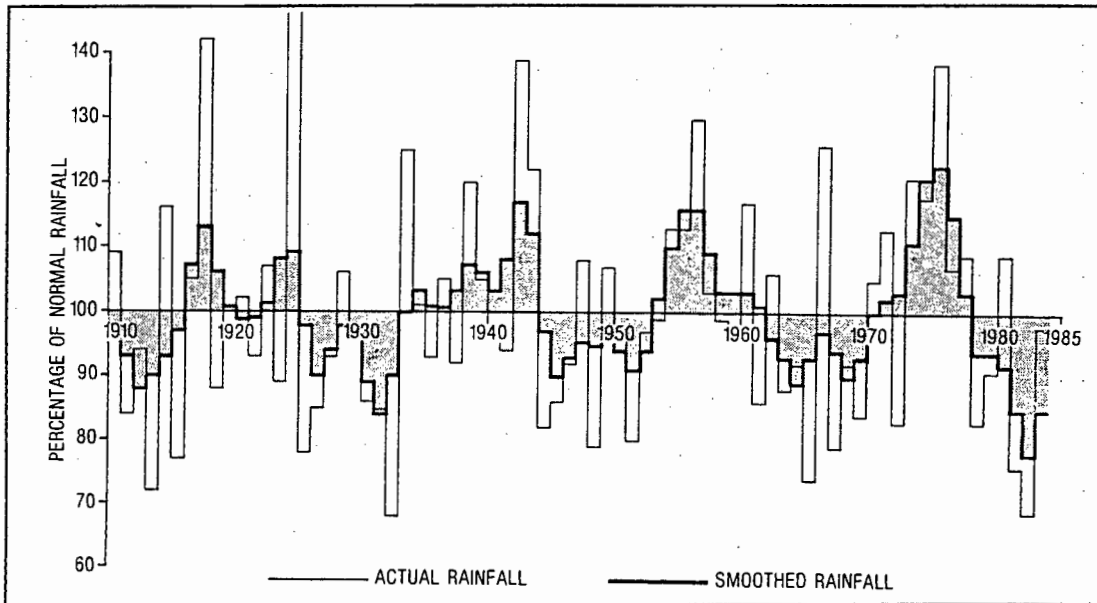


Figure. 5.6: Fluctuations in South Africa's rainfall patterns for the years 1910 to 1985 (from Tyson, 1986)

*Acacia mearnsii*, being shallow rooted, is prone to collapse easily from bank erosion or the force of floods, thereby exposing soils to further water action, while fallen stems divert the stem from channel to bank (Versfeld and Van Wilgen, 1986). Increased sediment content in streams will result in corresponding increases in sedimentation in dams and water courses, thereby reducing water storage capacity. Watson (1990) cites Begg (1986) who reported that the Gilbert Eyes Dam on the Umzimkulwana River had lost 41 % of its capacity in six years. Increased sediment content in water also decreases water quality and consequently results in increased costs for the purification of water.

Van Wilgen et al (in press) list several other activities in the Fynbos Biome that are dependent on alien free catchments. These include tourism, flower harvesting, medicinal

and food extracts. In the case of the Drakensberg, tourism is certainly one industry that is essential to the economy of the region and would benefit from an alien tree-free catchment.

## 5.4. Change in erosion

The various types of erosion that occur in the Cathedral Peak Area have been discussed in section 2.11.1. Before the ensuing discussion of eroded areas or surfaces the term erosion susceptibility must be defined. Garland (1987), defines erosion susceptibility as a characteristic of land, which is independent of the land use, describing erosion expected without the protection of vegetation or conservation measures, and without disturbing the land surface.

### 5.4.1. Erosion surfaces

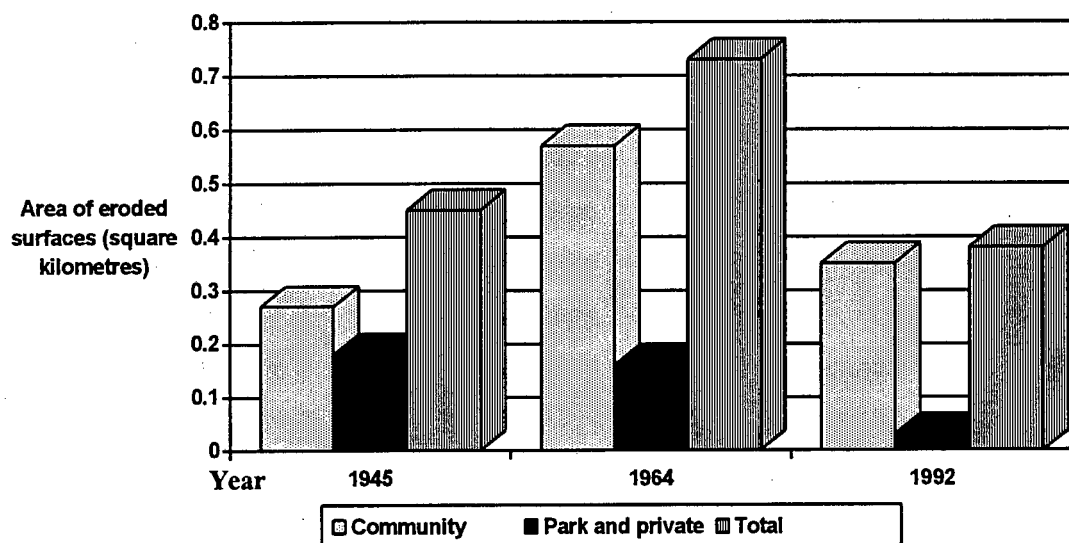
Analysis of eroded areas for the park and private lands as well as the community section of the Cathedral Peak Area shows the following (See Fig 5.7). Within the park and private lands erosion has decreased substantially. All eroded surfaces in the park and private lands is concentrated in areas with slopes greater than 10 degrees. The lower results for eroded area in the park section of the Cathedral Peak Area for more recent photography suggest that some degraded terrain had been re-covered by indigenous vegetation. This is expected since the conservation organisations administering the park, viz. the Department of Forestry up to the early 1980's and then the NPB which continues to administer the park to the present day, have implemented soil conservation measures to combat soil erosion within park areas

