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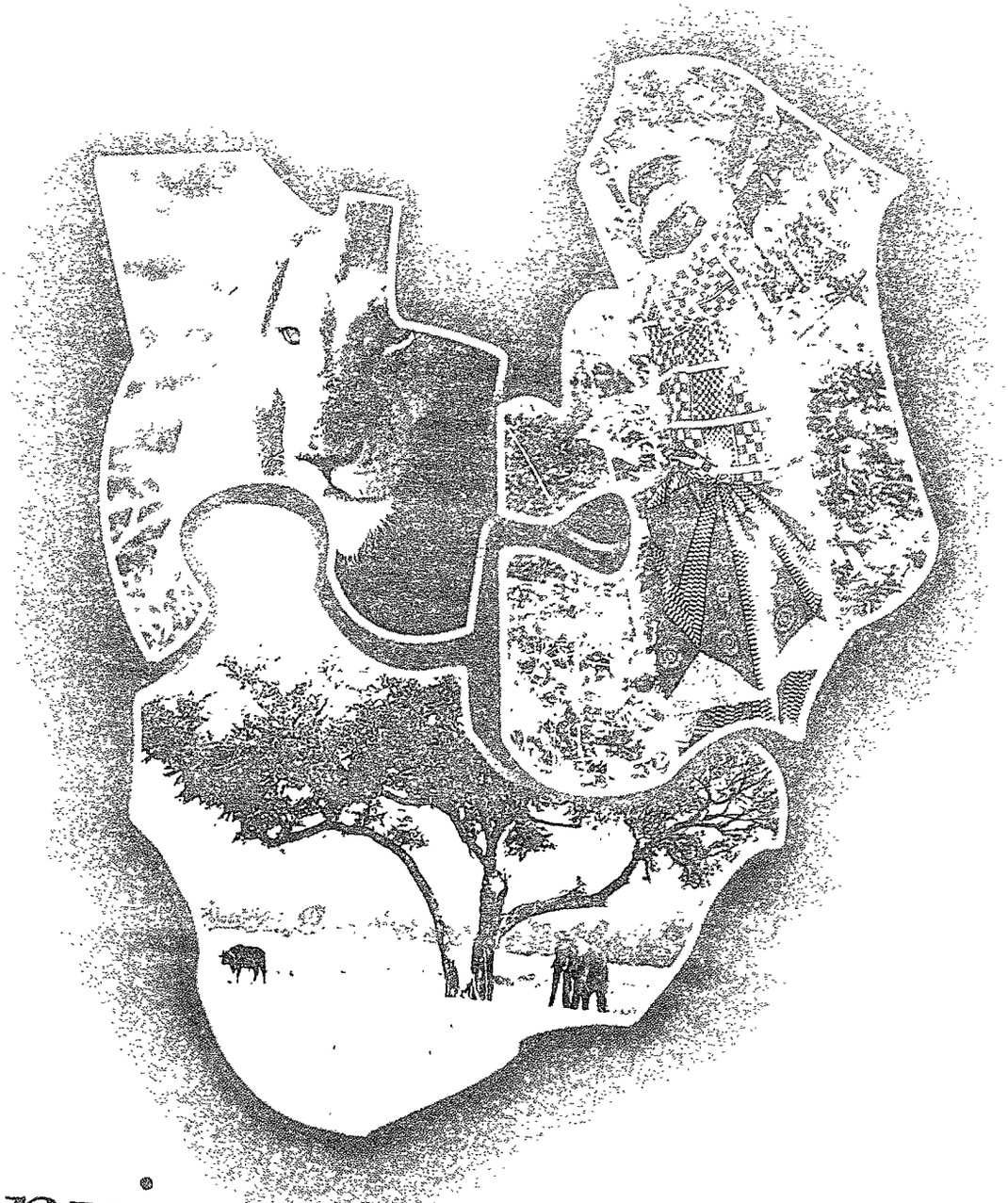
STUDY ON THE DEVELOPMENT OF TRANSBOUNDARY NATURAL RESOURCE MANAGEMENT AREAS IN SOUTHERN AFRICA



environmental context

David Cumming

Study on the Development of Transboundary Natural Resource Management Areas in Southern Africa

ENVIRONMENTAL CONTEXT:
Natural Resources, Land Use, and Conservation

David H. M. Cumming

B

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Contents

BACKGROUND TO THE STUDY iii

CLARIFYING TERMINOLOGY: TBCA/TFCA AND TBNRM v

FIGURES vi

TABLES vii

ACRONYMS viii

ACKNOWLEDGEMENTS ix

1. INTRODUCTION 1

2. ENVIRONMENTAL OVERVIEW 2

2.1 TOPOGRAPHY 2
2.2 GEOLOGY 3
2.3 CLIMATE 3
2.4 SOILS 4
2.5 VEGETATION 5
2.6 BIODIVERSITY 9

3. TRENDS IN LAND AND NATURAL RESOURCE USE 13

3.1 SOME HISTORICAL PERSPECTIVES 13
3.2 THE LAST 100 YEARS 14
3.3 INFRASTRUCTURE, INDUSTRIAL DEVELOPMENT, AND WATER 32

4. CONCLUSIONS 36

REFERENCES 38

ANNEX: ECOLOGICAL CRITERIA FOR THE ESTABLISHMENT OF TBNRMAS 47

FIGURES 67

Background to the Study

"Regional cooperation is not an optional extra; it is a matter of survival."

SADC Policy and Strategy for Environment and
Sustainable Development (ELMS, 1993, p.3)

International borders are political, not ecological, boundaries. As such, key ecological systems and components often occur in two or more nations and are subject to a range of often opposing management and land-use practices. In order to ensure that future generations have sufficient access to natural resources, the management of water catchments, ecosystems, and migratory wildlife must become more multinational and participatory across local, national, and international levels.

USAID's Regional Center for Southern Africa (RCSA) funded the Biodiversity Support Program (BSP), a USAID-funded consortium of World Wildlife Fund, The Nature Conservancy and World Resources Institute, to conduct an assessment and preliminary analysis of issues, approaches, and targets of opportunity related to the development of transboundary natural resource management areas in southern Africa. Geographically, the study covered: Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe.

The study was implemented by the following team:

John Griffin	Team Leader and Institutional, Policy, and Legal Analyst
David Cumming	Conservation Biologist/Park Management Specialist (WWF SARPO)
Simon Metcalfe	Sociologist
Mike t'Sas-Rolfes	Economist
Jaidev "Jay" Singh	Global Review Consultant
Ebenizário Chonguiça	Angola Consultant (IUCN Mozambique).
Mary Rowen	USAID Liaison, Technical Advisor, and Editor (AAAS Fellow, USAID)
Judy Oglethorpe	Study Manager and Technical Advisor (Executive Director, BSP)

GIS support was provided by WWF SARPO (Southern Africa Regional Programme Office). Peace Parks Foundation (PPF) undertook a literature collection and established databases on TBCA literature and regional contacts. Zimbabwe Trust provided administrative and logistical support in the region. Dorothy Zbicz provided information on the number and distribution of TBCAs worldwide.

The study process consisted of the following: a review of relevant available literature; individual consultations in the region with stakeholders; development and circulation of draft papers on specific topics; three consultative meetings (with stakeholders, SASUSG members, and a large final meeting with regional stakeholders); and distribution of a draft final report for comment.

The five reports from the **Study on the Development of Transboundary Natural Resource Management Areas in Southern Africa** are as follows:

1. Main Report,
2. Environmental Context,
3. Community Perspectives,
4. Global Review, and
5. Highlights and Findings

In addition to assisting USAID/RCSA in its strategic planning, this study, as well as the consultations and meetings associated with it, have encouraged and fostered TBNRM discussions in the region. It is hoped that the study's documents are used by all interested stakeholders to further the TBNRM process.

Clarifying Terminology: TBCA/TFCA and TBNRM

The terms *Transboundary Conservation Areas* (TBCA) and *Transfrontier Conservation Areas* (TFCA) are based upon the idea of some aspect of shared environmental management between nations. No real distinction exists between these two terms; they are used interchangeably in the region and in the literature.

The World Bank defines TFCAs as:

"Relatively large areas, which straddle frontiers (boundaries) between two or more countries and cover large-scale natural systems encompassing one or more protected areas."

World Bank, 1996

These terms were considered to have a strong "protected area" focus, and did not necessarily account for natural resource management outside of gazetted protected areas. Hence, the study team has coined a new term to incorporate a more holistic approach, known as Transboundary Natural Resource Management (TBNRM). TBNRM incorporates the concerns of natural resource management, people, political institutions, and national and international organisations, both inside and outside of gazetted protected areas.

The term *Transboundary Natural Resource Management Area* (TBNRMA) is defined as follows:

"An area in which cooperation to manage natural resources occurs across boundaries."

The process itself is called *Transboundary Natural Resource Management* (TBNRM) and is defined as:

"Any process of cooperation across boundaries that facilitates or improves the management of natural resources (to the benefit of parties in the area concerned)."

The emphasis here is on the process, not the geographic area. Hence, if it serves the function of TBNRM, then it is a TBNRMA. A TBNRMA exists as soon as there occurs any type of TBNRM activity represented by some institution (be it a contract, protocol, management plan, or communication forum [formal or informal].

Figures

(located in the back of the document)

1.1 Political boundaries of mainland southern Africa covered in this report
2.1 African general topography, regions of high and low elevation, and major rifts
2.2 Major drainage basins of southern Africa
2.3 Simplified geology map of southern Africa region
2.4 Map of mean annual rainfall in southern Africa
2.5 Rainfall deficit graph for Zimbabwe
2.6 Soil map of southern Africa region
2.7 Floristic regions of southern Africa
2.8 Simplified vegetation map of southern Africa
2.9 WWF ecoregion map for southern Africa
2.10 Savannas of southern Africa
2.11 Relationship between plant diversity and productivity
2.12 Distribution of species richness for selected taxa
2.13 Centers of endemism in southern Africa
2.14 Distribution of elephant in southern Africa
2.15 Distribution of black and white rhino in southern Africa
2.16 Distribution wild dog in southern Africa
2.17 Distribution of buffalo in southern Africa
2.18 Distribution of selected antelope in southern Africa
2.19 Distribution of veterinary disease control fences and tsetse fly in southern Africa
2.20 Major secondary drainage basins within the area covered by WWF SARPO, as well as WWF's priority basins
3.1 Human population growth in southern Africa since c. 1500 AD
3.2 Map of land tenure and distribution of extensive land uses in southern Africa
3.3 Human population densities in southern Africa
3.4 Population trends, livestock, and land cultivated in Zimbabwe, 1900-1995
3.5 Trends in livestock numbers in southern Africa
3.6 Rainfall and livestock biomass densities in southern Africa
3.7 Animal production levels in southern Africa and Europe
3.8 Comparison of standing crop biomass of domestic livestock and wild herbivores
3.9 Growth of protected areas in southern Africa, 1900-1997
3.10 Protected areas and wildlife areas in southern Africa
3.11 Potential transboundary natural resource management areas in southern Africa
3.12 Designated forestry areas in southern Africa
3.13 Major lakes, rivers and wetlands in southern Africa
3.14 Trends in elephant numbers in southern Africa, 1979-1995
3.15 Trends in black rhino numbers in southern Africa, 1980-1998
3.16 Trends in dominant ungulate populations in Marromeu Game Reserve, Mozambique, 1972-1994
3.17 Estimated numbers of the 10 most numerous ungulates in southern Africa
3.18 Biomass of 15 dominant ungulates (in terms of biomass) in southern Africa
3.19 International airports in the region
3.20 Major railways in the region
3.21 Major roads and customs ports in the region
3.22 Major energy (coal and hydroelectric) sites and deposits of coal, gas, and oil
3.23 Distribution of valuable mineral deposits/mines in the region

Tables

1 Phytochorial regions falling within southern Africa and proportion of areas protected and intact within each region
2 Country baseline data on species diversity and endemism for southern Africa
3 Summary of biodiversity rankings of countries in southern Africa
4 Land categories, human population size and growth, and agricultural and energy indicators in southern Africa
5 Trends in arable land, production of selected crops, fish, meat and milk, and fuelwood in southern Africa
6 Summary of major livestock diseases and their prevalence in southern Africa
7 Some links between important livestock diseases and wildlife
8 Communal land, private land and protected areas available to wildlife in southern Africa
9 Summary of the extent of protected indigenous forest reserves in southern African countries
10 Numbers and trends of the larger ungulates in southern Africa, showing status by region and country
11 Occurrence of fences and likely movement of selected large herbivores across international boundaries for the potential TBNRMAs in southern Africa
12 Megabasins in southern Africa that account for 75% of precipitation falling on the region
13 Annual internal renewable water resources, withdrawals, and proportion of withdrawals, by sector, for countries in southern Africa

Acronyms

ALCOM	Aquatic Resource Management for Local Communities
BSP	Biodiversity Support Program
CBD	Convention on Biological Diversity
CBNRM	Community-based Natural Resource Management
CBO	Community-based Organisation
CBPP	Contagious Bovine Pleuropneumonia
CDP	Centres of Plant Diversity Project
CITES	Convention on the International Trade in Endangered Species
DNA	Deoxyribonucleic Acid
ELMS	Environment and Land Management Sector
FAO	Food and Agriculture Organization
FMD	Foot-and-Mouth Disease
FSTCU	Forestry Sector Technical Coordination Unit
IIASA	International Institute for Applied Systems Analysis
IUCN	World Conservation Union
IUCN-ROSA	World Conservation Union-Regional Office for Southern Africa
M&E	Monitoring and Evaluation
NGO	Nongovernmental Organisation
NRM	Natural Resource Management
PA	Protected Area
PAM	Plant Available Moisture
PAN	Plant Available Nutrients
RCSA	Regional Center for Southern Africa
RSPB	Royal Society for the Protection of Birds
SADC	Southern African Development Community
SASUSG	Southern African Sustainable Use Specialist Group
SSC	Species Survival Commission
TB	Tuberculosis
TBCA	Transboundary Conservation Area
TBNRM	Transboundary Natural Resource Management
TBNRMA	Transboundary Natural Resource Management Area
TFCA	Transfrontier Conservation Area
TLU	Technical Livestock Unit
UNDP	United Nations Development Programme
UNFPA	United Nations Fund for Population Activities
USAID	United States Agency for International Development
USGS	United States Geological Survey
WB	World Bank
WMA	Wildlife Management Area
WRI	World Resources Institute
WSTCU	Wildlife Sector Technical Coordination Unit
WWF-US	World Wildlife Fund
WWF SARPO	World Wide Fund for Nature/Southern Africa Regional Programme Office
ZACPLAN	Zambezi River Basin Action Plan

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1. Introduction

There is extensive literature on the environment and natural resources of the mainland countries of southern Africa[1] (see Fig. 1.1 for the political boundaries of countries covered in this report)), but few studies exist on the region as a whole. Notable overviews of the ecology of the region include Werger and van Bruggen (1978) and Huntley and Walker (1982). Studies dealing broadly with the natural resources of the region, largely from an agricultural or development perspective, include Moyo, O'Keefe, and Sill (1993) and Chenje and Johnson (1994). Few studies deal with the environment of the region from a conservation perspective, but Huntley (1989) covers some aspects of biodiversity conservation in southern Africa and MacKinnon and MacKinnon (1986), Davis, Heywood and Hamilton (1994), and Stewart and Adams (1990) deal with conservation issues for the African continent. Few studies have examined southern Africa from the perspective of wildlife and land use (Cumming and Bond 1991; Cumming 1995).

This review attempts to bring together, at a macro level, selected key features of the southern African environment that have a bearing on land use and conservation issues and the creation of transboundary natural resource management areas (TBNRMAs). The focus of this review is on trends and changes in selected aspects of the ecology and land use of the region, and these can be examined at several temporal and spatial scales. The most useful scales, in the context of this review, are geological (millions of years at a continental scale), historical (hundreds of years over the subcontinent), and contemporary ecological changes over tens of years at national or local scales.

[1] Southern Africa, as used here, refers to the 11 mainland African countries that formed mainland SADC (i.e., Angola, Botswana, Lesotho, Namibia, Malawi, Mozambique, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe) before the Democratic Republic of Congo (DRC) became a member.

2. Environmental Overview

2.1 Topography

Africa is an ancient land mass, and its geological history is a major determinant of its present biology and biogeography. The continent comprises a pre-Cambrian shield that has formed over a period of more than 3,500 million years. Some 230 million years ago, Africa separated from Pangea to form the southern land mass of Gondwanaland, which, as it drifted north from the south pole, divided into South America, Africa, Madagascar, and India. From the end of the Cretaceous (67 million years ago) through the end of the Oligocene (about 25 million years ago), Africa was surrounded by seas, and its plants and animals evolved in relative isolation. Africa then drifted into Eurasia, and the fusion of these land masses across what has since become the Arabian peninsula allowed the movement of Eurasian fauna into Africa. The reverse, of course, also occurred with elephants and mastodons, among others, moving out of Africa into Europe and Asia. Changes in climate and the drifting apart of Africa from Eurasia about 15 million years ago resulted in Africa again becoming isolated during the Pleistocene, during which time the African fauna evolved into its present form.

Africa can be conveniently divided into "high" and "low" Africa (White 1983). Most of west and much of central and northern Africa are relatively low-lying, comprising sedimentary basins and upland basins located at 150-600 m above sea level. The major catchments are those of the Senegal, Niger, Chad, and Congo rivers and the lower Nile. Most of eastern and southern Africa, on the other hand, apart from Somalia and the Mozambique coastal plain, are situated at altitudes of above 1,000 m. Even the vast internal drainage basin of the Okavango lies above 1,000 m. The generally higher altitudes prevailing in eastern and southern Africa moderate tropical and subtropical climates and so influence patterns of human settlement and land-use systems and, ultimately, conservation in the region (see Fig. 2.1).

The Rift Valley system, a dominant feature of the relief of high Africa, extends from Turkey in Eurasia to northern Zimbabwe. The Eastern Rift runs from Tanzania north into Kenya, then northeast to split the Ethiopian plateaus before diverging north into the Afar depression and the Red Sea and east into the Gulf of Aden. The Western Rift starts in the upper Nile and Lake Edward, and runs south through lakes Kivu, Tanganyika, and Malawi to the coast near Beira. A branch extends along the Luangwa Valley and the Middle Zambezi to reach the margins of the Okavango swamps in Botswana. (see Fig. 2.1).

The narrow coastal plains of Tanzania and Mozambique give way to ranges of mountains that form a saucer-like rim on the east coast of Africa, extend southward to the Cape, and then northward along the west coast of Namibia and into the Angolan highlands. The interior of the region formerly held a vast internal drainage basin, giving rise to sedimentary deposits, such as the Karoo sandstones and the vast coal deposits in Botswana, South Africa, and Zimbabwe. The basin rim has been breached by the Orange River in the south and the Limpopo and Zambezi rivers to the north, with the remnants of the ancient internal drainage basin now represented by the Okavango drainage basin (see Fig. 2.2).

2.2 Geology

African geological formations span a period of more than 3,500 million years, with some of the world's oldest pre-Cambrian rocks appearing in outcrops in South Africa and Zimbabwe. The African pre-Cambrian shield, or basal complex, surfaces over much of Tanzania, Zambia, the Transvaal and Free State provinces in South Africa, and the western rim of southern Africa in the highlands of Namibia and Angola.

The major geological regions of southern Africa are outlined in Fig. 2.3 and described below (FAO-UNESCO 1977). The *Rift Valley zone,* comprising granite and metamorphic rocks of the basement complex lies in Tanzania, between the eastern and western Rift valleys. The *Mozambique belt*, extending southward from the Ethiopian highlands, through Kenya, eastern Tanzania, and into northern Mozambique, comprises mainly metamorphic rocks with some areas of recently unconsolidated fluvial, lacustrine, and coastal sediments, particularly in the region of the Rovuma Delta. The *Zambian-Zimbabwean highlands and Malawi trough* extends over most of Zambia, Malawi, and into southeastern Zimbabwe. As in the inter-Rift Valley zone, it is made up mainly of basement complex granite, gneiss, and migmatites. The major igneous intrusion of the Great Dyke of Zimbabwe falls within this area, and some consolidated carbonate sediments occur in northern Zambia. Karoo sandstone and shale outcroppings occur in the Zambezi River escarpment area in northwestern Zimbabwe. The *Mozambique Plain* extends from the Zambezi River southward to the Mkuze in northern Natal and comprises mainly unconsolidated Tertiary and Pleistocene aeolian and fluvial sediments. This formation is bounded in the southwest by the doleritic and metamorphic rocks of the Transvaal plateau escarpment. The *Transvaal Plateau, Limpopo depression, and Kaap Plateau*, with the adjoining *Karoo System*, form the major South African plateaus, which include a wide range of rock formations from the basement complex and from metamorphic and sedimentary series of the Karoo System. The *Kalahari Basin*, one of the largest geological regions in Africa, comprises mainly unconsolidated tertiary and Pleistocene aeolian and fluvial sediments. This is the vast region of Kalahari sands, which form the world's largest sand sea. Lying between the Kalahari basin and the coast is the *South Western Region*, which includes a wide range of lithological regions, but is mainly covered by metamorphic rocks, granites, and gneisses of the basement complex with some igneous intrusions. On the southernmost tip of Africa are the *Southern Cape Ranges*, which, along with the Atlas Mountains in north Africa, are the only folded mountain ranges on the continent.

2.3 Climate

In geological time scales, the climate of the region has fluctuated greatly. Detailed changes in climate over the past two millennia have been derived from oxygen isotope analysis of a speleothem from the Cango Caves in Cape Province and from diatomaceous sediments from Walvis Bay and other sites in South Africa (Tyson 1993). These data suggest the following main features: A cooler period (*c.* 100-200 AD), a warmer period (*c.* 250-600 AD), followed by a variable period of cooling until (*c.* 900 AD), four centuries of warmer conditions coinciding with the Medieval Warm Epoch, with highest temperatures in the tenth and eleventh centuries. This period was followed by the "Little Ice Age," which extended from 1300 to 1850 and has been followed by a period of recovery and warming, with the possibility of a superimposed human-induced greenhouse effect and global warming (Hume 1996). Current temperatures appear to be as high, if not higher, than they have been in the last 2,000 years.

Rainfall patterns in the subregion change from winter rainfall in the Cape to a single summer rainfall season in the subtropics and a dual rainy season close to the equator in the northern half of Tanzania. Mean annual rainfall varies between <100 mm per annum on the west coast to >1,800 mm per annum in the eastern montane regions range (see Fig. 2.4). However, a high proportion (about 60%) of the region receives less than 600 mm per year and thus falls within the semi-arid to arid category and most (> 75%) of the region is subhumid or drier.

Southern Africa's climate during the last century has been characterised by oscillating wet and dry decades, with droughts occurring in 1910, during the 1920s, 1947-1948, 1967-1973, 1981-1982, and 1991-1992 (Chenje and Johnson 1994), with an extended dry period (1980-1997) in such parts of the region as Zimbabwe (see Fig. 2.5) that resulted in a cumulative rainfall deficit of close to 2,000 mm. More recently, wet and dry periods in southern Africa have been linked to oscillations in temperature of the southern oceans and the El Niño phenomenon (Mason 1990; Glantz 1996). The relationship between southern ocean temperatures in winter and subsequent summer rainfall has now been sufficiently well established to allow reasonably confident predictions of broad temporal and spatial patterns of rainfall over southern Africa before the rains start (Cane, Eshel, and Buckland 1994).

In the land-use context of southern Africa, the key climatic feature is highly variable rainfall over both longer periods (hundreds of years) and shorter ones (decades). The productivity of most ecosystems in the region is more closely tied to rainfall than to temperature, although higher temperatures may result in increasing evapotranspiration and aridity.

Because rainfall is the prime driving variable in these ecosystems, primary and secondary production are closely linked to rainfall (Coe, Cumming, and Phillipson 1976). As a result, the savanna and rangeland ecosystems in particular can be characterised as event-driven or disequilibrial systems--a factor that has several consequences for resource management and land use (Westoby, Walker, and Noi-Meyer 1989; Behnke, Skoones, and Kerven 1993; Skoones 1994). The most important consequence of the highly variable and seasonally unpredictable levels of primary and secondary production is the highly variable levels of food production and financial returns to farmers. Production systems that can buffer the vagaries of weather and its effects on primary production and animal production systems are thus at a premium. Systems based on tertiary service products, such as tourism, rather than on primary production of crops or secondary production of meat and milk, offer a realistic supplementary or alternative land-use option under variable arid and semi-arid conditions. This general principle is, or should be, an important consideration in land-use policy, irrespective of whether areas suitable for wildlife use are adjacent to international boundaries or whether they are an option for TBNRMAs.

2.4 Soils

Soils in the region (see Fig. 2.6) are tied closely to the geological substrate modified by climatic weathering processes, particularly by moisture regimes. Because of the close links between soils and geological formations, soils in the region are generally derived from ancient nutrient-poor formations. Dominant soil types within southern Africa, in terms of area, are arenosols covering the Kalahari basin, acrisols that cover much of the Sudano-Zambezian savanna (the plateaus of Tanzania, Zambia, Malawi, and northern Mozambique), and luvisols and ferralsols that cover much of Zimbabwe and northern Mozambique. These soil types are poor and generally not suited for cultivation (FAO-UNESCO 1977). They cover some 66% of

the region. Fertile soils suited to intensive agricultural production are the vertisols of the Transvaal maize triangle and parts of Natal in South Africa, and the irrigable soils of the South East Lowveld of Zimbabwe. Vertisols cover about 2.5% of the region. The complex of volcanic ash soils and vertisols in northern Tanzania is also very fertile. Pockets of fertile alluvial soils occur along rivers throughout the region, and larger pockets are indicated in the soil map (Fig. 2.6). An important feature of the soils of southern Africa is that they are derived from an ancient landscape that has eroded over billions of years, resulting in soils that have been leached of important nutrients. Phosphorus deficiency is widespread in the region, and levels of phosphorus in forage are low enough to adversely affect growth of domestic livestock (Butterworth 1985).

2.5 Vegetation

Of the 20 phytochorial regions in Africa defined by White (1983), 10 occur within southern Africa (Table 1; see Fig. 2.7). The smallest phytochorial region is the *Cape regional centre of endemism (Region V)*, which, at a global level, is recognised as a distinct floral Kingdom (Cape Floral Kingdom). The dominant vegetation type is Fynbos, in which about 80% of the plant species occur. Other vegetation types include Renosterveld, Fynbos/thicket mosaic, Afromontane forest, and Thicket and Succulent Karoo (Cowling and Richardson 1995). This region is floristically one of the richest in the world, with some 8,500 species. It is, however, well removed from any transboundary conservation area considerations. This unit extends over 71,000 km^2, with only about 2.5% of it protected (MacKinnon and MacKinnon 1986).

Table 1. Phytochorial Regions Falling within Southern Africa and Proportion of Areas Protected and Intact within Each Region

Phytochorial Region	Area (km^2) of Region*	Area (km^2) Protected	Percent Protected	Percent Intact
II Zambezian	3,939,100	306,435	7.7	57
IV Somali-Masai	1,990,000	96,288	4.8	52
V Cape	71,000	12,364	17.0	40
VI Karoo Namib	692,600	48,510	7	57
VIII Afromontane	715,000	29,600	4.5	37
X Guinea-Congolia/Zambezia transition zone	705,000	2,600	0.3	49
XII Lake Victoria Mosaic	224,000	16,076	7.7	16
XIII Zanzibar-Inhambane regional mosaic	336,000	14,818	3.9	38
XIV Kalahari- Highveld Transition zone	1,223,000	92,839	7.2	38
XV Tongoland-Pondoland regional mosaic	148,000	8,926	6.0	46
Total	10,043,700	638,499	6.4	

* Note: some regions extend beyond the area of southern Africa defined in this report.
Source: MacKinnon and MacKinnon (1986).

The largest regional center of endemism is *the Zambezian (Region II)*, comprising 3.77 million km^2 that includes some 8,500 flowering plants, of which about 54% are endemic. This region is as rich in plant species as the central African lowland evergreen forests. The vegetation types mapped within this phytochorial region range from Zambezian dry forest;

through miombo, mopane, and Kalahari woodlands; to thickets, scrublands, and grasslands (see Fig. 2.8). About 8% of the region falls within protected areas, but a high proportion of the unprotected area has been transformed.

The *Somali-Masai regional center of endemism (Region IV)* extends from the Horn of Africa through Kenya and into northern Tanzania. It is mostly a low-lying, arid region with about 2,500 plant species, including 50 endemic genera. In Tanzania, this region covers the Serengeti plains and the Masai steppe, with the vegetation types covering Acacia-Commiphora bushland thickets, secondary grasslands and wooded grasslands, semi-desert grassland and shrubland, and East African semi-evergreen bushland and thicket on the drier slopes of mountains in central Tanzania. About 5% of the region as a whole is protected.

The Karoo-Namib regional center of endemism (*Region VI*) covers the southwestern and western Cape Province in South Africa and extends northward through Namaqaland, Namaland, and the Namib desert to the Cunene River and the arid coastal strip of southern Angola. Of the 3,500 or more plant species, more than 50% are endemic. The main vegetation types in this region are the Bushy Karoo scrubland, Succulent Karoo scrubland, Dwarf Karoo scrubland, Montane grassy Karoo scrubland, and the Namib Desert. The Namib desert can be subdivided into three regions: Northern Namib, which extends from the Huab northward; Central Namib, which extends from the Huab south to the Kuiseb rivers; and Southern Namib, which lies to the south of the Kuiseb. There is also a distinction between the inner Namib nearer the coast, which experiences fog, and the outer Namib, which is dry. Approximately 7% of the area is protected.

The *Afro-montane Archipelago regional center of endemism (Region VIII)* is a composite archipelago of mountainous areas of diverse geological formations and origins (see Fig. 2.7). The Ethiopian highlands are formed mainly of basalt, although pre-Cambrian rocks do occur as outcrops. The Kenyan highlands and mountains, such as Elgon, Kivu, and Kilimanjaro in Tanzania, are mainly volcanic in origin, while the Kivu ridge and Ruwenzoris are predominantly pre-Cambrian rocks. The montane areas of Malawi and eastern Zimbabwe are basement complex, while much of the Drakensberg in South Africa is capped by basalt. The flora is composed of about 4,000 species, of which nearly two thirds are endemic. Vegetation types vary widely on any particular mountain (from Afromontane forest, bamboo, evergreen bushland thicket, shrublands, Afromontane and Afro-alpine grasslands; to mixed Afro-alpine communities). Only about 4.5% of the region is protected.

The *Guinea-Congolia/Zambezi transition zone (Region X)* is a transition zone to the south of the lowland forests of the Congo. Within the SADC region, it occurs in northern Angola on Kalahari sands. Species richness is low, with only about 2,000 species, excluding invaders from adjacent regions. The zone includes the "Dembos" cloud forests on the coastal escarpment and tongues of lowland forest, which extend southward from the Guinea-Congolian forest to the north. Protected areas cover 1.7%.

The *Lake Victoria regional mosaic (Region XII)* covers Uganda and extends marginally into the northwestern corner of Tanzania. It is the meeting place of five distinct floras; nonetheless, it includes only about 3,000 species, with no endemic genera and very few endemic species. Nearly 8% of the region is protected.

The *Zanzibar-Inhambane regional Mosaic (Region XIII)* extends along the coastal belt from north of Mombasa on the Kenyan coast, south to Inharime north of Maputo in southern Mozambique. These are low-lying areas, most occurring at altitudes of less than 200 m, but

some extending to hills and plateaus, such as the Usambara Mountains in Tanzania and the Macondes Plateau in northern Mozambique. The mosaic includes about 3,000 species. Of its 190 forest tree species, nearly 50% are endemic. Less than 4% of the region falls within protected areas.

The *Kalahari-Highveld regional transition zone (Region XIV)* separates Zambezian and Karoo-Namib regional centers of endemism and occurs on the interior plateau of southern Africa, mainly in the Kalahari basin. In the east, it rises to the plateau rim of the great escarpment underlain by Karoo rocks and, in the west, reaches the highlands of the Windhoek Mountains of pre-Cambrian and Paleozoic rocks. The flora includes about 3,000 species, and the vegetation units range from Afromontane scrub and highveld grasslands, scrub woodlands, Acacia woodlands and wooded grasslands, mopane scrub, and Kalahari/Karoo/Namib transitions. About 7.2% of the region is located within protected areas.

The *Tongoland-Pondoland regional mosaic (Region XV)* extends from the Limpopo mouth in Mozambique to Port Elizabeth in the eastern Cape. The coastal plain of Cretaceous and tertiary sediments carry about 3,000 species, of which some 40% are endemic. Vegetation types include coastal forest mosaics, bushland, evergreen bushland thickets, and wooded bushlands often in a matrix of secondary grassland and wooded grassland. About 6% of the region lies within protected areas.

To date, the most comprehensive analysis completed of African areas under protection in relation to vegetation types and level of habitat transformation is that of MacKinnon and MacKinnon (1986). The levels of protection for the major biogeographical areas (i.e., White's 1983 Phytochoria) in Africa are summarised in Table 1, along with the estimated levels of habitat transformation in the early 1980s.

The environment of southern Africa has also been described in terms of "ecozones" (Chenje and Johnson 1994), "Ecofloristic zones" (Sharma 1988; Green et al. 1996), and "Ecoregions" (WWF-US 1997). In addition, several countries have developed land-cover maps that depict cover in terms of forest, woodland, grassland, and cultivated areas. The land-cover maps for northern Mozambique, Tanzania, Zambia, and Zimbabwe are presently being consolidated into a single map for the miombo ecoregion by the Miombo Network (Paul Desanker, pers. comm.). Land-cover maps for South Africa are available from the CSIR and for Zimbabwe from the Forestry Commission.

Green et al. (1996?) examined the extent to which ecofloristic zones in the tropics were protected. They covered all of sub-Saharan Africa, in which 65 ecofloristic zones were recognised. These, in turn, were grouped into 12 major habitat zones, in which the level of protection (as indicated by areas of national parks and protected areas) varied from 0.4% in Montane Dry habitat to 12.1% in lowland Sub-Dry habitat. In their summary map, most of southern Africa showed habitat protection levels of greater than 5%, with the Karoo-Namib area falling below 5% and the Drakensberg area falling below 1%.

WWF-US developed an ecoregion map for Africa; the ecoregions occurring in southern Africa are shown in Fig. 2.9. The delineation of ecoregions, based partly upon White's vegetation map and expert opinion, was part of a larger, worldwide program of ecoregion mapping (Olson and Dinerstein 1998). On the basis of biological diversity, threat, and global uniqueness, 200 ecoregions, known as the Global 200, have been selected by WWF for an ecoregion-based approach to conserving biodiversity. Of the ecoregions that wholly or partly fall within southern Africa, the following 15 ecoregions have been included within the

Global 200: Albertine Rift montane forests (7), East African coastal forests (8), Eastern Arc montane forests (9), Central and eastern mopane and miombo woodlands (88), Zambezian flooded grassland savannas (98), Southern Rift montane woodlands (103), East African moorlands (104), - Drakensberg montane shrublands and woodlands (105), Fynbos (118), Namib – Karoo - Kaokoveld desert (124), East African mangroves (136), Congo river and flooded forests (143), Cape rivers and streams (164), Rift Valley Lakes (182), and East African marine (233).

Other important vegetation descriptions and mappings include Acocks (1957) for South Africa; Wild and Grandvaux Barboza (1967), which covers the Flora Zambeziaca region and includes all of Botswana, Malawi, Mozambique, Zambia, and Zimbabwe, and the eastern portion of Angola. The vegetation map for the Flora Zambeziaca region has been digitized by the WWF Programme Office in Harare. A vegetation map of the Federation of Rhodesia and Nyasaland was compiled by Rattray (1962), and Rutherford and Westfall (1986) described the biomes of southern Africa. Giess (1971) has mapped the vegetation of Namibia, and vegetation mapping for Tanzania has been included in descriptions of the vegetation of East Africa (e.g., Greenway 1973).

A simple and functionally revealing classification of habitat types in the savannas of southern Africa is that of Huntley (1982), who distinguished moist, dystrophic (nutrient poor) savannas from arid, eutrophic (nutrient rich) savannas (see Fig. 2.10). Bell (1984, 1986) extended these ideas to link the presence of large, wild herbivores to food quality and habitat types that are, in turn, structured by plant available moisture (PAM) and plant available nutrients (PAN). The performance of mammalian herbivores depends largely on their body size, gut structure, and digestive physiology. African ungulates include a wide spectrum; from very small ruminants (e.g., duikers, dik-diks), which feed selectively on small, high-quality components of the vegetation and have very narrow dietary tolerances; to very large non-ruminants, which tolerate a wide range of low-quality plant material, but which require large quantities of forage (e.g., elephants, rhinos, and hippos). Thus, low nutrient levels combined with high moisture in the savannas result in poor-quality woodlands--i.e., woodlands where the nutrient quality of food available to herbivores is low in protein and high in fibre.

These conditions are characteristic of a large part of the miombo woodlands of the region, which carry a low biomass of large, wild herbivores and livestock. High nutrients and high moisture result in high-quality woodlands, such as those that occur in the Luangwa Valley, which carry a high large herbivore biomass and many species. Low PAM, combined with high nutrients, results in high-quality grasslands, such as the Serengeti, which carry a high biomass comprising many large herbivores. Low PAM or low infiltration rates, combined with low nutrients, characterise the montane grasslands of the region (e.g., Nyika, Nyanga) and large areas of the Kalahari sands, where large herbivore biomass is low and diversity low. The key implication of these insights is that attempts over the last century to replace a spectrum of wild large herbivores adapted to these various niches with a single species of domestic animal makes little sense ecologically (Owen-Smith and Cumming 1993; Cumming 1995), and are unlikely to be sustainable.