The decrease in erosion between the years of 1945 and 1964 is relatively minor. This may be attributed to boundary changes for sections of the land within the present park, (i.e. was previously held by private individuals or organisations). It would appear that erosion surfaces in the park area during this period were in the process of adjusting to a change in land use when the first European settlers had settled in the Cathedral Peak Area.

By the 1960's the land had shown indications of recovery and is manifested in the small margins of change that have been recorded in this study for the 1964 time interval. A second decrease in eroded area observed for the period 1964 to 1992, is more significant than for the period 1945 - 1964 because the decrease in extent of eroded surface has been substantial. This maybe attributed to the success of conservation bodies, such as the NPB and the Department of Forestry's soil conservation programme. Scott and Humphreys (1985) Drakensberg pathwork manual, describes a list of the different soil conservation methods used by the Department of Forestry in the Drakensberg.

Broderick (1987) and Garland and Broderick (1992), who used aerial photographs to monitor erosion in the Thukela River Catchment between 1944 and 1981, and Watson (1990), who used aerial photographs between the years of 1937 and 1983 to monitor changes in eroded surfaces for the Mkuzi Game Reserve and surrounding areas of Kwazulu also found that eroded surfaces had decreased in these time intervals.

**Figure 5.7. Changes in the extent of eroded surfaces/area over the study time span in the Cathedral Peak Area**



Garland and Broderick (1992) suggest that in some local situations changes to a less erosive land use or improvement in conservation farming techniques may account for recovery of land. In the Cathedral Peak Area, the marked improvement in the eroded surfaces for the present park section may be partly attributed to the successful soil conservation and management measures implemented by the successive conservation organisations i.e. Department of Forestry and NPB resulting in re-colonisation by vegetation. However Garland and Broderick (1992: 48) suggest:

“When considered with other Southern African studies, the observed stabilisation in Thukela Catchment erosion may be part of a regional trend. If this is the case, reasons for reductions in erosion rates are far more likely to be linked to medium and long term change in the intrinsic variables of the erosion system especially rainfall than to any human influence”

When rainfall data of four years prior to the aerial photograph is compared to total eroded area Garland and Broderick’s (1987) suggestion of rainfall affecting eroded surfaces is borne out (See Table 5.2).

Year	Total rainfall	Four years of rainfall data	Mean annual rainfall (over four years)	Erosion (km <sup>2</sup> )
1945	5125	1941- 1944	1281	45
1964	4576	1960 - 1963	1144	73
1992	5309	1988 - 1991	1327	38

Table 5.2. Relationship between rainfall and eroded area (obtained and modified from CCWR, pers comm). The data shown is given for 4 years prior to photograph and is for meteorological station M4 on Fig 1.1.

Using Schulze’s (1979) research for general droughts, which is defined as a drought or “dry” season with less than 1200 mm of rainfall for the Drakensberg, it is evident that 1964 is a drought or “dry” year, whereas 1945 and 1992 would be classified as wet years. When average rainfall data of four years prior to the photographs being taken, is compared against the surface area of erosion, an inverse relationship of high eroded surface with low rainfall and vice-versa is evident. 1992, with highest wet season data of the years stated in Table 5.2, has the least extent of eroded area whereas 1964, the dry year has the largest eroded surfaces or area. The year 1945 has an eroded surface and rainfall data between the

wet and dry years. From this relationship, it would appear that erosion area is a function of rainfall and may partly be attributed to better vegetation cover after good rain seasons.

Within community land, a different scenario exists with regards to erosion. The size of erosion surfaces increased during the years, 1945 to 1964. However, between 1964 and 1992 there are reductions apparent (See Fig. 5.7 and Section 4.3.). Eroded surfaces are generally concentrated into the areas with slopes greater than 10 degrees.