The ecological insights of the simple models derived from the interaction of soil nutrients and moisture have larger implications for land use, food production, and conservation. Huston (1993, 1995) argued that, while agricultural production increases with general soil productivity (a combination of soil, temperature, and nutrient properties), plant diversity tends to be highest at lower levels of soil productivity. Given this relationship between productivity and diversity, it is clear that a sensible approach to conserving biodiversity is to avoid subsidising agricultural

development on marginal soils and to promote it where subsidies are not required to sustain production (see Fig. 2.11).

2.6 Biodiversity

2.6.1 Distribution of species richness and endemism

A tabulation of species numbers, numbers of endemics, and species density for vertebrate groups and flowering plants reveals that, within the region of South Africa, Tanzania and Mozambique have the greatest diversity (at least for those groups and criteria included in the analysis). The lowest levels of diversity occur in Lesotho, Namibia, and Botswana (see Tables 2 and 3). While the distribution of species richness and species densities are readily compiled at the country level, few data are available at finer levels of resolution (e.g., 1° grid squares) for the region as a whole.

Ideally, we need to be able to plot species richness and levels of endemism at about the ¼ degree grid square level (or at least at 1° grid square level) across the region, but such data are not currently available or accessible. An impressive national level compilation has recently been completed for Namibia (Barnard 1998). Several good data sets exist for parts of southern Africa, the best example being the Bird Atlas, which covers southern Africa south of the Zambezi/Cunene rivers. Several studies of patterns of species richness and distribution of endemics have been published for South Africa (e.g., Skelton et al. 1993; Drinkrow and Cherry; 1995; Gelderblom, et al. 1995; Gelderblom and Bonner 1995). However, even in South Africa, there are large gaps in data coverage of vertebrate groups other than birds (Lombard 1995).

Species distribution maps in guidebooks (e.g., mammals, birds, trees) are often problematic (Freitag and van Jaarsveld 1995) and generally not readily available in digital form. Limited sets of data (e.g., distribution of antelope in southern Africa) have been digitized by WWF SARPO from East's Global Survey and Action Plans for the IUCN Antelope Specialist Group (East 1989).

Analyses of species richness at a continental scale have been published for butterflies (Carcasson 1964); passerine birds (Crowe and Crowe 1982); water birds (Guillet and Crowe 1985); plants, primates, and ungulates (MacKinnon and MacKinnon 1986); and mammals (Turpie and Crowe 1994). For butterflies, the highest levels of species in Africa occur in the region of Cameroon and in southern Africa along the Tanzanian coastal forest. The studies on birds and mammals show the highest levels of species richness occur in Tanzania and the lowest in the desert region of Namibia and the northern Cape Province of South Africa. The highest levels of species richness for plants, outside of the Cape floral kingdom, according to MacKinnon and MacKinnon (1986), falls across northern Angola, Zambia, and southern Congo; however, the origin and basis of their map is not given. Menaut (1983), in a review of the vegetation of African savannas, placed the highest species density in northern Tanzania. Combining the broad species distribution isolines for mammals, birds, reptiles, and amphibians into a composite, normalised score for species richness indicates highest levels of species richness along the Afro-montane belt and across into the Angolan highlands. These data provide no more than a broad and somewhat crude indication of the distribution of species richness and endemism in southern Africa (see Fig. 2.12). A key issue to emerge from many studies of species richness distributions of particular taxa is that the "hotspots" for one taxonomic group

Table 2. Country Baseline Data on Species Diversity and Endemism for Southern Africa

Criteria	Angola	Botswana	Lesotho	Malawi	Mozambique	Namibia	South Africa	Swaziland	Tanzania	Zambia	Zimbabwe
Area (km^2)	1246700	600372	30350	118484	783030	824292	1221040	17366	886040	752614	390245
No. species											
Mammals	276	154	33	187	179	154	247	47	310	229	196
Birds	872	569	288	630	666	640	774	496	1016	732	634
Reptiles	150	143	50	124	170	140	301	106	273	160	156
Amphibians	80	36	35	69	62	32	95	39	121	83	120
Fish	268	81	8	600	500	97	220	45	250	156	132
Flowering Plants	5000	2000	1576	3600	5500	3159	20300	2636	11000	4600	6000
Total	6646	2983	1990	5210	7077	4222	21937	3369	12970	5960	7238
Species density	5.33	4.97	65.57	43.97	9.04	5.12	17.97	194.00	14.64	7.92	18.55
Rank score											
Mammals	2	8	11	6	7	8	3	10	1	4	5
Birds	2	9	11	8	5	6	3	10	1	4	7
Reptiles	6	7	11	9	3	8	2	10	1	4	5
Amphibians	5	9	10	6	7	11	3	8	1	4	2
Fish	4	9	11	1	2	8	5	10	3	6	7
Flowering Plants	5	10	11	7	4	8	1	9	2	6	3
Rank score											
Vertebrates	3.8	8.4	10.8	6.0	4.8	8.2	3.2	9.6	1.4	4.4	5.2
Rank score											
Plants	5	10	11	7	4	8	1	9	2	6	3
Rank score											
Species density	9	11	2	3	7	10	5	1	6	8	4
No. endemics											
Mammals	4	0	0	0	2	0	4	0	12	6	2
Birds	0	0	0	0	0	0	4	0	13	1	0
Reptiles	0	0	0	5	1	0	116	0	48	0	0
Amphibians	20	0	2	4	2	2	49	0	40	1	2
Fish	0	0	1	450	400	0	0	0	230	0	1
Flowering Plants	1260	17	2	69	219	45	18000	4	110	211	95
Total	1284	17	5	528	624	47	18173	4	453	219	100
Rank Score											
Endemics											
Mammals	3	7	7	7	5	7	3	7	1	2	5
Birds	4	4	4	4	4	4	2	4	1	3	4
Reptiles	5	5	5	3	4	5	1	5	2	5	5
Amphibians	3	9	5	4	5	5	1	9	2	9	5
Fish	6	6	4	1	2	6	6	6	3	6	4
Flowering plants	2	9	11	7	3	8	1	10	5	4	6
Rank Score											
Vertebrates	21	31	25	19	20	27	13	31	9	25	23
Rank Score											
Flowering Plants	2	9	11	7	3	8	1	10	5	4	6

Note: Rank scores for species richness, endemism, etc. were assigned to each country (1 = highest and 11 = lowest).

Table 3. Summary of Biodiversity Rankings of Countries in Southern Africa

Criteria	Angola	Botswana	Lesotho	Malawi	Mozambique	Namibia	South Africa	Swaziland	Tanzania	Zambia	Zimbabwe
Ranks											
No. Vertebrate Species	3	9	11	7	5	8	2	10	1	4	5
No. Plant Species	5	10	11	7	4	8	1	9	2	6	3
Species per 1,000 km^2	9	10	2	3	7	10	5	1	6	8	4
No. Endemic Vertebrates	5	10	7	3	4	9	2	10	1	7	6
No. Endemic Plants	2	9	11	7	3	8	1	10	5	4	6
Total Rank Score:	24	48	42	27	23	43	11	40	15	29	24
OVERALL RANK:	4	11	9	6	3	10	1	8	2	7	4

Note: Rank scores from Table 2 (1 = highest and 11 = lowest).

seldom coincide with those of another. Kerr (1997), for example, found that endemism and species richness patterns coincided but only within a taxon and not between taxa. A reserve system based on species richness/endemism for carnivores did not provide significantly different levels of protection for invertebrates than did randomly selected quadrats.

Essentially, similar considerations apply to the mapping of centers of endemism and the summary map presented here (see Fig. 2.13). The distribution and boundaries of endemic areas or centers of endemism are derived from the literature (Bibby et al. 1992, for birds; Groombridge 1992, for reptiles, amphibians, and mammals). However, the basis upon which these maps have been compiled is not always clear, and the level of mapping accuracy, apart perhaps from that on birds, is, at best, crude.

Centers of plant species richness and endemism have been selected globally under the Centres of Plant Diversity Project (CDP), a major international collaborative exercise, which has chosen 82 sites in sub-Saharan Africa (Davies et al. 1994). Of these selected sites or areas of high species richness and endemism, 26 fall within southern Africa. Half of the 26 sites fall within Tanzania, and nearly half (11) are within the Afro-montane Regional Centre of Endemism. From the perspective of TBNRMAs/TBCAs, important sites include the Zambezi source area (Zambia/Angola), Kaokoveld (Angola/Namibia), Succulent Karoo (Namibia/South Africa), "middle Rovuma River" (Mozambique/Tanzania), Maputaland center (South Africa, Swaziland, and Mozambique), Drakensberg Afro-alpine region (Lesotho/South Africa), and the Chimanimani Mountains (Mozambique/Zimbabwe).

2.6.2 Distribution of endangered and "flagship" species

The distribution of certain key or "umbrella" large mammal species has a bearing, both ecologically and economically, on the development of TBNRMAs/TBCAs and corridors linking existing protected areas. Reasonably accurate range maps are available for such species as

elephant, rhino, cheetah, wild dog, buffalo, and the full range of antelope species in the region (East 1989; Skinner and Smithers 1990) (see Figs. 2.14-2.18). In several areas, important populations of these species straddle international borders, are located close to international borders, or cross-border movements are constrained by game fences. In many cases, constraining fences have been erected to control animal movements as a component of animal disease control measures taken to protect the livestock industry with little, if any, consideration given to the ecology or conservation of wild species in these areas (see Fig. 2.19).

Apart from a comprehensive digital data base on larger African mammals covering 356 species on 10 CDs (IEA 1998; Boitani 1999), distribution maps of threatened plant and animal species region as a whole are not available in digital format. As part of an ongoing program, WWF SARPO has started compiling and digitizing such data for plants and butterflies and is supporting work on the southern Africa fish atlas. The Royal Society for the Protection of Birds (RSPB) has facilitated the mapping of important bird areas in several countries in southern Africa. The Africa Biodiversity Centre in Copenhagen has developed a database of species distribution (using 1° grid squares) for the African continent, which includes mammals, birds, snakes, amphibians, and several plant taxa. Although a resolution of 1° is likely to be to be too coarse for making decisions about TBNRMAs, the data have not been published and do not appear to be available to workers in Africa.

2.6.3 Drainage basins and biodiversity conservation

An alternative approach to selecting hot spots or ecoregions for conservation is to focus on drainage basins. Preliminary work carried out on this approach by the WWF office in Harare used a range of criteria (e.g., altitudinal range, area of wetlands, forests, number of major vegetation types, protected areas cover, area of wetlands, presence of selected species, species richness of selected taxa) to score and rank catchments in the southern African countries other than Lesotho, South Africa, Swaziland and Tanzania. The priority basins and their names are indicated in Fig. 2.20.

Despite the crude nature of available data on the distribution of species richness and endemism, it is clear that the highest levels of diversity and endemism, outside of the Fynbos, occur in the higher rainfall areas in the north and east of the region, particularly in the Afro-montane archipelago.

3. Trends in Land and Natural Resource Use

Africa has long been shaped by the presence of humans, and the recent human- induced species extinctions in mammalian faunas that have occurred elsewhere in the world in the last 50,000 years (e.g., America, Australia, Europe, and New Zealand) have not occurred on this continent (Diamond 1998). Local extinctions are, however, on the increase as human activities (agriculture, forestry, mining, reservoirs, urban development) transform habitats and displace indigenous plant and animal species. The management of arid and semi-arid areas in southern Africa for subsistence cropping and extensive livestock production shows little promise of being sustainable at present, let alone for projected human densities (Jahnke 1982; Cumming and Bond 1991; Cumming and Lynam 1997), despite much recent argument to the contrary. At the same time, protected areas are also under siege. Declining and inadequate funding (Cumming, du Toit and Stewart 1990), impaired resources to protect and manage national parks (Leader-Williams 1988; Leader-Williams and Albon 1988), overpopulation of certain species, such as elephants, that impact on habitats and other species (Cumming et al. 1997), alien invasives, and the loss of species due to increasing ecological isolation of protected populations (Soule, Wilcox, and Holtby 1979; Western and Gichohi 1993), all contribute to the growing list of threats to standard approaches to protected area management. The crux of the issue is whether rural development has to continue to follow the path of transforming land and displacing biodiversity or whether there are alternative paths to rural development, particularly for farmers on marginal lands, which can take advantage of Africa's comparative advantage in its spectacular wildlife. These issues have a direct bearing on TBNRMAs, and this section examines some of the ecological land-use and natural-resource use trends that have a bearing on these issues. The economic, institutional, social, and political dimensions of the problem are, of course, critical to the process, but have been dealt with elsewhere in the TBNRMA study (Griffin 1999; Metcalfe 1999). From an ecological and conservation perspective, the time to look "beyond parks" is long overdue.

3.1 Some Historical Perspectives

The first humans evolved in Africa, with *Homo erectus* appearing about 1.7 million years ago and *Homo sapiens* about 500,000 years ago. Anatomically, modern Africans are evident in the fossil record of 100,000 years ago. Humans have occupied parts of southern Africa, such as Hwange National Park, almost continuously for the last 250,000 years (Haynes and Klimowicz 1998). Until about 1,800 years ago, most of southern Africa was occupied by San hunter-gatherers or by Hottentots in the Cape region of South Africa. At about 100 AD, the Bantu-speaking peoples started moving east and south across Africa and reached Tanzania at about 200 AD and northern parts of Namibia and South Africa by 500 AD (McDeevy 1980), by which time they had largely displaced the San people into the Kalahari. Arab trade occurred along the east coast and was largely supplanted by Portuguese and other European traders after 1500 AD and once Vasco da Gama had charted the sea route around the Cape of Good Hope in 1487. European colonisation of the Cape soon followed and moved further north into the Transvaal and Rhodesia during the nineteenth century. A comprehensive, readable account of "the scramble for Africa" can be found in Pakenham (1991).

In ecological terms, the last two millennia in Africa have been characterised, if not dominated, by human migrations, invasion of livestock, and the very recent explosion of human and livestock populations in the region (see Fig. 3.1). Livestock first moved into Africa from the middle east about 7,000 years ago and reached southern Africa about 2,000 years ago

(Denbow and Wilmsen 1986; Cumming 1982). Livestock populations, between their advent in southern Africa and recent times, will have fluctuated in relation to the expansion and contraction of tsetse-fly distributions (Summers 1963; Ford 1971; Cumming 1982) and other diseases whose vectors will have been closely controlled by climate (Rogers and Williams 1994).

The period 1600 to 1890 saw increasing and unsustainable harvesting of wildlife products from southern Africa. Ivory, hides, and ostrich plumes were in particular demand. Ivory was exported at the rate of about 120 tons per year from the east African coast (Mozambique and Tanzania) until the nineteenth century, when the rate increased rapidly to 340 tons per annum during the period 1879-1883. During the same period, nearly 1,000 tons of ivory were being exported from Africa as a whole each year (Spinage 1973). Elephant populations and the trade in ivory crashed during the 1880s, only to reach similar levels nearly 100 years later when, in 1988, nearly 1,000 tons left Africa, largely through illegal routes. Most populations of ungulates and rhinos had reached very low levels by the end of the nineteenth century, largely because of the widespread use of firearms and commercial exploitation linked to the colonisation of the region (Mackenzie 1988).

During the1890s, rinderpest, the ungulate equivalent of measles, reached southern Africa from the Arabian Peninsula and devastated livestock and wildlife populations in the region. The epidemic dealt the final blow to many already overexploited ungulate populations, particularly in South Africa, while the extinction of elephant, as result of overhunting, was anticipated south of the Zambezi (Bryden 1903). The range of the tsetse fly was also greatly reduced. The collapse of wildlife populations over large areas and the establishment of colonial governments set the stage for the establishment of the first game reserves and hunting areas, which later became national parks. Uncontrolled exploitation of timber resources early this century, particularly along newly established railway lines, prompted colonial governments to establish controls and forestry departments to oversee the resource and enforce regulations.

3.2 The Last 100 Years

3.2.1 Development of dual agricultural systems

Dominant features of land use and land-use change in southern Africa during the present century have been:

- Rapid human population growth;
- Establishment of dual agricultural sectors (i.e., widely separated commercial and peasant agricultural systems and services), particularly in South Africa, Namibia, and Zimbabwe;
- Development of single-species ranching systems with fenced paddocks; and
- Deployment of major resources in pricing subsidies and disease controls to support the livestock industry.

Although less land was involved in establishing dual agricultural systems in Angola, Malawi, Mozambique, Tanzania, Zambia, and parts of Botswana, the process nevertheless resulted in

major distinctions between large-scale agri-business (plantation) developments and peasant, subsistence agriculture. With tenfold increases in human populations since 1900, combined with low levels of urbanisation and a high dependence on wood fuel, dual agricultural systems have contributed to the impoverishment of small-scale farmers and the conversion of large areas of land to subsistence agriculture. Land transformation in South Africa has been described by Downing (1978), Macdonald (1989), and Mentis and Seijas (1993) and changes in policy and practices in land use in Zimbabwe were reviewed by Murphree and Cumming (1993). The current areas of land under different types of tenure in the region are summarised in Table 4, and their distribution is shown in Fig. 3.2. Figures on human population size, population growth, and agricultural and energy indicators are also indicated in Table 4. The broad patterns of human population distribution shown in Fig. 3.3 highlight the generally low population densities found in transboundary areas of the region.

Land-cover maps or images currently available for southern Africa (e.g., USGS and other land-cover images in the Miombo CD) do not adequately distinguish areas under cultivation from other land-cover classes to provide a reasonably accurate picture of the distribution of cultivated land in the region. Maps or images depicting areas of intensive and extensive land use in the region are therefore not provided here.

3.2.2 Trends in crop and livestock production

Human population growth in the second half of this century has been accompanied by declines in indicators of human welfare, such as per capita food production. The example of Zimbabwe is a case in point, where the gains made in the first half of the twentieth century have recently turned into declines both in areas cultivated per person and in livestock units per person (see Fig. 3.4). The pattern illustrated for Zimbabwe is probably characteristic of most countries within southern Africa, and an analysis of regional trends since 1961 bears this out.

In keeping with the combination of low soil fertility in the more humid parts of the region, low rainfall where soils tend to be more fertile, and the generally infertile soils of the region, only 5% of southern Africa is under cultivated or permanent cropland. This area is close to the generally accepted level for the region of 5-7% arable land, and the arable area per person has declined from 0.6 ha per person in 1961 to 0.27 per person in 1993. At a country level, Malawi is the highest at 14% cultivated land, while Botswana is the lowest at 0.7%. Only 0.28% of the region is under irrigation, with the highest level occurring in Swaziland at 3.9%, followed by South Africa at 1.1%. The potential for expansion of arable land, other than into marginal areas, is limited, and the potential for expanding irrigated land is constrained by the lack of suitable soils and water.

Optimistic predictions for agricultural expansion in the wetter parts of the region (FAO/UNFPA/IIASA study - Higgins et al. 1982; Fitzhugh 1993) need to be treated with caution as the recent study by Barnes and Lahm (1997) of human carrying capacity in the central African forests makes clear. Barnes and Lahm (1997) found that the actual patterns of crop yields and wild and domestic herbivore production in relation to geology and soils differed considerably from the predictions of the FAO/UNFPA/IIASA model. Furthermore, soil nutrients, agricultural pests, and the low protein harvest from game governed carrying capacity of the forest for humans, with game resources (and thus protein) being the limiting factor for humans. Similar soil nutrient and protein production constraints are likely to apply to much of the humid and sub-

Table 4. Land Categories, Human Population Size and Growth, and Agricultural and Energy Indicators in Southern Africa

Pop./Dev./Land Use	ANGOLA	BOTSWANA	LESOTHO	MALAWI	MOZAMBIQUE	NAMIBIA	S. AFRICA	SWAZILAND	TANZANIA	ZAMBIA	ZIMBABWE	TOTAL
Area (Km^2)	1,246,700	600,372	30,350	118,484	783,030	824,292	1,221,040	17,366	886,040	752,614	390,245	6,870,533
Land tenure												
State land (%)	6.6	23.0		17.0	4.1	15.0	4.6	1	14.5	7.9	16.0	10.51
Communal land (%)*	88.0	71.0		78.7	93.0	40.0	13.0	60	84.0	89.0	48.6	64.86
Private farmland (%)	5.4	6.0		4.3	2.9	45.0	73.4	39	1.5	3.1	35.4	23.17
Human population (1990)												
Numbers (millions)	10.01	1.3	1.80	7.9	15.5	1.16	35.8	0.8	26.0	7.6	10.1	117.97
Growth rate	2.67	3.51	2.85	3.31	2.65	2.66	2.2	3.4	3.67	3.76	3.15	3.08
Ha per person	12.5	46.2	1.7	1.5	5.1	71.1	3.4	2.2	3.4	9.9	3.9	5.8
Rural Pop. (% total)	71.7	76.4	79.70	85.2	75.2	75	41.5	66.9	70.7	44.4	72.4	62.2
Ha per rural person	17.4	60.4	2.1	1.8	6.7	94.7	8.2	3.2	4.8	22.3	5.3	9.4
Agriculture												
Arable land (km^2)	35,000.0	13,600.0	3200	23,330.0	30,800.0	6,570.0	134,730.0	1800	52,300.0	52,080.0	2,782.0	356192.00
Area under tsetse fly	419,781.0	3,000.0	0	13,737.0	388,318.0	1,471.0	3,583.0	0	354,416.0	367,137.0	21,366.0	1572809.00
Grazing land	709,612.0	479,819.0	25000	68,795.0	331,662.0	709,125.7	1,026,227.0	15000	479,324.0	273,946.0	316,679.0	4435189.70
Cattle (1,000s)	3,350.0	2,900.0	530	910.0	1,450.0	2,000.0	12,215.0	660	14,000.0	2,400.0	5,800.0	46215.00
Sheep and goats (1,000s)	1,200.0	965.0	2490	859.0	469.0	8,300.0	36,111.0	362	10,200.0	392.0	1,600.0	62948.00
TLUs per km^2	5.2	6.6	50.5	16.9	4.8	6.3	22.3	51.1	35.5	9.2	19.8	14.6
Energy												
Per capita consumption (GJ)	14.9	27.3	?	26.8	26.9	?	?	?	24.5	26.1	33.0	
Wood fuel as % total fuel	77.3	56.1	?	94.3	89.1	?	?	?	91.4	58.3	52.0	

* Note: Communal land refers to land under traditional use or tenure and occupied by small-scale, often subsistence, farmers. In some countries in the region, communal land is legally state land (e.g., in Mozambique and Zimbabwe). State land includes protected areas and agricultural estates managed by the state and where occupation and use by peasant farmers is largely precluded.

Source: Partially updated from Cumming (1991).

humid zone lying within southern Africa, which are covered largely by dystrophic miombo woodlands.

Given the severe constraints to agricultural production in both the arid and humid zones of the region, the sooner the myth of vast, untapped agricultural potential in the subregion is laid to rest, the better. From the point of view of TBNRMAs, the key issue is that large areas of good arable land in the region will eventually be needed for that purpose.

The production of cereals and root crops (largely maize, sorghum, millet, and cassava; which form the primary staple foods in the region) have increased since 1961, but have not kept pace with population growth. The production levels of cereals and roots crops in southern Africa doubled between 1961 and 1994, but the production level per person declined over the same period, from 412 kg/person/year to 305 kg/person /year. Similar patterns are apparent in meat, milk, and fish production, and overall per capita food production in southern Africa has declined by 25% since 1980. The sensitivity of the region to the vagaries of climate was made clear in the 1991-1992 drought (see Table 5).

Declining rainfall over the last two decades has not helped, but much of the problem relates to inappropriate land use and subsidies to farmers (both peasant and commercial) to cultivate marginal lands. A clear example is the settlement of the Zambezi Valley following the clearance of tsetse fly and the increasing levels of food aid being supplied to the valley. Some districts in the Zambezi Valley require food aid in as many as 8 years out of 10--a clearly unsustainable situation (Cumming and Lynam 1997).

Major cash crops in the region include tobacco, cotton, copra, coffee, tea, citrus, grapes, bananas, palm oil, and sugar. These are mostly grown in fertile areas with higher rainfall or under irrigation and large-scale commercial operations. The extension of large- and small-scale tobacco farming involving estates and tenant farmers in Malawi and Tanzania has greatly increased the rate of land clearance and wood fuel harvesting (to cure the tobacco) over the last two decades (Temu 1979; Misana et al. 1996). Favorable prices and expansion of smallholder cotton production have, for example, contributed to the rapid expansion (about 9% per year) of land under cultivation in the Zambezi Valley of Zimbabwe (Cumming and Lynam 1997). Exotic timber plantations producing softwoods (pine), wattle and eucalypts for building timber and pulp dominate the coastal zone of Natal and pose a potential threat to the development of TBNRMAs in that region. Areas of montane grassland in the eastern highlands of Zimbabwe/western Mozambique and Malawi have been replaced with exotic timber plantations of pine and wattle, which have also become serious invasive plants in protected areas (Macdonald and Frame 1988). The invasion of natural forests by exotics in South Africa has become a particularly pressing problem (Macdonald 1989).

The features apparent in the comparative growth of human and livestock populations in Zimbabwe also apply more generally (see Fig. 3.4). Within southern Africa as a whole, there are now fewer livestock units in the region than there are people (i.e., for each person in southern Africa there is less than one livestock unit). Furthermore, the overall number of livestock in the region has shown little growth over the last three decades (see Fig. 3.5). Sheep have declined, goats have increased, and cattle numbers have shown little change. The region is sharply divided into those countries where livestock densities approach the limits set by rainfall (i.e., high densities) and those where livestock are well below expected densities (i.e., low densities) (see Fig. 3.6). Countries with "high" cattle densities are characterised by eutrophic savannas or grasslands, with little if any land infested by tsetse fly. The "low" density

Table 5. Trends in Arable Land, Production of Selected Crops, Fish, Meat and Milk, and Fuelwood in Southern Africa

Item	1961	1965	1970	1975	1980	1985	1990	1991	1992	1993	1994	Ann. Rate (%)
Human population (1,000s)	54054	59803	68084	78074	90512	104150	117273	120504	123824	127227	130569	2.71
Arable land (km^2)	306870	312040	325350	331540	331380	338840	345740	346470	347990	348010	-	0.39
Irrigated land (km^2)	1020	1290	11865	12995	15655	16320	18795	18725	19015	19045	-	9.58
Fertiliser used (1,000 MT)	68	118	744	1047	1454	1206	1150	1094	1071	1247	-	9.52
Arable land/person (ha)	0.57	0.52	0.48	0.42	0.37	0.33	0.29	0.29	0.28	0.27	-	-2.26
Cereals (1,000 MT)	14079	14422	14909	20490	23076	17759	21529	20924	10808	23895	23934	1.67
kg/person	260.5	241.2	219.0	262.4	254.9	170.5	183.6	173.6	87.3	187.8	183.3	-1.02
Root crops (1,000 MT)	7345	8015	9749	11989	13290	14983	18042	16759	15781	16043	16427	2.47
kg/person	135.88	134.02	143.19	153.56	146.83	143.86	153.85	139.07	127.45	126.10	125.81	-0.23
Cereals + roots	21424	22437	24658	32479	36366	32742	39571	37683	30780	39938	40361	1.97
kg /person	396.3	375.2	362.2	416.0	401.8	314.4	337.4	312.7	248.6	313.9	309.1	-0.73
Freshwater fish (1,000 MT)	84	144	283	310	309	419	512	508				
Marine fish	1264	1595	1843	1596	1083	931	947	833				
Total fish	1348	1739	2126	1906	1392	1350	1459	1341				
Fish/person	24.9	29.1	31.2	24.4	15.4	13.0	12.4	11.1				
Meat (1,000 MT)	1006	1179	1362	1591	1797	2076	2239	2316	2360	2306	1943	2.63
Milk	3371	3143	3960	3760	3982	4176	4273	4114	4035	3946	3812	0.49
Meat and milk /person	81.0	72.3	78.2	68.5	63.8	60.0	55.5	53.4	51.6	49.1	44.1	-1.55
Kg animal protein/person	105.9	101.3	109.4	93.0	79.2	73.0	68.0	64.5	51.6	49.1	44.1	-2.37
Fuelwood + charcoal	29143	35966	51286	56214	65889	76820	87638	89745	91468	93178		3.7
Fuel/person	0.54	0.60	0.75	0.72	0.73	0.74	0.75	0.74	0.74	0.73		0.96

Note: Data compiled and summarised from FAO Year Book Country Tables of 1985, 1990, and 1995.

countries are characterised by dystrophic savanna and include large areas infested by tsetse fly. The elimination of tsetse fly will not, on its own, bring about a massive increase in livestock numbers in these countries because the major constraint to higher production is low-quality fodder on dystrophic, or nutrient poor, soils.

The very real and serious constraints to livestock production in the region are linked to fundamental aspects of soil nutrient status and quality of food for livestock. The comparison of the levels of animal production in temperate and tropical regions, such as between southern Africa and Europe, makes this clear. The nearly twenty-fold differences between southern Africa and Europe in levels of meat and milk production per animal and per person serve to emphasise that southern Africa's comparative advantage in world markets clearly does *not* lie in domestic livestock production (Cumming and Bond 1991) (see Fig. 3.7). Nevertheless, domestic animals dominate the southern African landscape, and the biomass densities of wild ungulates are about one tenth those of domestic livestock for nearly all countries in the SADC region (see Fig. 3.8). In Botswana and Zambia, wildlife biomass is about one quarter to one third of the livestock biomass.

The problem of low levels of production on some 60% of the land surface of southern Africa (nearly 80% of South Africa), which is suited to extensive animal production rather than cropping, are exacerbated by the declines in stocking rates, which have occurred over the past century. Dean and Macdonald (1993), in a study of livestock holding in Cape Province over the 70-year period from 1911 to 1981, found that reductions in stocking rate differed significantly between biomes and showed a general trend toward being greater in the more arid districts. The reduction was significantly greater in the succulent Karoo, where seven out of eight districts experienced stocking rate reductions of more than 50% as a result of a decline in rangeland productivity following persistent overstocking.

Given the declining fortunes of livestock production in much of southern Africa, it is not surprising that, where appropriate institutions exist for farmers to turn to wildlife as a land use, this option has been increasingly used (Cumming 1991a, 1995). Countering this view are arguments that livestock have an intrinsic cultural value that does not extend to game animals and that accounts for high stocking rates and low levels of commercial exploitation of livestock by communal farmers. While strong cultural traditions with respect to livestock do exist in many ethnic groups in the region, the persistent myths surrounding the "Bantu Cattle complex" (Herskovits 1926) as an explanation for livestock keeping and management practices have been discredited (e.g., Mtetwa 1978; Doran et al. 1979; Low et al. 1980; Steele 1981). Past and current livestock practices in communal farming areas of the region reflect financially efficient and risk averse strategies at the individual and household level under prevailing national economic and agricultural policies (e.g., Buchan 1988; Barrett 1992). (Trends in the development of wildlife as a land use are discussed in Section 3.2.4 below.) It is, however, clear that where appropriate institutional arrangements and incentives exist, communal farmers often choose wildlife as a land use (Bond 1993; Ashley 1995; Fortmann 1997; Barnes 1998).

3.2.3 Animal diseases and implications for TBNRMAs

Diseases affecting wild and domestic animals are a central concern of the livestock industry. Because many wild, large herbivores were seen as the primary reservoirs of livestock diseases, control of these diseases has had a considerable influence on the status and distribution of game populations in southern Africa. The co-existence of livestock and wildlife were, for a long time, seen as incompatible, and game eradication programs, veterinary cordon fences, or both

were used as major instruments of disease control. The impacts of veterinary control measures on wildlife in southern Africa over the last century have not, so far as this author is aware, been reviewed. There is, however, little doubt that they have been considerable, as Taylor and Martin's (1987) analysis of the impacts of fences on wildlife in Zimbabwe reveals. Clear examples from the region involve the elimination of game animals over large areas to control tsetse fly (vector of trypanosomiasis) and the fences erected to control the movement of wildlife and livestock and the spread of foot-and-mouth disease (FMD), a virulent disease of cattle. Wildlife populations were eradicated in much of Zululand and in large areas of Zimbabwe and Zambia to control the spread of tsetse fly (Child and Riney 1987). Early hunting operations targeted all large herbivores (Jack 1914), but once it was possible to identify the hosts on which tsetse fed (Weitz 1956), hunting was more selective (Cockbill 1971). FMD control fences in Botswana contributed to the spectacular decline of wildebeest herds in Botswana (Williamson, Williamson, and Ngwamotsoko 1988) (see Fig. 2.19). During the 1970s, buffalo were eradicated from the southeast lowveld of Zimbabwe because they were considered the major source of FMD virus. Warthog and bushpig eradication programs were widely undertaken in eastern and southern Africa to control African swine fever.

The main diseases of livestock in southern Africa and a broad indication of their prevalence are summarised in Table 6, while the links between some livestock diseases and wildlife are summarised in Table 7. Animal diseases continue to have major impacts in the region on both domestic stock and wildlife. A major outbreak of Contagious Bovine Pleuropneumonia (CBPP) occurred in cattle in northwestern Botswana during the early 1990s, and thousands of head of livestock were slaughtered in order to contain the disease. A recent CBPP outbreak in Namibia resulted in the erection of additional control fences by Botswana (Albertson 1998), which interrupted the movement of wildlife between the two countries. Tuberculosis has recently been found in the buffalo population, and in some other ungulates, in Kruger National Park. FMD outbreaks in Zimbabwe periodically interrupt beef exports. Outbreaks were invariably blamed on buffalo until the recent discovery, using DNA fingerprinting techniques, that some of the outbreaks in cattle originated from carrier cattle. A recent FMD outbreak in cattle adjacent to the Save Conservancy in the southeast Lowveld of Zimbabwe did, however, originate in buffalo and was passed to cattle via impala, which broke through the FMD control fences. While a resolution of disease control problems and their impacts on wildlife are difficult enough within countries, they are likely to be doubly so across international boundaries.

An important goal of TBNRMAs is to re-establish historical patterns of wildlife movement and dispersal that have been disrupted mainly by veterinary cordon fences and conflicting land uses along international borders. Changes in these patterns of land use and disease control to accommodate the development of viable and sustainable TBNRMAs will require strategies and agreements to deal with wildlife/livestock disease monitoring, prevention, control, and eradication. Assessments of disease issues for individual TBNRMA areas will need to be carried out, similar to that of Pereira (1995), which discusses the potential animal health hazards of three TFCA areas in Mozambique, Zimbabwe, and South Africa.

In their simplest form, protocols will need to address issues of standardising disease-monitoring programs between neighbouring countries. At its most complex, the success of TBNRMAs will depend upon agreements to address issues where one country's livestock or wildlife is disease free, while those of its neighbour(s) are infected or act as carriers. If support of stockholders and the livestock industry for the establishment of TBNRMAs is to be gained, then careful and early attention will need to be given to minimising the transfer of diseases from wildlife to livestock and vice versa. Where transboundary areas to be included in a TBNRMA are governed by differing livestock/wildlife land use regulations and controls, it may be

Table 6. Summary of Major Livestock Diseases and Their Prevalence in Southern Africa

Disease	Angola	Botswana	Lesotho	Malawi	Mozam-bique	Namibia	S. Africa	Swaziland	Tanzania	Zambia	Zim-babwe
Foot-and-mouth disease	+	1980	-	+	+++	+	1991	1969	+++	++	++
Rinderpest	-	1896	1896	1898	1896	1904	1904	1898	1982	1896	1898
Pleuropneumonia	++	1939 1994	-	-	-	1924	1924	-	+	+	1904
Lumpy skin disease	+	1984	+	+	+	+	+	+	++	+++	+
Rift valley fever	?	-	-	+	+	-	-	?	++	+	1987
Bluetongue	+	+	+	+	+	+++	+++	+	+	+	+
Anthrax	+	+	+	+	+	+	+	+	+	+	+
Echinococcosis	+	+	+	+	++	-	-	+	+	+	+
Heartwater	++	++	-	++	++	+++	+++	++	++	+	+
Leptospirosis	+	-	+	+	+	+	+	?	+	+	+
Anaplasmosis	++	+	+++	++	++	+	++	++	++	++	+
Babesiosis	++	+	+	++	++	+	++	++	++	++	+
Brucellosis	++	+	+	++	++	+	+++	++	++	++	+
Theileriasis	++	-	-	++	+	-	+	+	++	+	+
Trypanosomiasis	++	+	-	++	++	+	1952	-	+++	+++	+
Malignant catarrh	-	+	-	-	?	+	++	-	++	-	+

+, ++, +++, indicate low, intermediate and high levels of prevalence in the region

Source: Office International des Epizooties (1990); World Animal Health (1989), Vol. V, No. 2; Animal Health Status and Disease Control Methods (Part One: Reports and Part Two: Tables). Table from Cumming and Bond (1991).

Table 7. Some Links between Important Livestock Diseases and Wildlife

Disease	Causal Agent	Vector	Buffalo	Impala	Kudu	Eland	Wildeb.	Warthog	Zebra	White Rhino	Cattle	Sheep	Pigs
Foot-and-mouth	Virus	none	C/S	S	S	S	S	S	-	-	C/S	S	S
Malignant catarrh	Virus	none	-	-	-	-	C	-	-	-	S	C/S	-
Rinderpest	Virus	none	S	S	S	S	S	S	-	-	C/S	S	S
African swine fever	Virus	Sand tampan	-	-	-	-	-	C	-	-	-	-	S
Heartwater	Rickettsia	Bont tick	C	?	?	C	C	-	-	-	S	S	-
Trypanosomiasis	Protozoa	Tsetse fly	C	?	C	-	-	C	-	-	S	S	S
Theileriosis	Protozoa	Brown ear tick	C	-	-	-	-	-	-	-	S	-	-

Note: C = carrier, S = susceptible, - = unaffected. Table from Cumming and Bond (1991).

necessary to harmonise grazing rights, disease prevention, and monitoring strategies and to make provision for control measures and compensation should disease outbreaks occur. A clear example relates to the developing TBNRMA in the Kruger, Banhine, Gonarezhou area, which involves Mozambique, South Africa, and Zimbabwe. FMD is endemic in Kruger National Park, and disease cycles are recurrent (Pereira 1995). Tuberculosis has recently been discovered in several species in Kruger National Park, particularly in buffalo. Both livestock and wildlife populations on the Mozambique and Zimbabwe borders are free of the disease, and further development of the TBNRMA will require careful attention to and agreement on how tuberculosis and other diseases, such as FMD, should be controlled.