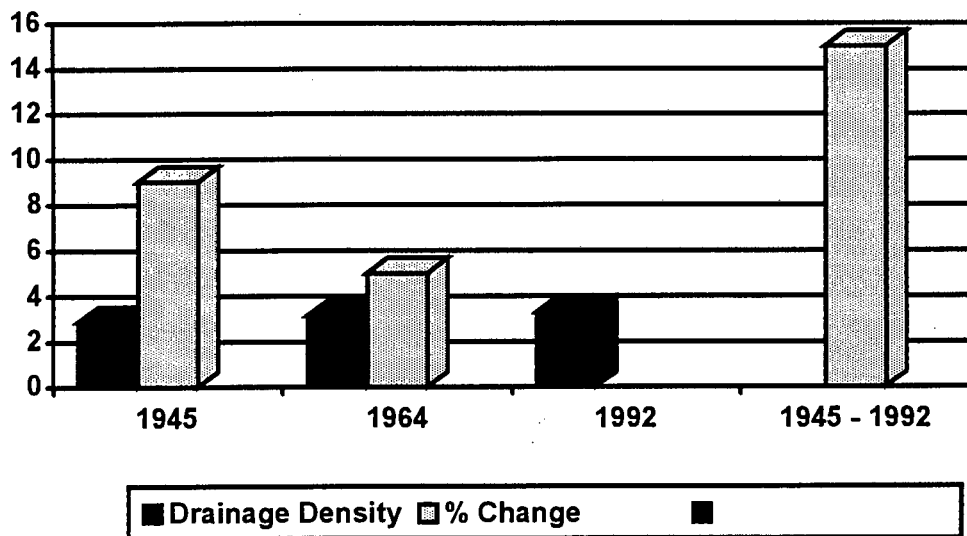
In 1945, eroded surfaces appear to have been localised in the Cathedral Peak Area. Once anthropogenic activities upon these lands had increased (as evident in the 1964 photograph), the erosion surfaces seems to have increased in extent dramatically. Swart and Allanson (1988) found that sediment yields of South African rivers were greater during flood events following dry spells, than following wet spells. The low rainfall (Table 5.2) coupled with the change in land use from natural grasslands to cultivated area appear to have increased the eroded surfaces. Watson (1990; in press) used aerial photographs from the years of 1937, 1960, 1970, 1975 and 1983 found a comparable situation where soil erosion increased dramatically during the first few years after settlement by peasant farmers. She ascribed the change in eroded surfaces for these periods to the change in land use from natural veld to cultivated conditions in the study area. She further stated that the magnitude of increase in erosion surfaces during the 1960's was no doubt additionally due to a dry year preceding a wet year. In this study the number of years for which aerial photographs could be examined was limited by time constraints. Future studies should take cognisance of the years not incorporated in this study to obtain a larger sample.

Although the most significant change in land use for the community section of the Cathedral Peak Area i.e. increase in homesteads and cultivation, occurred during the years 1964 to 1992, the erosion situation appears to have improved to some extent over this time. Inspection of aerial photographs indicated that much of the land had been cultivated sometime in the past or was being cultivated in 1964. This would suggest that, although intensification in cultivation has occurred, eroded surfaces or areas had not increased in extent.

### 5.4.2. Gullies and drainage density

Although drainage density has increased over the time span from 1945 to 1992 (See Fig. 5.8) in the Cathedral Peak Area, change in drainage density between 1964 and 1992 shows a smaller increase than the change in drainage density for the 1945 to 1964 time span.

**Figure 5.8: Change in drainage density (km\km<sup>2</sup>) for the Cathedral Peak Area**



One reason for the increase in drainage density between 1945 and 1992 may be attributed to bedrock streams in the Drakensberg, which are eroding their beds and banks at a rapid rate, and that fluvial processes constitute a powerful erosive force in the region (Garland, 1987).

Piping is a form of erosion in the Drakensberg worthy of note (Beckedahl, 1977) and may provide a second reason related to the increased drainage density. Gullies may originate as a consequence of the collapse of soil pipes. In southern Africa, the potential for soil pipe formation is enhanced by the presence of a high sodium content and duplex soils, both of which are widespread in southern Africa (Beckedahl et al, 1988). Another possible reason

for the formation of soil pipes in the Cathedral Peak Area is that concentrations of water frequently result from activities such as road building and accelerate natural pipe formation (Beckedahl et al, 1988). In the Cathedral Peak Area, the increase in the number of roads and changes in road surfaces, from corrugated to bitumen covered roads, together with an increase in footpaths associated with homesteads would cause concentration of water and create the necessary conditions for enhanced pipe formation. When roof collapse ultimately occurs, a well developed gully system appears almost instantaneously (Beckedahl et al, 1988). Certainly, the appearance of several gully systems over the study period lend evidence that subsurface erosion together with human interference have enhanced the rate of pipe and gully formation.

The smaller increase in gullies between 1964 and 1992 may be partly explained by changes in the geomorphological variables suggested by Garland and Broderick (1992) discussed under the section of eroded areas (Section 5.2).

#### **5.4.3. Land use and erosion in the Cathedral Peak Area**

The hypothesis that a rapid increase in soil erosion initiated by a change in land use will stabilise at a lower rates once a new equilibrium has been reached, is consistent with general systems theory (White et al, 1988, cited in Watson, 1990). In the case of the community section of the Cathedral Peak Area, the increase of eroded surface observed up to 1964 and the subsequent decrease in eroded surfaces between 1964 and 1992 would support the theory of White et al (1988). Watson's (1990; in press) studies of erosion similarly concluded that soil erosion processes are more sensitive to a change in land use than an intensification of an existing land use.

Erosion scars, once formed, rarely recover unaided since revegetating with indigenous species is slow and revegetation is more difficult on destabilised soils (Garland, 1987; Everson, 1995) Bainbridge (1979) states that erosion scars in the Drakensberg rarely recover unaided. This, as well as the observation that gully erosion in the Cathedral Peak Area is concentrated along roads and footpaths suggests, firstly, that developmental projects should keep clear of eroded areas and secondly, that areas already eroded, are

rills and gullies. The processes have in many cases become linear and violent and are indicative of a deteriorating environment (Verstappen, 1983).

With regards to changing land use in the rural areas of the former Kwazulu districts that surround the Umfolozi Game Reserve, Watson (1990: 186) states:

"should current general aspiration for rural development succeed, erosion processes triggered by the communications infrastructure and intensive market based agriculture, unless actively controlled, are likely to attain unprecedented levels."

Extrapolating the theory of White et al (1988) and Watson(1990; in press), that erosion increases with a change in land use rather than an intensification in land use, points to the fact that changes in erosion patterns can be expected as development priorities change. The potential for development of the Okhahlamba District and other regions of the Thukela River Catchment has long been recognised and is pointed out in several research reports (Thorrington-Smith, 1960; Van der Eyk et al, 1969 and Philips, 1973) that investigate various environmental and economic facets of the Thukela River Catchment.

Any development in the Okhahlamba District should consider Garland's (1987) research. Garland (1987) investigating erosion risk from footpaths and vegetation burning within the Drakensberg noted two points. Firstly that without remediation of affected areas soil loss in the Drakensberg may well accelerate, even if land treatment causing initial erosion is halted. Secondly, that increasing (recreational) pressure upon the Drakensberg will create demand for more facilities. He stated that unless new facilities are carefully planned, sited and maintained, the number of erosion degraded sites will become steadily greater without soil and environmental conservation measures.

Garland (1990) mentions that soil erosion has already cost the Kwazulu/Natal Province more than R500 million. Any conservation planning policies should take into account the erosional changes that have been discussed by Watson (1990; in press) and Garland and Broderick (1992) and that have been identified in the study.

Overall it would seem most appropriate that the state, development and conservation agencies implement soil conservation measures in tangent with, or prior to, bringing about

change in land use in the Cathedral Peak Area. This would serve to maximise the benefits of soil conservation measures at the most critical periods of changing land use. Postponement of soil conservation measures will result in further impoverishment of the environment and inhabitants of the Okhahlamba District.

## Chapter 6

# Conclusions and Recommendations

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## **6.1. Introduction**

The photogrammetric and photo interpretation research upon which this report is based has added a new perspective on the changes that have occurred in the Cathedral Peak Area both in terms of the human environment as well as biophysical environment during the recent past. The research has also shown that there are marked similarities between some of the results obtained for this study and those of other studies in Kwazulu/Natal. This chapter draws conclusions regarding the homesteads, cultivation, forests, eroded areas and gullies and drainage density categories that have been identified in this study. Recommendations are identified for possible environmental improvements in the Cathedral Peak Area.

## **6.2. Aims of study**

Changes in homestead population and cultivation have been employed to describe, explain and assess environmental changes observed in the Cathedral Peak Area. The changes in homestead numbers and area of cultivation give a good idea of the extent of changes that has occurred during the period 1945 to 1992, and the corresponding increase in pressure upon environmental resources. The historical development and assessment of land degradation in the Cathedral Peak Area has been reviewed by mapping changes in forests and erosion over the study period. Causes of potential increased land degradation have been identified using existing literature and results from this project. The conclusions drawn from this study for the Okhahlamba District are based on observations in the Cathedral Peak Area. Future data collection from larger portions of the Okhahlamba District will ensure a more representative sample. In summary, the aims of this study listed in section 1.4. have largely been achieved.

## **6.3. Results of the study**

Homestead population was shown to have grown at a geometric rate and by approximately 354 % in the eMhlwazini Ward over the period in question. Increases in homestead numbers as a consequence of increased human population has resulted in larger area of land being cultivated to meet the growing population of the area. For the same time span,

total area under cultivation in the eMhlwazini Ward grew at an arithmetic rate. The increased number of homesteads and area under cultivation in the eMhlwazini Ward has certainly increased the pressure on environmental resources.