3.2.4 Protected areas and other land under wildlife, forestry, and fisheries

The area and number of national parks and game reserves in southern Africa have grown exponentially over the last century (see Fig. 3.9), while, in the second half of the century, the average size of protected areas declined with the addition of generally smaller areas. The largest mean size of protected area occurs in Tanzania (about 4,800 km^2), while the smallest mean size occurs in South Africa (about 370 km^2). The extent of communal land, privately owned land, and state protected areas in the region is summarised in Table 8 and mapped in Fig. 3.10.

During the 1930s, colonial governments in Anglophone Africa were encouraged to develop protected areas in the wake of the widely acclaimed Convention Relative to the Preservation of Fauna and Flora in their Natural State, which was held in London in 1933. At this convention, a national park was defined as an area that is:

(a) "placed under public control, the boundaries of which shall not be altered or any portion be capable of alienation, except by the competent authority;

(b) set aside for the propagation, protection, and preservation of fauna and flora and objects of aesthetic, geological, prehistoric, historical, archaeological, or other scientific interest for the benefit, advantage, or enjoyment of the general public;

(c) in which the hunting, killing, or capturing of fauna and destruction or collection of flora is prohibited except by or under the direction and control of the park authorities. In accordance with the above provisions, facilities shall, so far as possible, be given to the general public for observing the flora and fauna in national parks."

Here the emphasis was on biological conservation rather than on the protection of superlative scenery for public enjoyment, which was the main emphasis of the Washington Convention on national parks held in 1940.

The development of game ranching in southern Africa was greatly encouraged by the work of Fulbright scholars (Dasmann, Mossman, and Riney) during the late 1950s and early 1960s, and then later by changes in legislation in South Africa, Namibia, and Zimbabwe during the 1970s. These developments led to the rapid expansion of game ranching and sport hunting on private properties (Cumming 1993a, 1993b), with the more recent developments of larger conservancies where several private ranchers have established common or joint management regimes for their wildlife and removed intervening fences (du Toit 1992). The extension of wildlife as a land use to communal areas of the region followed in the 1990s, with the establishment of several CBNRM programs in the region.

Table 8. Communal Land, Private Land, and Protected Areas Available to Wildlife in Southern African Countries

Wildlife Management Conservation	ANGOLA	BOTSWANA	LESOTHO	MALAWI	MOZAM-BIQUE	NAMIBIA	S. AFRICA	SWAZILAND	TANZANIA	ZAMBIA	ZIMBABWE	TOTAL
Communal land												
Game area (km^2)	?	120,074.4	0.0	0.0	56,750	50,000.0	0.0	0.0	90,000.0	160,488.0	12,000.0	432563.4
% communal land	?	28.2	0.0	0.0	0.0	15.2	0.0	0.0	12.1	24.0	6.3	21.15
Private land												
Game area (km^2)	?	1,000.0	0.0	0.0	0.0	22,725.0	160,000.0	45.5	0.0	0.0	28,000.0	211770.5
% private land	0.0	2.8	0.0	0.0	0.0	6.1	17.9	0.7	0.0	0.0	20.3	16.86
No. farms	?	5.0	0.0	0.0	0.0	450.0	8,500.0	1.0	0.0	0.0	187.0	
% farms	?	2.5	0.0	0.0	0.0	8.2	7.1	?	0.0	0.0	4.7	
State land (protected areas)												
Total area (km^2)	82,307.0	103,953.0	68.1	12,622.0	36,50.0	107,125.3	56,500.0	49.8	134,881.0	59,451.0	49,418.0	638625.2
% country	6.6	17.3	0.2	10.7	4.1	13.0	4.6	0.3	15.2	7.9	12.7	11.62
No. protected areas	13.0	9.0	1.0	21.0	9.0	13.0	153.0	5.0	15.0	19.0	30.0	
Mean size (km^2)	6,331.3	11,550.3	68.1	601.0	4,052.0	8,240.4	369.3	10.0	8,992.1	3,129.0	1,647.3	
Total area under wildlife	?	225,027.4	68.1	12,622.0	93,250.0	179,850.3	216,500.0	95.3	224,881.0	219,939.0	89,418.0	1200652.1
% country	?	37.5	0.2	13.4	11.9	21.8	17.7	0.5	25.4	29.2	22.9	25.56

Source: Partially updated from Cumming (1991).

The database on private and communal lands under wildlife use is not well developed. Figures on the precise number of farms, their areas, and the species involved are not routinely available and the summary figures presented in Table 9 are nearly 10 years old. Similar difficulties surround the basic statistics for CBNRM areas within the region. The baseline information is not readily available and, for many areas, may not be available.

Some indications of long-term trends may be gained from the changes toward wildlife as a land use in Zimbabwe, particularly in northwestern Zimbabwe, where the area under wildlife has increased from 10,000 km^2 in 1930 when Hwange Game Reserve was proclaimed to more than 20,000 km^2 today, involving several land categories (National Parks, Safari Areas, Forestry Areas, Private Land, and Communal Land (Cumming 1993a). Substantial wildlife conservancies have developed in Zimbabwe, where about 22% of the county's land is under wildlife, with nearly half of this area being outside the National Parks and Wildlife Estate (Cumming 1991).

The potential terrestrial-based TBNRMAs in southern Africa fall into approximately 17 clusters (see Fig. 3.11), which vary between those encompassing two protected areas (one on either side of an international boundary) to cluster # 2, which potentially encompasses 4 countries and more than 10 protected areas. The names of the protected areas in each of these areas are given in detail in Table 1 of the Annex.

Indigenous forests and woodlands

The development of game reserves and related protected areas for large wild mammals in the region was accompanied by an essentially similar movement in several countries to preserve areas of indigenous woodland. These woodlands were perceived as valuable timber resources or occurred in mountainous areas in the headwaters of catchments where watershed protection was important. Forest Reserves were also established in an attempt to reduce the uncontrolled "mining" of valuable timber resources (Judge 1993; Pierce and Gumbo 1993). For the most part, forest reserves tended to be smaller than game reserves and covered a smaller total area (see Table 9 and Fig. 3.12). They have also been more prone to illegal resource exploitation and settlement than game areas;[2] where population pressures have been high, boundaries have often been revised and settled areas excised (e.g., Malawi, Tanzania, and Zimbabwe), and the area under protection within the region is probably diminishing rather than increasing.

Over the last two decades, there has been a surge in interest in social forestry, non-timber products, and local management of woodland resources. A review of the extensive literature in this field is beyond the scope of this study. However, some points need to be examined in relation to the exploitation of timber and non-timber woodland resources in the context of TBNRMAs. These are as follows:

1. Timber resources in some areas are as valuable, if not more so, than large game animals (e.g., Gorongosa/Marromeu coutadas in Mozambique, although this situation could change with a full recovery of wildlife populations). However, valuable as they

[2] Presumably because forestry departments and forest officers did not develop under the military traditions (and armed pursuit of poachers) that characterized the early development of national parks and game reserves in the region.

may be, they are unlikely to contribute significantly to local economies without major changes in national policies on timber harvesting rights and benefits, which are held by government agencies rather than local communities. Appropriate developments in technology and marketing opportunities for rural peasant farmers will also be a prerequisite.

2. The undoubted value of harvestable non-timber products is largely offset, in the context of incentives to create conservation areas, by their dispersed nature, small size, usually low value per item, highly variable local resource access rights and controls, and the high transaction costs of developing controls on use, marketing, and distribution of benefits in a community (Campbell and Byron 1996).

3. Once rural populations exceed quite low density thresholds, their energy requirements in wood fuel (exacerbated if charcoal is a marketable commodity) are likely to lead to unsustainable use of woodlands and to deforestation (O'Keefe and Munslow 1985; Cumming 1985).

Table 9. Summary of the Extent of Protected Indigenous Forest Reserves in Southern Africa

Country	No. Reserves	Total Area (km^2)	Mean Area	Range in Area	No. on Boundary	Source
Angola	?	?	?	?		No data
Botswana	6	4555	759	162-2400	6	World Bank,1993
Lesotho	?					
Malawi	29	1317	45	0.5-262	8	World Bank, 1993
Mozambique	13	4471		16-1954	2 ?	Proagri Report , 1997
Namibia	?					
South Africa	41	18801	458	11-1900	1	IUCN/UNEP, 1987
Swaziland	?					
Tanzania	5	6257	1251	3-6213		IUCN/UNEP, 1987
Zambia	See Note*					World Bank, 1993
Zimbabwe	14	12800	914	7-1994	3	
Totals	103	48201			20	

***Note:** The World Bank (1993) lists more than 350 forest reserves in Zambia, but the status and level of protection of these are unclear. They have been digitized by WWF SARPO from a 1:1,500,000 scale, and the larger areas are reflected in Fig. 3.12.

Despite these potential problems, there are some non-timber woodland resources of high value that are harvested mainly in low-lying border areas within the region. These include the use of *Hyphaene* palm leaves for weaving baskets and the bark and roots of *Berchemia discolor* for making dyes (Cunningham and Terry 1993), the harvesting of caterpillars for food (Cunningham 1996), and the marketing of some fruits, such as those of *Zizyphus mauritiana* (Brigham et al. 1996).

Fuelwood and charcoal probably constitute the greatest direct use of woodland resources in

the region and, as indicated in Table 4, wood fuel provides about 75% of per capita energy consumption. The reason for this high proportion is that the majority of people (more than 60%) live in rural areas without access to electricity or other energy resources for cooking and heating. Wood fuel and charcoal production for southern Africa have more than doubled since 1961 (see Table 6), and per capita production has remained at about 0.7 t of fuelwood and charcoal per person per year. The rate of growth in charcoal and fuelwood production has been 3.7% per year over the last three decades--a rate that has kept pace with, if not exceeded, human population growth (see Table 6. About 10 ha of woodland are needed to sustainably support the wood fuel requirements of a rural family (Cumming 1985), and the area of woodland available per family over the region is 7.5 ha (ranging from 0 ha in Lesotho to 94 ha in Botswana). If these estimates are correct, then the current levels of harvesting (and growth in levels of woodland harvesting) are unlikely to be sustainable.

The all-important issue of catchment protection, water yields, and downstream impacts, often across international boundaries, are receiving some attention in regional programs aimed at integrated management of catchments. Examples include the Zambezi Action Plan (ZACPLAN) and the management of the Letaba and Olifants river catchments, which run through Kruger National Park into Mozambique. From the point of view of TBNRMAs in the region, montane areas with potentially important transboundary links would include the Drakensberg mountains in Lesotho; Lebombo Mountains in Swaziland; northern part of the Drakensberg, which drains into Mozambique; eastern highlands of Zimbabwe and Malawi, both of which drain into Mozambique; and the highlands of Angola, where rivers running into the large internal drainage basin of the Okavango/Kwando arise.

Freshwater fisheries and wetlands

Major wetlands cover some 1.3% of southern Africa. The various, large natural lakes in the region (Victoria, Tanganyika, Rukwa, Nyasa/Malawi, Chilwa, Bangweulu, and Mweru) support substantial fisheries as do the two major manmade lakes in the region (Kariba and Cahora Bassa). All lakes except Rukwa and Bangweulu in Zambia are split by, or run along, international boundaries. There are several major wetlands in the region that are important fisheries and conservation areas (see Fig. 3.13). Those straddling international boundaries include the Mweru-Wantipa marsh; the swamps upstream of Lake Mweru; part of the Bangweulu swamp; swamps on the lower Shire in Malawi; Cuando/Linyanti/Chobe swamps in the Caprivi; and the wetlands in the upper Zambezi, which straddle the Angola/Zambia border. An area of saline pans in the Cunene drainage straddles the Angola/Namibia border; and the Pongola river floodplain and associated wetlands, which fall within South Africa, Swaziland, and Mozambique, flow into the Maputo River.

From a conservation perspective, Lake Nyasa has the highest species diversity of any lake in the world, but Lake Tanganyika has a greater diversity of fish families and, in terms of genetic diversity, is the richer lake. Both lakes fall within the boundaries of three nations and therefore provide opportunities for the development of freshwater/lacustrine TBNRMAs. Conservation threats to these great lakes are the introduction of exotics, overfishing, and the impacts of land use in surrounding catchments on the water chemistry of the lakes (Bootsma and Hecky 1993). The introduction of the Nile perch has eliminated about 65% of the endemic haplochromid fauna of Lake Victoria and caused the loss of about 200 taxa from the lake (Goldschmidt et al. 1993; Lowe-McConnell 1993). It provides an eloquent, if not tragic, example of how a fish fauna, which has taken 750,000 years to evolve, can be decimated within 30 years by the introduction of exotic fishes (McConnell 1993).

There is, of course, a large number of impoundments within the region. These range from small-farm dams of a hectare or so in size to several major dams in South Africa, Lesotho, Zimbabwe, Zambia, Mozambique, and Tanzania, which serve urban and industrial water supply needs, irrigation, aquaculture, and, household and livestock water needs in farming areas.

Official figures for freshwater fish indicate that production (landings) doubled between 1960 and 1990, while, during the same period, the mass of marine fish landed halved (see Table 6). The FAO figures are those reported by each country and do not include the informal sector and harvesting from the multitude of small dams in the region.

3.2.5 Regional trends in large wild mammal populations and wild habitats

Elephant populations south of the Zambezi River have recovered from extremely low levels during this century. At the turn of the last century, they were expected to become extinct south of the Zambezi River (Bryden 1903) and, despite major declines in elephant numbers in Tanzania and Zambia, there are presently approximately 300,000 in southern Africa (Said et al. 1995; Craig1997). The recovery of elephants in Zimbabwe provides a clear example of a population that has increased from less than 4,000 animals (Cumming 1993a) to more than 70,000, despite attempts to maintain populations at lower levels (Martin et al. 1989). In many protected areas, their numbers by the mid-1960s had reached such high densities that woodlands were being destroyed. Many agencies in the region implemented culling programs to control elephant numbers (Laws 1970; Anderson and Walker 1974; Cumming 1980; Spinage 1990; Hall-Martin 1992; Martin et al. 1989; Cumming et al. 1997). High levels of poaching during the 1980s in Tanzania (Douglas-Hamilton 1987), Zambia (Jachmann and Billiouw 1997), and Mozambique from the mid-1970s to the mid-1990s resulted in marked reductions in the elephant and rhino populations in those countries (Cumming et al. 1990; Said et al. 1995). Numbers in Botswana, Namibia, South Africa, and Zimbabwe were stable or increased (see Fig. 3.14 and Table 10).

The fate of black rhino has been less fortunate. Whereas the overall elephant population in southern Africa is about 300,000, black rhino number less than 2,500. The continental population declined drastically during the twentieth century, especially during the 1970s and 1980s (Cumming et al. 1990). Overall, black rhino in Africa declined from more than 80,000 in the 1950s to less than 10,000 in 1980 (Martin and Martin 1982; Cumming and Jackson 1994). Further dramatic declines occurred during the 1980s and early 1990s (see Fig. 3.15). The largest declines occurred in Tanzania and Zambia, while in Namibia, South Africa, and Zimbabwe, black rhino increased over the same period. However, from 1990 to 1992, populations in Zimbabwe declined rapidly, as a result of rampant poaching, from about 2,000 to some 300. The population is now slowly recovering. In 1998, the black rhino population in southern Africa numbered about 2,200 (Brooks 1999).

The southern white rhino, which was reduced to less than 50 animals by the 1920s, has recovered dramatically to a population of over 8,000 in 1998 (Brooks 1999). The species was re-introduced to several areas within its former range in Botswana and Zimbabwe during the 1960s. The Zimbabwe population increased to more than 300 animals and then declined to less than 200 in the poaching onslaught of 1990-1992, while the Botswana population now stands at only 23 animals.

Table 10. Numbers and Trends of the Larger Ungulates in Southern Africa

Species	Number	Regional Status	Country Status										
			An	Bw	Le	Ma	Mz	Na	SA	Sw	Tz	Zam	Zim
Elephant	300,000	I	d	i	-	s	s/i	i	i	-	s/i	s/i	i
White Rhino	8,300	I	-	i	-	-		i	i	i	-	i	i
Black Rhino	2,218	S/I	ex	ex	-	d	d	i	i	?	s/d	ex	i
Hippo	95,000	?	?	s	?	?	?	s	s	?	?	s/i	s
Warthog	250,000	?	?	?	?	?	?	?	?	?	?	s	i
Bushpig	200,000	?	?	?	?	?	?	?	?	?	?	s	s
Burchell's Zebra	492,000	S/D	?	d	ex	s/d	?	s	i	s/i	s/d	d	s/i
Mountain Zebra	8,000	I	ex?	-	-	-	-	i	i	-	-	-	-
Giraffe	61,720	S	ex	s/i	-	-	ex?	i	s/i	s/i	s/d	s/d	s/i
Buffalo	470,000	D	d	d	-	s	d	s/d	i	s/i	s/d	s/d	s
Bushbuck	106,000	S/D	d	s	ex?	s/d	s/d	s/d	s/d	s/d	s/d	s/d	s/d
Sitatunga	20,000	S	s/d	s/i	-	-	?	s/i	-	-	s/d	s/d	?
Nyala	30,000	S/I	-	i	-	i	d	s/i	i	s/i	-	-	?
Lesser Kudu	3,000	S/D	-	-	-	-	-	-	-	-	s/d	-	-
Greater Kudu	300,000	S/I	d	s	-	s/d	d	i	i	s/d	S?	s/d	s/d
Eland	100,000	S?	d	s	?	s/i	d	i	i	d	s/d	d	s/i
Bohor R'buck	37,000	D	-	-	-	-	-	-	-	-	d	-	-
Sthn R'buck	33,000	S	d	s/i	-	s/d	d	i	i	s/i	s/d	s/d	s/d
Mtn R'buck	32,000	S/D	-	?	d	-	?	-	s/d	s	s/d	-	-
Puku	75,000	D	d	s/d	-	s/i	-	?	-	-	s/d	d	-
Waterbuck	52,000	D	d	s/i	-	d	d	?	i	s/i	s	s/d	s/i
Black Lechwe	30,000	S	-	-	-	-	-	-	-	-	-	s	-
Kafue Lechwe	65,000	I	-	-	-	-	-	-	-	-	-	i	-
Red Lechwe	71,000	D	d	s/d	-	-	-	d	-	-	-	?	-
Rhebok	10,000	S/D	-	-	?	-	-	-	s/d	s/d	-	-	-
Red Hartebeest	108,000	I	ex	s/i	-	-	-	i	i	s	-	-	i
Lichtenstein's Hb	36,000	S/D	-	-	-	?	s/d	-	?	-	s/d	d	i
Bontebok	2,300	S/I	-	-	-	-	-	-	i	-	-	-	-
Blesbok	237,000	I	-	s/i	s/i	-	-	i	s/i	s	-	-	s/i
Tsessebe	85,000	I	d	s	-	-	ex?	i	s/i	-	d	s	i
Blue Wildebeest	1,183,000	D	d	s	-	-	d	s/i	i		d	d	s/i
Black Wildebeest	18,000	I	-	-	s/i	-	-	i	s/i	s	-	-	-
Roan	14,650	D	d	s/d	-	s/i	?	i	s/i	?	s/d	d	s/d
Sable	53,000	S/I	d	s/d	-	s/i	s/d	i	?	?	s/d	d	i
Gemsbok	326,650	I	ex?	i	-	-	-	i	i	-	-	-	s/i
Impala	1,500,000	S/I	d	s	-	s/i	s/d	i	s/i	s/i	s/d	s/d	s
Black faced Impala	2,200	S/I	d	-	-	-	-	i	-	-	-	-	-
Gerenuk	?	D	-	-	-	-	-	-	-	-	?	-	-
Th. Gazelle	390,000	D	-	-	-	-	-	-	-	-	s/d	-	-
Grant's Gazelle	35,000	D	-	-	-	-	-	-	-	-	s/d	-	-
Springbok	670,000	I	d	s	-	-	-	i	s/i	-	-	-	-
Number of species present		41	25	28	9	18	21	30	30	22	27	25	25
Number of species increasing		10	0	4	0	1	0	18	15	5	0	2	8
% of Species increasing		24%	0%	14%	0%	5%	0%	60%	50%	5%	0%	8%	32%

Note: I = increasing, S = stable, D = decreasing, ? = status uncertain or unknown, ex = extinct. Data for antelope, giraffe and zebra summarised from East (1998); data for pachyderms from African elephant and rhino specialist groups reports; and data on hippo from Oliver (1993).