Forests (indigenous and alien) on the 1945 and 1964 aerial photographs was identified by the shape of the forest plantations and by the general rule that indigenous montane forests grow mainly on moist south facing slopes. Personal communications with individuals and organisations in the Cathedral Peak Area also assisted in the identification of afforestation and alien tree felling programmes. For the 1992 aerial photograph, field visits to and personal communications, with organisations and individuals in the Cathedral Peak Area assisted in identification of forest types .

Within the park section of the Cathedral Peak Area, the total extent of forested area has decreased. However, this decrease can be seen as a positive impact as it has mainly been due to felling of stands of alien trees. There has also been some marked improvements in the extent of the riverine vegetation that occurs within the park section of the Cathedral Peak Area. The improvement in the quality (from alien to indigenous trees) and density (overall decrease of alien trees but increase in indigenous trees) of forested area of the park sections has been attributed to the conservation programmes of the Department of Forestry Affairs and that of the Natal Parks Board. Within the surrounding eMhlwazini Ward there has been a gradual increase in the total area of forested land. The increase in forested land has been attributed to the spread of alien vegetation as a result of human activities and dispersal of seeds through the actions of running water.

Some impacts of alien vegetation on the biophysical environment include decrease in water availability and an increase of soil erosion. Presently the eMhlwazini Ward is covered mainly by grasslands. Increasing stands of alien trees may in future result in a decrease in water quality and quantity. Research by Schulze (1979) in the CPSF has shown that the water yield had decreased between 25 % to 33 % in an afforested catchment compared grassland catchment. Sediment yield after a fire in a *Pinus patula* catchment was found to be 0.25 tons km<sup>2</sup> yr<sup>-1</sup> compared to 0.4 tons ha<sup>-2</sup> yr<sup>-1</sup> in a grassland catchment, for two years after a fire (Van Wyk, 1985 cited in Versfeld and Van Wilgen, 1986). Since the

eMhlwazini Ward is located within the Thukela River Catchment (See Fig 1.1), water quality for the entire catchment will be affected. Assuming that the consequences of increasing forests in the eMhlwazini Ward are representative for the entire Okhahlamba District, then the water quality and quantity for the entire Thukela River Catchment may be negatively impacted, particularly during drier years of southern Africa's fluctuating climate. Schulze's (1979) research in the CPSF, noted that streamflow had decreased mainly during the "dry" winter season in an afforested catchment compared to a grassland catchment.

The results of the survey of changes in erosion over the 47 year interval from 1945 to 1992, show that the total eroded surfaces or area for the park and private lands decreased during this period. The major decrease in eroded land in the park is due to the successful, but expensive, conservation measures that have been implemented by the Natal Parks Board and the Department of Forestry. Bainbridge's (1979) cited in Garland (1987), figures shows, that the cost of rehabilitation of eroded land was R400 per km<sup>2</sup> i.e. was more than four times the market value of the land (Garland, 1987). Veld and fire management research over several decades and soil conservation research mainly by Scott and Humphrey's (1985) whose "Drakensberg path manual" deals with aspects ranging from design, construction, maintenance and rehabilitation to monitoring of paths in the Drakensberg, has been undertaken to provide conservation measures for roads and paths related to recreational use in the Natal Drakensberg Park. Garland's (1987) research of "Erosion risk from footpaths and vegetation burning" to assess erosion hazard, has also contributed to this cause of soil and environmental conservation pursuit in the park and private land section of the Cathedral Peak Area.

The correlation between eroded area data for the park and private lands and the gully drainage density for the Cathedral Peak Area has been found to be comparable to results of Garland and Broderick (1992), who found that erosion had decreased in the Thukela River Catchment and suggested that the decrease in erosion was related to long term geomorphological variables, of which, the most important was rainfall. When rainfall data is considered to the results of this study an inverse relationship is noted between eroded surface or area and rainfall data. Swart and Allanson's (1988) research which showed that

changes in erosion following dry spells was more severe than changes in erosion following wet spells could account for the observation of the inverse relationship. The dry spell in the four years prior to 1964, has been correlated to the highest eroded surface or areas of this study in the Cathedral Peak Area, whereas the lowest eroded surface is related to the four year wet season prior to 1992.

Within the community land, as opposed to the park land, eroded areas increased substantially during the period 1945 to 1964. The major increase in erosion between these years can be attributed to the change in land use from natural grasslands to cultivated lands. By 1992 however, total eroded area had decreased to some extent, even though there had been increases in the total area of land used. The results of this study on eroded surfaces within communal lands in the Cathedral Peak Area, have been found to be similar to those found by Watson (1990; in press) who found that erosion increased substantially after introduction of a new land use in the peasant farming communities surrounding the Umfolozi Game Reserve. A further finding of the study was that erosion is more susceptible to a change in land use than an intensification in them, (See also White et al ,1988 and Watson, 1990; in press).

## 6.4. Recommendations

It is believed that a change in land use is likely to occur in the Cathedral Peak Area for two reasons:

1. The potential for development of the of the Okhahlamba District together with the Thukela River Catchment has long been recognised and numerous reports e.g. Thorrington-Smith (1960), Van der Eyk et al (1969) and Philips (1970) bear testimony to this fact.
2. More importantly, since the democratic changes that have occurred in South Africa last year, the RDP, aims to improve conditions in rural areas by initiating appropriate rural development programmes (ANC, 1994). The ambition of the people of the Cathedral Peak Area to bring about change in the form of roads, schools, electricity etc. (Masters Group, Vol. 2, 1995), suggests that a change in land use is likely to occur.

The results of this study suggest, that erosion is more susceptible to a change in land use rather than an intensification in them (See also Watson's, 1990; in press). Based on the above assumptions, the following recommendations are made:

- ◆ Any development or conservation programmes associated with the RDP in the Cathedral Peak Area as well as the Okhahlamba District should include environmental conservation measures within design, construction and maintenance phases of their projects.
  
- ◆ A critical consideration when devising a conservation strategy for any area is that local people should be considered and involved in the generation of any plans that affect them. Stocking (1985: 753), discussing soil conservation states:

"If soil conservation measures are to be sustained, they must be designed within the context of the people that they will affect. It is here that a second objective of soil conservation enters to provide a good and one hopes living standard for people. This entails the integration of technical measures into socio-political and economic circumstances."

Simply stated, development and conservation initiatives should remember that people are their own best advocates given the opportunity. They often know what they want and understand better than outsiders the local ecological, social, political and cultural context. Initiatives that respect local knowledge, support rather than supplant local leadership, and work with existing institutions, supplementing but not replacing local wisdom with technical expertise, have the best chances of success (W.R.I, 1992)

- ◆ Development and conservation initiatives should include environment education programmes for surrounding communities which deal with aspects that inform the local communities of the impacts of alien trees and empowers them to contribute positively in the eradication of alien vegetation. The enthusiasm of the people of the eMhlwazini community to setting up traditional medicinal herb gardens was noted by the Masters Group (1995, Vol. 2). Development programmes for the area can be extended to include the cultivation of indigenous forests, possibly in the form of a social forestry programme, and methods or ways of combating the spread of alien

vegetation. Social forestry have been implemented to encourage people in impoverished communities to plant and grow their own trees. In the case of the Cathedral Peak Area indigenous trees should be favoured against alien trees in such programmes. The implementation of an environmental education programme and a social forestry programme must include all interested and affected parties that are located in the area and also prospective contributors to such programmes.

In other regions of Kwazulu/Natal, as well as the Boland and Swartland, social forestry programmes have already been initiated to educate, train and inform the people and enable the communities to establish, operate and maintain nurseries (Anon, 1995). The CSIR has been exploring the use of Participatory Rural Appraisal (PRA) as a tool for involving communities in practical forestry and land management (CSIR, 1995). One area that the CSIR has been actively exploring is community watershed rehabilitation and their approach has more typically been used for tackling problems of rural agriculture, drought relief health and land reform (CSIR, 1995). These suggestions could also be used by conservation and non-governmental organisations e.g. NPB to improve their neighbour relationship with the surrounding communities.

- ◆ In conjunction with the improvement of environmental education, any attempt to improve the environmental conservation measures should remember that people are powerless to the threat of land degradation and are forced to further degrade their environments largely because of unemployment and the lack of opportunities to improve their conditions (Nowicki, 1992). Any attempt to improve environmental conservation will need to consider the socio-economic conditions of people who live in the Cathedral Peak Area. The improvements in environmental conditions can easily be included into the RDP initiatives that are planned for the Cathedral Peak Area.
- ◆ Reconstruction and Development Programme (RDP) initiatives are being planned for rural development and small scale agriculture. With regards to the people in the Cathedral Peak Area, there are several important concepts that need to be taken into account in generating a RDP plan for small scale agriculture and rural development. The people of the Cathedral Peak Area are deeply connected to the Zulu monarchy,

hence the Zulu cultural tenets must be taken into account (See section 2.9.1. on community land use). The eMhlwazini Ward was found to be overstocked (Masters Group, Vol. 2, 1995). Destocking as a soil conservation technique seems unlikely to be successful in the Cathedral Peak Area as livestock, especially cattle, are seen as being essential and provide many socio-economic and agricultural functions to the people of the Cathedral Peak Area (See Section 2.4.1) Therefore conservation programmes should note the importance of livestock and develop programmes around these factors.

In the words of Stocking (1985: 750):

"erosion of grazing lands cannot be tackled by destocking. Overstocking is a symptom of deeper problems and there is little point in merely treating the symptoms. Because the small farmer is trapped into a position where cattle are of ever increasing importance, a sensitive incremental approach to rural development could de-emphasize the role of cattle. At the same time, simple forms of range management and improvement, marketing facilities, improved oxen and other measures will enable improved oxen, and other measures will enable a wider ownership of cattle but increase quality and reduce grazing pressure."