The IUCN Antelope Specialist Group reviewed the numbers and status of antelope species in the region by country (East 1998). Broad current estimates and trends are summarised for larger ungulates in Table 10. In some areas, dramatic reductions in antelope and other species have occurred (see Fig. 3.16). A clear example is the crash in large mammal populations that occurred in the Gorongosa National Park and Marromeu Game Reserve as a result of rampant poaching during the period of recent conflict (early 1980s to early 1990s). Impacts of armed conflict on large mammal populations can vary greatly. In some cases, it can result in decimation (e.g., in zones of prolonged conflict where troops may use wildlife for food and/or trophies to fund operations). In other areas (e.g., where rural populations have been evacuated, and troops pass by rapidly), wild animal populations may increase. These issues are extremely important for Mozambique and Angola (J. Oglethorpe, pers. Comm).

Overall, the trends in large ungulate populations in the region are down. Only 25% of the species listed in Table 10 are unequivocally rated as increasing, and, in only two countries (Namibia and South Africa), are 50% or more of the listed species rated as increasing. In most countries of the region, the number of species rated as increasing is less than 25%, and, in some countries (Angola, Lesotho, Mozambique, and Tanzania), none are rated as increasing. These data suggest that the status of large wild mammals in the region is generally declining and that their conservation requires far greater attention than they have been receiving.

An analysis of the numbers and biomass of larger ungulates (i.e., gazelles and larger) reveals that elephants rank amongst the top 10 in southern Africa (see Fig. 3.17). In terms of biomass, elephants rank the highest. Of the 38 larger ungulates occurring in southern Africa, only 10 species comprise 90% of the large, wild herbivore biomass of the region (see Fig. 3.18), with 15 species contributing 95% of the biomass. The remaining 5% comprise 24 species.

All of the potential TBNRMAs (Fig. 3.11) can play a significant role in enhancing wild herbivore populations that might otherwise be constrained by fences or small ranges within existing parks (see Table 11). The number of species that would benefit from having larger areas across which to move, that are likely to benefit from moving across international boundaries, or both, varies between 3 species in the Drakensberg to more than 14 species in the Chobe/Hwange area. The number of potential TBNRMAs involved in enhancing space for particular species varies from 3 areas, in the case of nyala, to 13 for eland, with zebra, buffalo, wildebeest, and impala populations benefiting in 10 or more potential TBNRMAs (see Table 11).

Habitat monitoring at a regional scale seems to be non-existent, and one of the largest gaps in information is the rate of conversion of wild land to other uses. Some data are available for limited areas, such as the Sebungwe (16,000 km^2) and the Dande-Chiswiti (8,000 km^2) areas of the Zambezi Valley in Zimbabwe, where human settlement and land under cultivation increased at about 9% per year over the period 1973-1993 (Cumming and Lynam 1997). In the absence of incentives to peasant farmers to manage, protect, and benefit from wildlife resources, wild land will continue to be converted into subsistence agriculture over much of the region. The rate at which this is occurring is not being monitored in any systematic fashion at national or regional levels.

Table 11. Occurrence of Fences and Likely Movement of Selected Large Herbivores across International Boundaries for the Potential TBNRMAs in Southern Africa

Area No.	Transboundary Area	Fence	TBM	Ele	WRh	BRh	Hip	Gir	Ze	Buf	Wbst	Imp	Gmb	Ku	Ela	Spbk	Wbk	Nya	Roan	Sa	Hb	No. Sp.
1	Iona/Skeleton Coast	0	1	1	0	1	0	1	1	0	0	1	1	0	0	1	0	0	0	0	0	**7**
2	Caprivi/Sioma/Luiana	1	1	1	0	0	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	**9**
	Chobe/Hwange	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	0	1	1	1	**14**
	Kaudom/Caprivi/WMA in Bw	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	0	**13**
3	Gemsbok/Kalahari	0	1	0	0	0	0	1	1	0	1	0	1	0	1	1	0	0	0	0	1	**7**
4	Mana/Zambezi/Cahora Bassa	1	1	1	0	0	1	0	1	1	0	1	0	1	1	0	1	1	1	1	0	**11**
5	Kruger/Zinave/ Gonarezhou	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	**16**
6	Niassa/Selous	0	1	1	0	0	1	0	1	1	1	0	0	1	1	0	1	0	0	1	1	**10**
7	Ais Ais/Richtersveld	0	?	0	0	1	0	0	1	0	0	1	1	1	0	1	0	0	0	0	0	**6**
8	Drakensberg	0	?	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	**3**
9	Malalotja	1	?	0	1	0	0	0	0	1	1	1	0	1	1	0	0	0	1	1	0	**8**
10/11	Ndumu/Tembe/Maputo	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	0	0	0	**13**
12	Tuli	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	1	0	0	1	1	**12**
13	Chimanimani	0	?	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	**3**
14	Nyika	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1	1	**6**
15	Kasungu/Lukusizi	0	1	1	0	0	1	0	0	1	1	1	0	1	1	0	0	0	1	1	1	**10**
16	Lengwe	1	1	0	0	0	0	0	0	1	0	1	0	1	1	0	0	1	1	1	1	**8**
17	Mwabvi	0	1	0	0	0	0	0	0	?	0	1	0	1	1	0	0	1	1	1	1	**7**
	Scores	**8**	**11**	**9**	**4**	**5**	**5**	**8**	**12**	**10**	**10**	**10**	**6**	**12**	**13**	**4**	**6**	**3**	**6**	**9**	**6**	

Note: The names associated with potential TBNRMAs are given as a convenient "handle", based upon existing protected areas or other well-known features and are not intended to define a TBNRMA in any way.

Species abbreviations: Ele = elephant, WRh = white rhino, BRh = black rhino, Hip = hippo, Gir = giraffe, Ze = zebra, Buf = buffalo, Wbst = wildebeest, Imp = impala, Gmb = Gemsbok, Ku = kudu, Ela = eland, Spbk = springbok, Wbk = waterbuck, Nya = nyala, Roan = Roan, Sa = sable, and Hb = hartesbeeste (Red and Lichtenstein's, depending upon locality).

Fence: 0 = absent, 1 = present.

TBM=Transborder movement likely in absence of barriers and would enhance population status, ? = importance of occurrence of transboundary movement uncertain, 1 = transboundary movement occurs or will occur in the absence of fences.

3.3 Infrastructure, Industrial Development, and Water

3.3.1 Transport and tourism

Tourism is recognised as the world's largest industry (Goodwin 1996). It is the fastest growing sector in southern Africa and worldwide, with the potential to become a significant engine for growth in the economy of the region. Despite an impressive growth in tourism arrivals in Africa (8% in 1997 over 1996), the continent still only generates 1% of the world tourism output (WTO figures quoted by Hanks [1998]). The potential for growth in the tourism sector thus seems to be considerable. A SADC-wide review of the tourism sector does not, however, appear to have been carried out within the last few years. The result is that tourism figures (numbers and origin of tourists, levels of international vs. local tourists, prime destinations within the region, and levels of expenditure and national and regional income) for the southern African region are not readily available. The broad infrastructure of the region in terms of airports, particularly international ones, roads, and rail links[3] is indicated in Figs. 3.19-3.21.

It is apparent from these maps and Fig. 3.11 that there is a dearth of international airports (those with immigration and customs facilities and suitable runways) within reasonable distances of the major protected areas and potential TBNRMAs in the region. The only exceptions to this observation are those parks in the vicinity of the Victoria Falls, Livingstone, and Kasane and those near Kruger National Park, where a new international airport is being opened at Hoedspruit. The Maputo airport services the Maputo TBNRMA. Essentially similar considerations apply to rail and road links to the main national parks and potential TBNRMAs of the region; apart from the parks in South Africa, Namibia, and northwestern Zimbabwe, road and rail links are generally poor or non-existent.

3.3.2 Energy and minerals

The region relies for its energy on coal-fired thermal power stations and on hydroelectricity generated from a few major reservoirs in the region (see Fig. 3.22). The location of major coal, oil, and gas deposits in the region are, not surprisingly, the key sites for the generation of thermal power, whose distribution is also indicated in Fig. 3.22. None of the major coal, oil, or gas production sites are currently located within potential TBNRMAs, but some existing and potential hydroelectric dams are, e.g., Lake Kariba or Lake Cahora Bassa.

As noted above, the early development of southern Africa centred on mineral exploitation; the richest deposits tend to be situated in the middle of countries with boundaries having been set in low-lying areas, which were perceived as having little value. The sites of major mineral deposits are indicated in Fig. 3.23.

3.3.3 Water supply and demand

Precipitation over southern Africa is almost entirely in the form of rain, with snow falling over limited mountainous areas in South Africa during brief periods in winter. Using mean monthly

[3] Some sections of railway may not be functional due to wartime destruction.

rainfall data for the period 1961-1990 and the ALCOM drainage basin model, the calculated total annual precipitation over southern Africa amounts to approximately 5,105 km^3 (or 5,105 billion m^3 of water). Of this amount, 50% falls on the five major catchments of the region, namely, the Zambezi (1,328 km^3), Okavango (367.5 km^3), Orange (366.5 km^3), Rufiji (265.6 km^3), and Limpopo (256.1 km^3). About 75% of the precipitation in the region falls in 23 out of 167 mega drainage basins (see Table 12).

Table 12. Megabasins in Southern Africa That Account for 75% of Precipitation Falling on the Region

MEGABASIN	Area of basin (ha)	Annual Av. Precip. (mm)	Total Precip. over Basin (cubic m)	Cumulative Vol.(cubic m)	Cumulative %
ZAMBEZI	137 570 522	960	1 328 328 942	1 328 328 942	26.0
OKAVANGO DELTA	69 552 613	544	367 570 360	1 695 899 302	33.2
ORANGE	97 879 134	421	366 499 859	2 062 399 161	40.4
RUFIJI	18 343 883	1 269	265 589 554	2 327 988 715	45.6
LIMPOPO	42 222 887	617	256 118 837	2 584 107 552	50.6
CUANZA (Kwanza)	15 142 191	1 257	195 311 095	2 779 418 647	54.4
ROVUMA (Ruvuma)	15 402 905	1 174	178 506 599	2 957 925 246	57.9
NIARI	6 160 726	1 708	105 828 906	3 063 754 152	60.0
CUNENE	11 249 234	789	91 929 251	3 155 683 403	61.8
ETOSHA PAN	16 133 424	560	82 601 997	3 238 285 400	63.4
LAKE RUKWA	7 341 949	1 044	82 533 635	3 320 819 035	65.0
SAVE	10 588 358	783	79 668 216	3 400 487 251	66.6
LURIO	6 165 269	1 207	72 913 285	3 473 400 536	68.0
LAKE EYASI	6 373 194	741	48 240 973	3 448 728 224	67.6
WAMI	4 149 982	1 153	44 079 826	3 517 480 362	68.9
INCOMATI	4 663 950	890	43 743 603	3 561 223 965	69.8
PUNGOE	3 218 775	1 377	43 713 395	3 604 937 360	70.6
LICUNGO	2 328 663	1 633	41 104 918	3 646 042 278	71.4
GALANA	4 841 519	809	39 414 063	3 685 456 341	72.2
LONGA	2 262 191	1 595	36 457 994	3 721 914 335	72.9
BUZI	2 887 657	1 279	36 019 527	3 757 933 862	73.6
PANGANI	3 484 004	1 167	34 773 400	3 792 707 262	74.3
CUACUA	1 922 028	1 699	32 851 223	3 825 558 485	74.9

Data from ALCOM (Lieven Verheust, pers. comm., 1998).

The total amount of precipitation over the region, or in any one basin, however, is only a part of the equation for determining water flows and yields. Moisture is "lost" primarily through evapotranspiration, and, in arid areas, this exceeds precipitation for most of the year. Water is absorbed into the soil and percolates into groundwater storage systems, where it may later be discharged into rivers as groundwater flow. The remaining water, in the form of surface runoff, accumulates in wetlands, streams, and rivers. Until recently, the prevailing view has been that all such water was available as a resource to be used by humans. Increasingly, it is becoming apparent that, if wetlands, rivers, and estuaries are to retain their biological and ecological roles and provide vital "ecosystem services," then a minimum flow of water is required to maintain their functional integrity (O'Keefe 1986; Ferrar 1989). Apart from recent legislation and associated research in South Africa and recent legislation in Zimbabwe, the principle of a drainage basin's right to a share of the water flowing through it ("nature's share") does not seem to have been seriously factored into water-yield and water-demand equations.

Detailed, recent regional data on runoff and water yields (i.e., water available for use by humans) for catchments in the region as a whole have not been located. As part of a study on climate change in southern Africa, Hume (1996) modelled runoff as a function of total precipitation less losses to evapotranspiration, soil infiltration, and groundwater. Over a large part of southern Africa, annual runoff is < 50 mm per annum, and, for most of the rest of the region, it is < 200 mm per annum. Estimates of "annual internal renewable water resources" in WRI (1992) and summary data on withdrawals are provided in Table 13. These data indicate that "available renewable water resources" are about 10% of overall precipitation (i.e., 502 km^3 out of 5,105 km^3). The estimated available water resources derived from Chenje and Johnson (1996); using their tables' country areas, human populations, and per-capita water resources; provide an overall figure of 748 km^3 of water for the region or 50% more than the WRI figure.

Table 13. Annual Internal Renewable Water Resources, Withdrawals, and Proportion of Withdrawals for Countries in Southern Africa, by Sector

	*Water Resources**		*Withdrawals*			*Sectoral Withdrawals*		
	Total (km3)	Per capita (mega litres)	Total km3	%	Per capita (mega litres)	Domes-mestic	Indus-try	Agri-Culture
Angola	158	15.8	3	16	166	22	4	74
Botswana	1	0.8	0.09	1	98	5	10	85
Lesotho	15	0.6	0.05	1	34	22	22	56
Malawi	9	1.1	0.16	2	22	34	17	49
Mozambique	58	3.7	0.76	1	53	24	10	66
Namibia	9	5.1	0.14	2	77	6	12	82
South Africa	50	1.4	9.2	18	404	16	17	67
Swaziland	7	8.8	0.29	4	414	5	2	93
Tanzania	76	2.8	0.48	1	36	21	5	74
Zambia	96	11.4	0.36	0	86	63	11	26
Zimbabwe	23	2.4	1.22	5	129	14	7	79
Total	502	4.2	15.75	3.1	131.2			

* Note: The levels of water given by the WRI data as runoff, inflows, and groundwater (i.e., Annual Internal Renewable Water Resources) accumulations in rivers are very close to the total precipitation falling on the region and are therefore unlikely to be correct. (See text for further comments.)

Source: WRI (1992).

The WRI data (Table 13) indicate total withdrawals of about 16 km^3 in 1987 or about 3.1% of available water. Chenje and Johnson (1996) provide an estimate of water demand for the region, which covers requirements for domestic use and industry, stock, mining and energy, irrigation, and nature by country. Their estimated demand (with provisions for nature included only for South Africa, Swaziland, and Botswana) amounts to 60,515 million m^3 per annum (or 60.5 km^3 per annum). This figure is about 12% of the estimated available renewable water resources (i.e., 60.5 out of 502 km^3) before the requirements to maintain functional rivers and wetlands have been fully considered.

Although adequate water resources appear to be available at a gross regional scale, the mismatch between water resources and the distribution of human populations, agricultural

production, and industry are such that several countries in the region are already facing severe water supply constraints. There is little doubt that water will be a serious limiting factor to development in southern Africa in the near future (Falkenmark 1989; Falkenmark et al. 1990) and the need for transboundary management of water resources will assume increasing importance.

The direct implications for TBNRMAs of a broad-scale analysis of regional water yields and demands are presently unclear. However, as the demand for water grows with increasing human populations and industrialisation, there is little doubt that rivers and wetlands will be placed under increasing stress. Many of these wetlands occur on transboundary areas (see Fig. 3.11). The effective management and protection of large, high-yielding watershed areas will also be extremely important for the region as a whole. The areas of particular importance include the upper reaches of the Zambezi on the Angola/Zambia border; highlands of central Angola, which feed the Okavango and the Zambezi; and the highland areas of northeastern Zambia, Malawi, eastern Zimbabwe, Swaziland, and Lesotho. All of these areas either supply water to neighbouring countries or are close to, or situated on, international boundaries.

4. Conclusions

An overview of the ecology of southern Africa in relation to land use and transboundary conservation areas reveals major opportunities for TBNRMA development and the management of wild natural resources as primary land uses in the region. The opportunities arise from several key constraints to conventional agricultural development in the region. While the constraints apply generally to the region, they are most pronounced in marginal lands, which lie adjacent to national boundaries in the region. These constraints are summarised below followed by a brief outline of the opportunities and challenges.

- ***Southern Africa is predominantly arid or semi-arid.*** Approximately 65% of the land area of southern Africa can be classified as arid or semi-arid, with a mean annual rainfall of less than 750 mm. This means that, for most of the region, the primary determinant of plant growth is moisture, where rainfall is characterised by high spatial variability within seasons, high variability between years, and recurrent but unpredictable droughts. Furthermore, mean annual temperature in the region has increased over the last century, resulting in increased aridity.

- ***Soils are mostly infertile.*** Soils in southern Africa are derived from an ancient basement complex and are mostly infertile, with some 66% of the region comprising Arenosols, Acrisols, Luvisols and Ferralsols; all soils which have low or no agricultural potential. Soils in the high rainfall areas have been leached and produce plants that are of generally low nutrient quality for livestock, resulting in low carrying capacities. Soils in arid areas are richer in nutrients, but plant growth is constrained by moisture and short growing seasons.

- ***Range animal production is limited by rainfall in arid areas and by nutrients in moist areas.*** Livestock production in extensive systems is tied to rainfall and nutrients. Within southern Africa, livestock populations have grown little in the last 30 years, suggesting that they have reached a ceiling. Human population growth, on the other hand, has remained high, and there are now more humans than livestock units in the region. Per capita production of meat and milk for southern Africa has declined by some 25% over the last 20 years. Levels of meat and milk production in temperate and developed regions of the world, such as Europe, are about 20 times higher than in southern Africa. At a global level, the region is unlikely to compete in international markets without major subsidies.

- ***Arable land covers about seven percent of the region and irrigable soils less than one percent.*** At present, about 5% of the region is cultivated and only 0.28% is irrigated. There is a major mismatch between the distribution of human populations and land suitable for cultivation. The result is that cultivation is expanding rapidly into marginal lands, where sustainability is unlikely.

- ***Staple food products are not keeping pace with population growth.*** Food production in southern Africa over the last 20 years has not kept pace with human population growth, with the result that there has been a 20-25% decline in the per capita production of staple cereal and root crops.

In direct contrast to southern Africa's poor agricultural potential is its enormous wealth in attractive wild landscapes and charismatic wild plants and animals, particularly its spectacular

large wild mammals. Although under pressure from expanding rural populations and settlement, these resources are still largely intact, and large areas, *particularly along national boundaries*, carry rich wildlife resources and have low human populations. A major opportunity exists for the region to diversify land-use practices in these areas to encompass biodiversity as an ecologically and economically viable and sustainable primary land use. A significant proportion of the transboundary area in southern Africa has the potential to make a greater contribution to sustainable development than would be the case if these marginal lands were to be used for extensive or subsistence agriculture.

About 20% of the region is already under some form of wildlife or forestry use. The potential to extend biodiversity as a primary land use to an additional 20% of the region, where about 65% is only marginally suitable for agriculture, clearly exists. The major challenge, however, is to develop the institutional and incentive structures that will allow and encourage landowners and resource managers, both within and across national boundaries, to realise these opportunities.

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ANNEX: Ecological Criteria for the Establishment of TBNRMAs

Early in the study, work was done to define ecological criteria relevant for TBNRM area establishment. This process included a preliminary approach to choosing and ranking criteria to identify key TBNRM areas. Stakeholders in the region expressed some concern about the ranking of areas in general and about how rankings might be used, so the approach was not developed further. However, the work is presented here as the assessment methodology. Its findings are informative, and some aspects may be useful in the future. It is important to note that changes in emphasis in ranking criteria by adjusting various weightings could change the order of priority of individual TBNRMAs.

1. Introduction

The creation of TBCAs/TBNRMAs can be viewed purely in terms of biological conservation criteria, such as the need to preserve particular species, habitats, or ecosystems. The development of TBNRMAs can also be viewed in the wider context of sustainable land use in southern Africa. Sound land-use and conservation arguments can be (and have been) advanced for extending wildlife[4] as a land use in the region, particularly in arid and semi-arid areas and in agriculturally marginal areas (e.g., Cumming and Bond [1991]; Cumming [1993, 1995]; Child [1995]).

Boundaries in southern Africa, formed by colonial powers, tend to be in marginal areas where natural resources were seldom disputed and ecological criteria were minor considerations. Because border areas were, and largely remain, peripheral to the key mineral and agricultural resources, and therefore peripheral to major development thrusts of southern African countries, they also tend to be the least developed in terms of infrastructure. The options for alternative land uses are thus more likely to remain open in these areas than in central, more richly endowed, or developed areas within each country. Similar considerations apply to land-use boundaries in marginal areas within countries (e.g., between differing tenurial systems, such as commercial and communal farming areas and the boundaries of existing protected areas). There may thus exist considerable opportunity for functional, if not *de jure,* changes in land-use boundaries in marginal border areas, both within and between countries. On this basis, it seems appropriate to examine criteria for potential TBNRMAs from two perspectives:

1. their suitability for meeting national, regional or international biodiversity conservation goals; and

2. their suitability as areas in which to maintain intact wild land and use it for the direct benefit of local landowners (communal and commercial farmers and agencies responsible for state land).

In many cases, potential TBNRMAs may meet both objectives, and the selection criteria and analysis should highlight areas where biodiversity as a primary land use might be most suitable

[4] The term *wildlife* here refers to the full range of indigenous plant and animal species and includes fisheries and indigenous forestry.

(Walker 1999; Cumming 1999). Although beyond the scope of this study, such an analysis might usefully be extended to areas not adjacent to international boundaries.

2. Criteria for Establishing Conservation Areas: A Brief Review

Approaches to defining priorities for conservation and sustainable use were reviewed by Johnson (1995a, 1995b), who divided these into: a) genetically based, b) species based, c) ecosystem based, and d) integrative approaches

Genetic-based approaches are usually considered in the conservation of particularly rare and endangered species for which it may be important to maintain genetically distinct subpopulations or ensure that a full range of genetic variability is preserved in small populations or in a single small population. Genetic approaches have been most used, and are perhaps most appropriate in the *in situ* preservation of plant species and in the preservation, often in gene banks, of varieties of the same species.

Species-based approaches generally focus on population sizes and the geographical distribution of sites important to the survival of the rare or endangered species under consideration. These may be linked to habitat-based approaches, which include a number of species. A clear example is the identification of 221 endemic bird areas by the RSPB (Bibby et al. 1992).

Ecosystem-based approaches include several attempts to classify terrestrial habitats into "natural regions." However, because ecosystems vary greatly, are poorly understood, and change with time, they are also difficult to define. The result is that several classifications exist for the same areas, and there is often little consensus regarding boundaries and the units recognized.

Integrative approaches attempt to accommodate the dynamic nature of ecosystems and emphasize the entire range of landscapes, from protected wilderness areas to intensively-managed landscapes and urban areas. These approaches take into account the social, economic, and other criteria, in addition to biological criteria.

Johnson (1995b) suggested the following principles for setting biodiversity conservation priorities:

1. Link biodiversity priorities with clear conservation goals and objectives.
2. Use a replicable, transparent process to develop credible priorities.
3. Clarify local, national, and global biodiversity conservation priorities.
4. Evaluate the advantages and disadvantages of any chosen priority-setting scheme.
5. Make full use of relevant and available information.
6. Involve those responsible for implementing conservation actions in the priority-setting process.
7. Involve other constituencies, including local communities, in the priority-setting process.
8. Establish a process to revise and reassess priorities at regular intervals.
9. Consider how priorities fit within a policy and institutional context.
10. Link conservation priorities to other planning and policy processes, such as national biodiversity strategies and action plans.

These are eminently sensible and workable principles. It was also clear at the outset of the TBNRMA study that neither time nor resources were available to address all of these principles. The suggested criteria presented here for selecting TBNRMAs should therefore be seen as no more than a preliminary basis upon which to start the debate.

In practice, the four types of approaches suggested by Johnson (1995b) can be re-arranged as follows:

1. *Species-based, "hot spot" approaches*

Here the focus is on protecting species-rich areas or areas rich in endemics. It has been applied at global, regional, national, and local levels. At a global level, the tendency has been to identify those countries with the greatest number of species and focus conservation efforts in these areas (e.g., WWF's focal country approach of the 1980s; Bibby et al. [1992]; McNeeley et al. [1990]).

2. *Conservation of particular species*

The development of Species Action Plans by IUCN Specialist Groups has, over the last two decades, involved developing criteria for establishing priority populations of particular species, priority geographical areas, and conservation actions needed. Criteria have been developed to meet specific needs and species, and these have changed over time. Increasingly, they have attempted to meet the principles outlined above. Examples include the criteria developed by the African Elephant and Rhino Specialist Group in 1981 and again in 1987 (Cumming and Jackson 1984; Cumming, du Toit, and Stewart 1990), in which species, genetically distinct populations within species, and protected areas holding these species were scored and ranked on biological, conservation, and socioeconomic criteria. This approach was readily extended into developing criteria to rank protected areas.

3. *Protected areas and habitats*

The species-based approach, which included criteria for selecting specific geographical areas for their protection, was also readily generalized into developing criteria for prioritizing investment of resources in protected areas and prioritizing areas for inclusion in protected area systems (e.g., Cumming [1983]; Branch of Terrestrial Ecology, Zimbabwe Dept. NPWLM Workshop [1983]; Bell and Martin [1984]; Clarke and Bell [1986]).

4. *Biomes, ecoregions, and endangered spaces*

On the basis of the global distribution of biological diversity and threats to species diversity and environments, organizations such as WWF have given priority to the conservation of forests and freshwater and marine biomes. At a more specific level, several organizations have adopted an ecoregion-based approach in which continents have been classified into ecoregions and the levels of biological diversity, threat, and global distinctiveness have been used to select priority ecoregions for conservation support. In Canada, the Endangered Spaces program has focused on increasing the area under protected status for those habitats that are either not represented or poorly represented in the national protected area system. This approach and others often

involve using GIS gap analysis techniques to first define habitats, their distribution, and level of protection or threat (Scott et al. 1993; Dinerstein et al. 1995).

5. *Opportunistic and final default option*

Several protected areas in the region were initially designated as such because the land was not seen as being useful for agricultural or other, more intensive uses. Mountainous areas, areas of broken terrain, and remote areas with low agricultural potential often featured in such choices, which partly explains the prevalence of protected areas in low-lying, remote border areas of countries in southern Africa. At a smaller scale, the same thinking was applied in the planning of agricultural land. Standard classifications of land capability were ranked from various categories of arable and grazing land to land unsuitable for any form of agricultural production and therefore suitable for wildlife or recreation (e.g., Agritex Landuse Planning Manual, Zimbabwe, 1977). In many parts of the region, land unsuited to agricultural production is being cultivated or grazed, and the option of turning such land into productive wildlife use could be explored as part of the TBNRM program.

To date, the development of TBNRM initiatives in southern Africa appears to have been on a local, opportunistic basis and not part of a larger plan or strategy other than that outlined in *Getaway Magazine* ("Superparks: The impossible Dream," Pinnock, Nov. 1996). Despite its limitations, this article boldly mapped the potential corridors that might serve to join the existing protected area system of southern Africa from north to south and east to west into a vast conservation areas network. Similar suggestions were made for the development of multispecies animal production systems, involving both wildlife and livestock, over large areas of southern Africa, to facilitate the development of opportunistic management systems required to meet the spatial and temporal vagaries of arid lands and semi-arid, tropical rangelands in the region (Cumming 1993). The potential TBNRMAs considered in this Annex are indicated in Fig. 3.11.

Of course, there is extensive literature on decision-making, both in terms of mathematical theory and in relation to options and choices in environmental management and the selection of conservation areas (see References). In many cases, the most effective techniques and approaches that have been developed require far more accurate and detailed information than is available for the current exercise. However, without major resources for data collection, consultation, analysis, and communication amongst stakeholders, such techniques are unlikely to be widely used in reaching conservation decisions.

3. Regional and National Policies and Goals for Conservation?

Biological, ecological, and conservation criteria for scoring or ranking potential conservation areas clearly need to be in harmony with regional and national goals for conservation. A draft SADC-level policy statement on wildlife (i.e., excepting forestry and fisheries) conservation goals for the region was developed in 1998, and the Protocol was signed in August 1999 (SADC 1999). The Protocol is clearly supportive of regional and cross-border conservation and management of wildlife. Key elements of the Protocol relating to TBCAs are as follows:

From the Preamble (note that not all paragraphs are included below):

"AFFIRMING that Member States have the sovereign right to manage their wildlife resources and the corresponding responsibility to sustainably use and conserve these resources;

NOTING that Article 5 of the SADC Treaty states that the sustainable use of natural resources and effective protection of the environment is one of the objectives of SADC;

NOTING also that Article 21 of the SADC Treaty designates natural resources and environment as an area of cooperation for SADC Member States;

AWARE that the conservation and sustainable use of wildlife in the SADC Region contribute to sustainable economic development and the conservation of biological diversity;

CONVINCED that the viability of wildlife resources in the SADC Region requires collective and cooperative action by all SADC Member States;"

BELIEVING that the regional management of wildlife and wildlife products will promote awareness of the socioeconomic value of wildlife and enable equitable distribution of the benefits derived from sustainable use of wildlife;

DESIRING to establish a common framework for the conservation and sustainable use of wildlife resources in the SADC Region and to assist with the effective enforcement of laws governing those resources;

HEREBY agree as follows:

ARTICLE 2, SCOPE: This protocol applies to the conservation and sustainable use of wildlife, excluding forestry and fishery resources."

ARTICLE 3, PRINCIPLES: Each State Party shall ensure the conservation and sustainable use of wildlife resources under its jurisdiction. Each State Party shall ensure that activities within its jurisdiction or control do not cause damage to the wildlife resources of other states or in areas beyond the limits of national jurisdiction.

ARTICLE 4, ATTAINMENT OF PRINCIPLES:

1. Pursuant to the attainment of the principles contained in Article 3 of this Protocol, States Parties shall:

a) ensure cooperation at the national level among governmental authorities, nongovernmental organisations hereinafter referred to as NGOs, and the private sector;

b) cooperate to develop as far as possible common approaches to the conservation and sustainable use of wildlife, and,

2. *In implementing this Protocol, States Parties shall:*

c) cooperate with other Member States to manage shared wildlife resources as any transfrontier effects of activities within the jurisdiction or control.

ARTICLE 5, OBJECTIVES:

1. *The primary objective of this Protocol is to establish within the Region and within the framework of the respective national laws of each State Party, common approaches to the conservation and sustainable sue of wildlife resources and to assist with the effective enforcement of laws governing those resources.*

2. *To this end, specific objectives of this protocol shall be to:*

f) promote the conservation of shared wildlife resources through the establishment of transfrontier conservation areas; and

g) facilitate community-based natural resources management practices for management of wildlife resources.

ARTICLE 8, WILDLIFE MANAGEMENT AND CONSERVATION PROGRAMMES

9. *States parties shall in recognition of the location of key wildlife resources near international boundaries, promote the development of trans frontier conservation and management programmes."*

At an international level, the conservation goals elaborated in the Convention on Biological Diversity (CBD), to which most countries in the region are signatories, also provide guidance on the matter. In summary, these are as follows for *in situ* conservation:

"Each Contracting party shall, as far as possible and as appropriate:

(a) *Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity;*

(b) *Develop, where necessary, guidelines for the selection, establishment and management of protected areas or areas where special measures need to be undertaken to conserve biological diversity;*

(c) *Regulate or manage biological resources important for the conservation of biological diversity whether within or outside of protected areas, with a view to ensuring their conservation and sustainable use;*

(d) *Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings;*

(e) *Promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering protection of these areas;*

(f) *Rehabilitate and restore degraded ecosystems and promote the recovery of*

threatened species, inter alia, through the development and implementation of plans or other management strategies;

(g) *Establish or maintain means to regulate, manage and control the risks associated with the use and release of living modified organisms resulting from biotechnology which are likely to have adverse environmental impacts that could affect the conservation and sustainable use of biological diversity, taking also into account the risks to human health;*

(h) *Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species;*

(i) *Endeavor to provide the conditions needed for compatibility between present uses and the conservation of biological diversity and the sustainable use of its components;*

(j) *Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote wider application, etc.;*

(k) *Develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations;*

(l) *Where a significant adverse effect on biological diversity has been determined persuant to article 7, regulate or manage the relevant processes and categories of activities; and*

(m) *Cooperate in providing financial and other support for in-situ conservation outlined in paragraphs (a) to (l) above, particularly to developing countries."*

Articles 10 (Sustainable use of components of biological diversity) and 11 (Incentive measures) also have a bearing on the develop of TBCAs.

The creation of new protected areas, development of TBCAs and the ***development of conservation areas where sustaining and using biological diversity are the prime form of land use*** are clearly supported, if not endorsed, by both the SADC agreement on Wildlife and the CBD

4. An Approach to Identifying and Ranking Potential TBNRM Areas

The approach suggested here includes elements of several of the approaches outlined above by including them in a graded series of filters and criteria. The criteria are scored, which allows them to be weighted (if necessary) and potential areas to be ranked on the basis of the scores and weightings assigned to them. The system facilitates the inclusion of criteria that cover both conservation objectives and wildlife as a land use.

The first step in the process is to establish criteria for including or excluding land in border areas. This "coarse filter" provides an initial set of areas that have some potential to form TBNRMAs, which for the purposes of this study are defined as:

"Relatively large areas, which straddle frontiers between two or more countries and cover large-scale natural systems encompassing one or more protected areas." (Statement of Work, page 2)

The second step is to score these potential areas on the basis of biological, conservation, and land-use criteria that allow the areas to be ranked in relation to each other along one or more axes. The advantage of this approach is that socioeconomic and other criteria can then readily be applied to the areas and used as additional axes or filters in selecting priorities.

First filter: Criteria for Inclusion/Exclusion of Land in or from TBNRMA

Criteria for potential inclusion in TBNRMAs

1. Existing designated national park, protected area, game or wildlife management area, indigenous forest area on an international boundary, or sufficiently close to a boundary to be part of a larger transboundary ecosystem, where there is a protected area on the boundary, or within the same ecosystem, in a neighbouring country.

2. An area under extensive land use with low human population densities adjacent to an existing conservation area on an international boundary or forming an ecologically functional corridor between conservation areas.

3. Areas under extensive, mainly wildlife use (conservancies, CBNRM areas, indigenous forest areas, lakes, wetlands) that meet on, or straddle, international boundaries.

The first underlying assumption in these criteria is that an existing protected area, GMA, WMA, or forest reserve is a prerequisite to form the "nucleus" of a TBCA. A second assumption is that the areas concerned are part of a larger transboundary ecosystem. Both assumptions comply with the definition of a TBNRMA adopted for the purposes of this study (see above).

Criteria for exclusion of an area from a potential TBNRMA

1. Land adjacent to an existing or proposed conservation area where more than 50% of the landscape has been transformed into intensive agricultural land uses.

2. Land with high human density (>25 people per km^2), under subsistence cropping, and where more than 30% of the landscape has been transformed.

3. Land of very high mining or agricultural production potential--particularly under irrigation, unless such land is in small pockets where people and crops can be protected from wildlife in surrounding areas, or where it may be a relatively small area forming a vital corridor or a provide key resources to wildlife populations over a much large area. Narrow, alluvial flood plains are an example of key dry-season resources without which many large herbivore populations would collapse.

The key assumption underlying these criteria is that larger areas of prime agricultural land (i.e., land suitable for intensive agricultural production and cropping) should be so used. To do otherwise is to ignore the precarious food security situation of the region and its demographic realities. The protection of representative habitats and species of at least some highly fertile areas is important. However, the "relatively large areas of intact, sparsely settled land", with which TBNMRAs are concerned, are unlikely to encounter the problem.

Criteria for Ranking Areas with Potential for Inclusion in TBNRMAs

Each potential TBNRMA area would be scored using the following sets of criteria covering:

1. Biological properties;
2. Conservation value;
3. Cultural, archaeological, and historical values;
4. Scenic and amenity values; and
5. Land-use capability and suitability for wildlife/tourism use.