- ◆ The environmental modifications that have occurred in the Cathedral Peak Area have important bearing upon the people that live in the area. The positive changes that have occurred, in terms of the decrease in alien tree infestations and decrease in total eroded area in the park section reflect the intense felling programmes and soil conservation measures respectively of the conservation organisations in the area. Expertise and resources that have helped in the improvement of the overall forest status in the park section can be channeled into improving environmental education for the surrounding communities as well as improving neighbour relations, thereby contributing to the aims of the RDP.

In conclusion, environmental conservation and rehabilitation in the Cathedral Peak Area is inseparable from the problems of the poverty in the region. Poor people generally have no choice but to opt for immediate benefit, very often at the expense of long term sustainability, and they may be quite aware of this (Barrow, 1991, eMhlwazini Community Leader, pers comm). A better life for the communities in the Cathedral Peak Area is a step towards ensuring sustainable improvement in the quality of life of the inhabitants and the environment in the Cathedral Peak Area.

In the Cathedral Peak Area, although eroded surfaces appear to be linked to oscillations in rainfall, the changes in land use during 1960's show that erosion may be exacerbated as a result of changes in land use. New land use to the Cathedral Peak area is likely to occur in the future as a result of the GNU's RDP, which aims to address rural underdevelopment and the severe socio-economic disparities that exist in these areas. Attempting to maintain the status of the Drakensberg and its immediate surrounds as a conservation and water management region in tandem with addressing the severe socio-economic disparities that exist in the Drakensberg region and Okhahlamba District respectively, is likely to present one of the key challenges to the local, regional and national government.

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## **Personal Communication**

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# Appendices

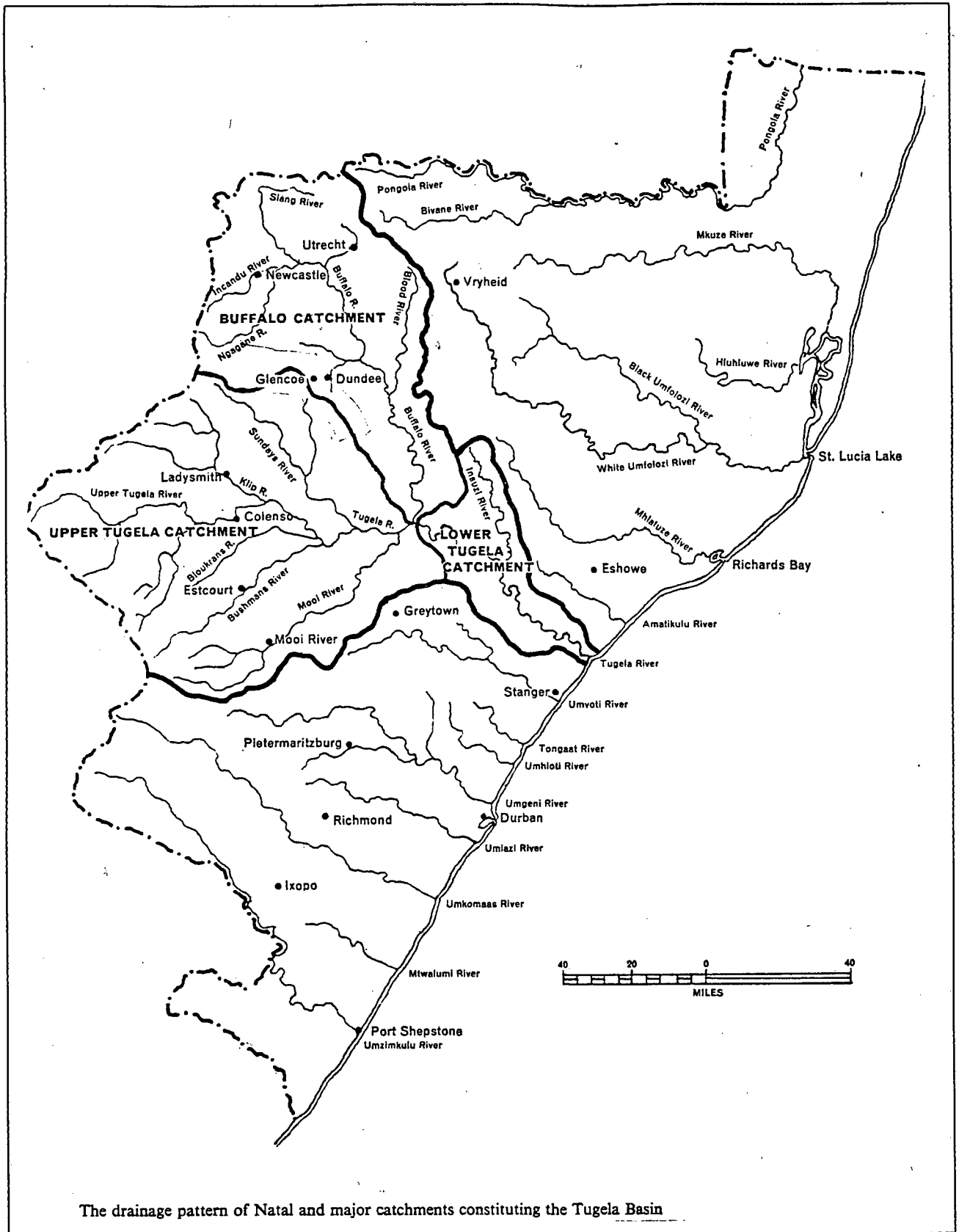
Appendix 1 - Upper Thukela Catchment

Appendix 2a - Firm transparent plastic used for initial tracing of categories

Appendix 2b - tracing paper for tracing categories used to calculate area

Appendix 2c - 2mm blocked graph paper or grid paper

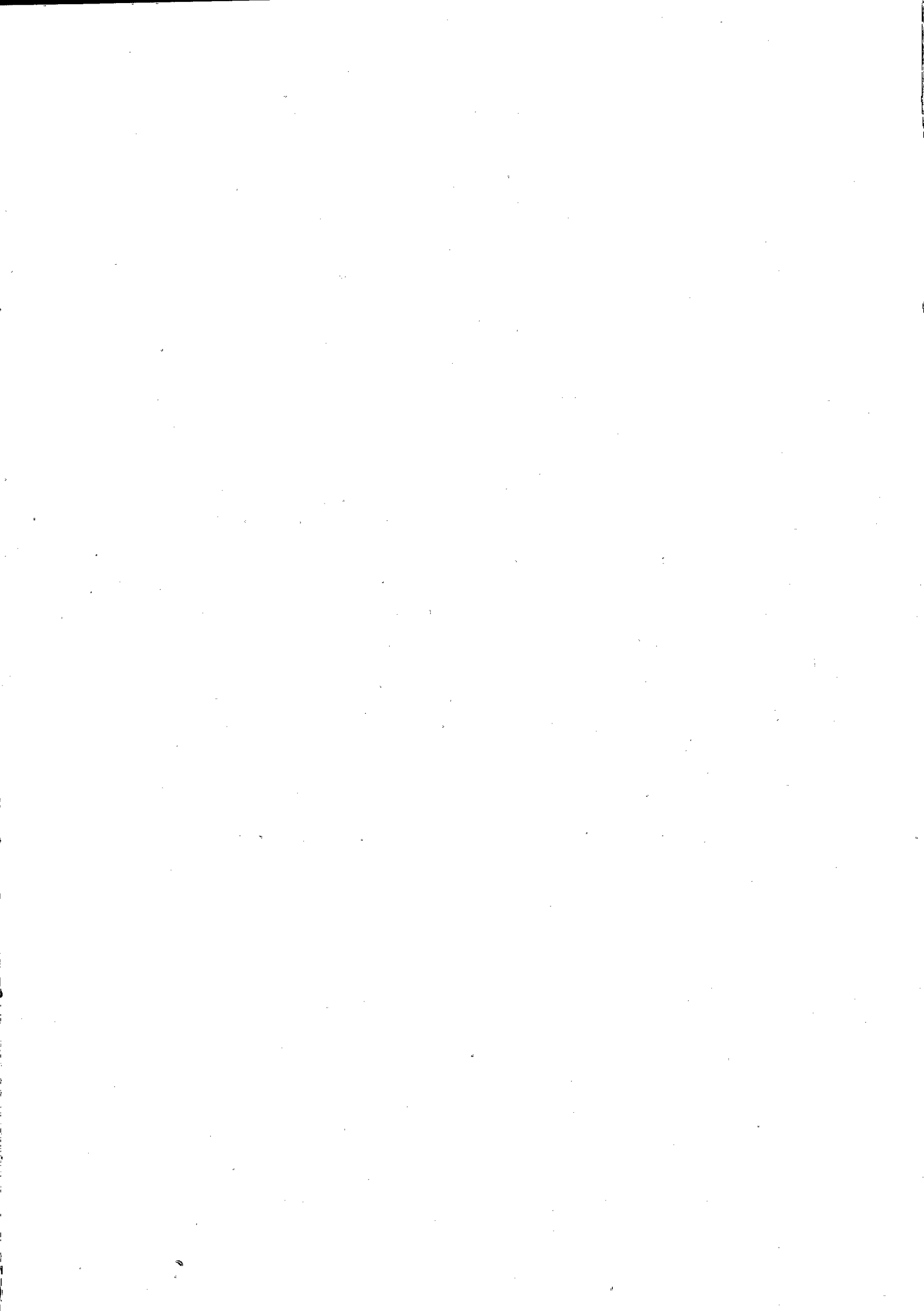
Appendix 1 - Upper Thukela Catchment



Appendix 1: The Upper Thukela Catchment, after Van der Eyk, (1969)

Appendix 2a - Firm transparent plastic used for initial tracing of categories

Appendix 2b - tracing paper for tracing categories used to calculate area



Appendix 2c - 2mm blocked graph paper or grid paper