Each of these is elaborated in the subsections below:

There is a justifiable emphasis on biodiversity at species, habitat, and ecosystems scales because the TORs for this study specified the development of "ecological criteria" and a stated aim of TBCAs/TBNRMAs is conservation of biodiversity. The conservation criteria thus reflect value systems more explicitly than biophysical criteria and, as one moves into historical, scenic, land-use and tourism criteria, so cultural and market values assume greater importance. The additional criteria dealing with more explicit resource values, such as amenity value, scenery, tourism, and land-use potential are, however, presented as a means of illustrating where the present approach may lead in terms of providing a more inclusive framework for ranking potential TBNRMAs. Such a ranking system will need to include cultural, institutional, and economic criteria.

Biophysical properties

1. Size of area

Score:
0 = Less than 100 km^2
1 = 100-1,000 km^2
2 = 1,000-5,000 km^2
3 = 5,000-10,000 km^2
4 = > 10,000 km^2

Area is clearly an overarching property since it is linked to underlying ecological processes, population dynamics, dispersal and viability (particularly for larger, more mobile and often less numerous species), and to species richness. It also has implications for economic viability.

2. **Structural diversity**

Score:

0 = Flat landscape, no major river, small perennial river(s)

1 = Undulating landscape, altitude range of < 300 m or flat with larger rivers

2 = Dissected landscapes, more than one land form, altitude range < 500 m, perennial rivers

3 = Flat, undulating and dissected landscapes, altitude range >500 m, at least one large river

4 = Variety of land forms (flat, dissected, scarps, mountains, lakes), altitude range > 1,000m, major river

Biological diversity is likely to be linked to underlying geological and structural diversity in the environment (Burnett et al. 1998; Nichols et al. 1998). Easily used, unambiguous criteria to capture this diversity (more effectively than those given here) would be useful. Riparian systems are also an important correlate of biological diversity.

3. **Habitat diversity**

Score:

0 = single vegetation/habitat type

1 = At least two major vegetation/habitat types, with little inter-digitation

2 = At least two major vegetation/types, with some inter-digitation

3 = 2 or more vegetation types and significant inter-digitation

4 = 3 or more major vegetation types, with significant inter-digitation

Major vegetation types refer to those in White's (1983) vegetation map. Wild and Barbosa's (1967) Flora Zambeziaca map provides a finer and perhaps more useful scale, but does not cover the region.

4. **Species richness (plants and animals)**

Score:

0 = Low level of species richness (species richness = number of species)

1 = Moderate species richness

2 = Moderate species richness, with at least one endemic species

3 = High species richness and/or two or more endemics

4 = Exceptional species richness and endemics

Within the region, the lowest levels of species richness (i.e., number of species) occur in southwestern Botswana and in Namibia; the highest levels (excepting the Fynbos in the Cape) occur in the moister, higher-elevation forests in the northeast of the region. It is in these areas that "exceptional" levels of species richness and endemism occur.

Conservation value: Regional level

1. **Dominant ecosystem type**

Score:

0 = Woodland-savanna (dominant ecosystem type in the region)

1 = Desert-steppe

2 = Grassland

3 = Lowland evergreen forest/forest savanna mosaic

4 = Swamp, flood plains, lakes, montane evergreen forest (cover the smallest areas in region)

The gradation from woodland to wetlands and montane forest is intended to capture the level of protection already afforded to habitats in the region, where more than 10% of savanna woodlands are included in protected areas. There is some overlap with category 3 below.

2. **Rare or threatened species and threatened endemics (plants and animals)**
   Score:
   0 = No rare or threatened species or endemics (limited distribution species)
   1 = No endemics and at least one threatened species at national level
   2 = At least one endemic and one species threatened at regional level
   3 = At least two species threatened at regional level
   4 = Two or more endemics and at least one threatened species at regional level

3. **Rare, threatened, or underprotected habitats**
   Score:
   0 = None of the habitats in the area are under threat or poorly represented in protected areas
   1 = Includes some habitat that is poorly represented (< 5%) in PA systems in region
   2 = Includes at least one habitat that is poorly represented in PAs in region
   3 = Includes more than one habitat poorly represented in PAs
   4 = Includes at least one habitat that is badly represented (< 2%) in PAs in the region

Although partially overlapping with category 1 above, it is intended to provide some weight to smaller areas of particularly important habitats within larger areas.

4. **Conservation function (corridor, migrant stopover, dry-season refuge, key breeding area)**
   Score:
   0 = Area does not serve as a corridor, refuge, etc.
   1 = Serves as (or includes) a corridor between two small (<1000 km^2) protected areas (PAs)
   2 = Serves as (or includes) a corridor between large (> 3000 km^2) PAs
   3 = Serves as (or includes) a corridor between PAs and as a refuge for migratory species
   4 = Serves as (or includes) a corridor and is an important refuge and/or breeding area

This set of criteria applies to particular areas, but not to an overall TBNRMA comprising several areas; if "serves as" is replaced by "includes," then the criteria can be applied to a TBNRMA comprising several areas as is indicated in Tables 1 and 2.

Cultural and tourism value

This category could be divided into several sets of scores, as in the biophysical or conservation sections but the following three sets of criteria may suffice.

1. **Cultural and historical interest or significance**

   Score:

   0 = No known cultural or historical sites of particular importance locally
   1 = At least one cultural, historical or archaeological site of local importance
   2 = Includes cultural, historical, or archaeological site of national importance
   3 = Site(s) of high regional historical/cultural interest or archaeologically important sites
   4 = Site(s) of high international cultural, historical, or archaeological significance

2. **Scenic values**

   Score:

   0 = Unattractive, monotonous landscape
   1 = Reasonably attractive, some diversity
   2 = Attractive, diverse landscape
   3 = Attractive, diverse landscape, with perennial water or lakes or coastal area
   4 = Impressive scenic vistas, diverse habitats, with perennial water, lakes, or coasts

These are, of course, subjective, and more objective criteria or well-founded preference data are needed.

3. **Tourism potential and access**

   Score:

   0 = Unattractive area with very low potential and very limited access
   1 = Low tourism potential (one or two attractions) and inaccessible
   2 = Some tourism potential (more than two attractions) and reasonable access
   3 = Good tourism potential (several attractions) and accessible
   4 = Excellent tourism potential (varied attractions) and good access

Attractions could include hunting, angling, hiking, game viewing, photography, scenic drives, historical and cultural sites (note: Climate - comfort zones and disease aspects might be included).

Landuse capability and suitability for wildlife / NRM / fisheries / forestry / multi-species use

1. **Agricultural land-use capability**

   Score:

   0 = Prime arable agricultural land with irrigation potential or mineral-rich, high mining potential
   1 = More than 10% of area suitable for productive dryland cropping
   2 = Limited dryland cropping (<10%), limited grazing, supports low human population (< 10/km^2)
   3 = Unsuitable for dryland cropping, supports very low human population density (<5/km^2)
   4 = Unsuitable for habitation and livestock grazing (e.g., deserts, rocky mountainous areas, or swamps)

The criteria score areas of high agricultural potential lowest because the demographic realities of the region suggest that such land will most likely be used for agriculture.

2. **Indigenous resource-use potential**
   Score:
   0 = None or very limited potential for game, fisheries, and woodlands (timber and non-timber products)
   1 = Some potential for game use (safaris, cropping)
   2 = Reasonable potential for game and timber use
   3 = Good potential for game, timber, fisheries, and consumptive tourism (safari hunting, fishing)
   4 = Excellent potential for game, timber, fisheries, and consumptive tourism based on these

Tourism, in the sense of sightseeing, is excluded here because it is included under cultural and tourism value. Thus, an area could score zero for resource-use potential but have scenic vistas, resulting in a high tourist potential score.

Assessment of Criteria and Scoring System

The scoring system outlined above is no more than a preliminary attempt to outline a system upon which further discussion can be based. The system could be greatly simplified in terms of the numbers of categories scored and the range of scores or number of questions within each category. A larger working group is probably needed to fully examine and develop the criteria.

5. Regional Analysis of Conservation Areas in Relation to Habitats/Vegetation Types

In order to determine the level of protection of various habitats or vegetation types, a simple "gap analysis" may be needed to determine what proportion of the various habitats types occur within conservation areas of various types in the region. MacKinnon and MacKinnon (1986), using crude map overlays and counting grids to measure areas, carried out such an analysis for the Afrotropical Realm. Repeating the measurements for the SADC region using computer-based GIS techniques may thus be necessary.

6. Regional Analysis of Potential TBNRMAs

The potential TBNRMAs in the region fall into three groups. The first group, Large Potential TBNRMAs (see Table 1), cover six TBNRMA areas ranging between 18,000 and 110,000 km^2. The second group includes the smaller TBNRMAs, of which there are 11 and which cover areas of less than 5,000 km^2 (see Table 2). The third group involves lakes and coastal zones, of which there are at least eight but which are not included in the analysis here.

The scoring system has been applied to each area within a potential TBNRMA and then to the area as a whole. The scores of the individual areas are not additive because the total score would depend too greatly on the number of areas within the complex. The scores for particular, legally defined or otherwise recognisable areas nevertheless do highlight the prime areas within a particular complex and may also serve to highlight areas that should be excluded. The scores for each complex (shown in bold in Annex Tables 1 and 2) illustrate fairly clear separation of the

potential TBNRMAs into high and low scoring areas.

TBCAs, such as the Kgalagadi (Kalahari-Kalahari Gemsbok area), score low largely because they are flat, rather uniform areas at the macro-scale, with very low diversity compared to the Chobe/Victoria Falls complex. Similarly, the well-watered, mountainous, and forested areas score high on diversity across the board and outrank the larger, less diverse although vast, areas of savanna scrub, such as in the Kruger/Banhine/Gonarezhou complex.

It is also clear that some of the complexes outlined here could be extended into even larger areas. The Chobe/Victoria Falls complex could be linked to the Luiana/Sioma/Caprivi complex, and this large area could be linked to the Kafue National Park in Zambia. The Mana-Sapi/Chewore/Zambezi National Park complex could be linked in the west to Matusadona National Park and in the northeast to the Luangwa National Park through existing Game Management Areas.

From an ecological perspective, coordination in the management of these vast areas could be beneficial to all concerned and could probably be achieved. It need not necessarily involve all of the complications that may be attached to trying to make international boundaries within TBNRMAs (already permeable to most organisms) open to humans.

7. Transboundary Freshwater and Marine Conservation Areas

TBNRMAs on lakes Tanganyika, Malawi/Niassa, Kariba, and Cahora Bassa would most likely focus on resource management and exploitation, although conservation issues in both Tanganyika and Malawi are also likely to be very important. There are few coastal/marine protected areas in the region; thus, exploring the potential of these TBNRMAs would need a fuller examination of the current conservation status of the coast of southern Africa in order to place them in a regional perspective. Marine areas were outside of the scope of this study.

Annex: Table 1. Larger (>10,000 km^2) Potential TBNRMAs in Southern Africa

TBNRMA No.	Name of Area	Area km^2	1st Filter	Biophysical					Conservation Value					Culture/Tourism				Land-use Capacity				
				1	2	3	4	Score	1	2	3	4	Score	1	2	3	Score	1	2	Score	Area Score	TBNRMA Score
1	**Iona NP – An**	15,150	1	4	2	1	0	7	1	2	0	2	5	0	2	1	3	4	2	6	21	
	Skeleton Coast NP - Na	16,390	1	4	1	0	0	5	1	2	0	0	3	0	1	2	3	4	2	6	17	
		31,540		4	3	1	0	8	1	2	0	0	3	0	3	3	6	4	2	6	23	**23**
2	**Caprivi NP – Na**	5,300	1	3	2	2	2	9	0	2	0	0	2				0				11	
	Sioma-Ngwezi - Zm	5,276	1	2	2	2	2	8	0	2	2	1	5	0			0			0	13	
	Luiana Reserve - An	8,400	1	4	3	4	3	14	0	2	2	2	6	0	1	0	1			0	21	
	Chobe NP – Bw	9,980	1	3	1	2	2	8	1	1	0	2	4	0	1	3	4	4	4	8	20	
	Chobe Forest Reserve - Bw	1,200		2	0	0	1	3	0	0	0	2	2	0	0	1	1	4	4	8	13	
	Moremi GR	3,900		2	1	2	1	6	4	0	1	0	5	0	3	4	7	4	4	8	19	
	Zambezi/Vic Falls NP - ZW	583	1	1	4	0	1	6	0	0	0	2	2	2	4	4	10	4	4	8	18	
	Matetsi/Forestry - Zw	2,920	1	2	1	2	1	6	0	0	0	0	0	0	2	2	4	4	4	8	14	
	Kazuma Pan NP - Zw	313	1	1	0	1	1	3	0	0	0	0	0	0	1	1	2	4	4	8	11	
	Hwange NP – Zw	14,651	1	4	1	2	1	8	0	1	0	0	1	1	2	3	6	4	4	8	18	
	Kasane FR – Bw	637		1	1	1	1	4	0	0	0	2	2	0	0	1	1	4	4	8	14	
	Kazuma FR – Bw	237		1	0	0	1	2	0	0	0	0	0	0	0	1	1	4	4	8	10	
	Sibuyu FR – Bw	1,175		2	0	0	1	3	0	0	0	0	0	0	0	1	1	4	4	8	11	
	Khaudom NP – Na	3,841	1	3	1	1	2	7	0	0	1	0	1	0			0			0	8	
		58,413		4	2	4	2	12	0	2	2	3	7	2	3	4	9	4	4	8	36	**36**
3	**Gemsbok NP – Bw**	24,800	1	4	1	1	0	6	0	1	0	0	1	0	0	1	1	4	1	5	13	
	Kalahari Gemsbok NP - Za	9,591	1	4	1	0	0	5	0	1	0	0	1	0	1	1	2	4	1	5	13	
		34,391	1	4	1	1	0	6	0	1	0	0	1	0		1	2	4		4	13	**13**

Note: The locations of TBNRMAs and corresponding areas are shown in Fig. 3.11.

Annex: Table 1 *(Continued).*

TBNRMA No.	Name of Area	Area Km^2	1st Filter	Biophyscial					Conservation Value					Culture/Tourism				Land-use Capacity			Area Score	TBNRMA Score
				1	2	3	4	Score	1	2	3	4	Score	1	2	3	Score	1	2	Score		
4	**Mana-Sapi-Chewore - Zw**	6,766	1	3	3	2	1	9	0	2	0	1	3	1	3	3	7	4	3	7	26	
	Lower Zambezi NP - Za	4,140	1	3	3	2	1	9	0	2	0	1	3	1	3	2	6	4	3	7	25	
	Hurungwe SA - Zw	2,870	1	2	2	2	1	7	0	2	0	1	3	1	2	2	5	4	3	7	22	
	Charara SA - Zw	1,690	1	2	3	2	1	8	0	1	0	1	2	1	2	2	5	4	3	7	22	
	Dande SA - ZW	523	1	1	2	0	1	4	0	0	0	1	1	1	1	2	4	4	3	7	16	
	Chuma Chato - Mz	1,000	1	1	2	0	1	4	0	0	0	1	1	1	1	1	3	4	3	7	15	
	Cahora Bassa - Mz	2,700		2	4	1	1	8	4	0	0	1	5	1	3	2	6	4	3	7	26	
	Kariba (2,800 km2 in Zw)	5,000		3	4	1	1	9	4	0	0	1	5	1	4	4	9	4	3	7	30	
		24,689		4	4	3	1	12	0	2	0	3	5	1	4	3	8	4	3	7	32	**32**
5	**Kruger - Za**	19,485	1	4	2	2	1	9	0	2	0	1	3	1	2	4	7	4	4	8	27	
	Coutada 16 - Mz	10,000	?	4	2	2	1	9	0	0	0	2	2	1	0	1	2	2	3	5	18	
	Banhine NP - Mz	7,000	1	3	1	0	1	5	0	0	0	0	0	0	0	1	1	3	3	6	12	
	Zinave NP - Mz	3,700	1	2	1	0	1	4	0	0	0	0	0	0	0	1	1	2	3	5	10	
	Gonarezho NP - Zw	5,053	1	3	2	1	1	7	0	1	0	1	2	1	2	2	5	4	3	7	21	
	Malapati SA - Zw	1,136	1	1	1	0	1	3	0	0	0	0	0	0	1	2	3	3	3	6	12	
	Malilangwe	1,000		2	1	1	1	5	0	2	0	2	4	1	0	2	3	3	3	6	18	
	Save Conservancy	3,000		2	1	0	1	4	0	2	0	0	2	0	0	2	2	3	3	6	14	
		50,374		4	1	1	1	7	0	3	1	2	6	1	1	3	5	3	3	6	24	**24**
6	**Niassa - Mz**	40,000	1	4	2	3	2	11	0	1	1	0	2	1	2	1	4	1	4	5	19	
	Selous + corridor - Tz	70,000	1	4	3	3	2	12	0	1	0	2	3	1	2	2	5	1	4	5	25	
		110,000		4	3	3	2	12	0	1	0	2	3	1	2	2	5	1	4	5	25	**25**

Note: The locations of TBNRMAs and corresponding areas are shown in Fig. 3.11.

Annex: Table 2. Smaller (< 5,000 km^2) Potential TBNRMAs in Southern Africa

TBNRMA No.	Name of Area	Area km^2	1st Filter	Biophysical					Conservation Value					Culture/ Tourism				Land-use Capacity			TBNRMA Score
				1	2	3	4	Score	1	2	3	4	Score	1	2	3	Score	1	2	Score	
7	Ais Ais/Richtersveld (Na-Za)	5,361	1	3	3	1	1	8	1	2	1	0	4	0	2	3	5	4	4	8	**25**
8	Drakensberg (Le-Za)	3,002	1	2	4	1	0	7	4	1	3	0	8	2	4	3	9	4	4	8	**32**
9	Malolotja (Sw-Za)	181	1	1	1	0	0	2	0	1	1	0	2	1	1	3	5	1	4	5	**14**
10/11	Ndumu/Tembe//Maputo/Mlawula	2,223	1	2	4	4	4	14	4	4	4	1	13	2	3	4	9	0	4	4	**40**
12	Tuli (Bw-Za-Zw)	4,872	1	2	1	0	1	4	0	0	0	0	0	0	1	2	3	3	3	6	**13**
13	Chimanimani (Mz-Zw)	171	1	1	4	3	4	12	4	4	5	0	13	1	3	3	7	0	0	0	**32**
14	Nyika / Vwaza Marsh/ ? (Mw-Zm)	4,134	1	2	4	1	3	10	4	4	5	0	13	1	3	2	6	0	0	0	**29**
15	Kasungu /Lukusuzi (Mw-Zm)	2,316	1	2	1	0	1	4	0	0	0	2	2	1	1	2	4	1	3	4	**14**
16	Lengwe NP (Mw -Mz)	548	1	1	1	1	1	4	0	0	0	0	0	1	1	2	2	1	2	3	**9**
17	Mwabvi GR (Mw-Mz)	104	1	1	1	1	1	4	0	0	0	0	0	1	1	2	4	1	2	3	**11**

Note: The locations of TBNRMAs and corresponding areas are shown in Fig. 3.11.

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Figures

Fig. 1.1 Political boundaries of mainland southern Africa covered in this report

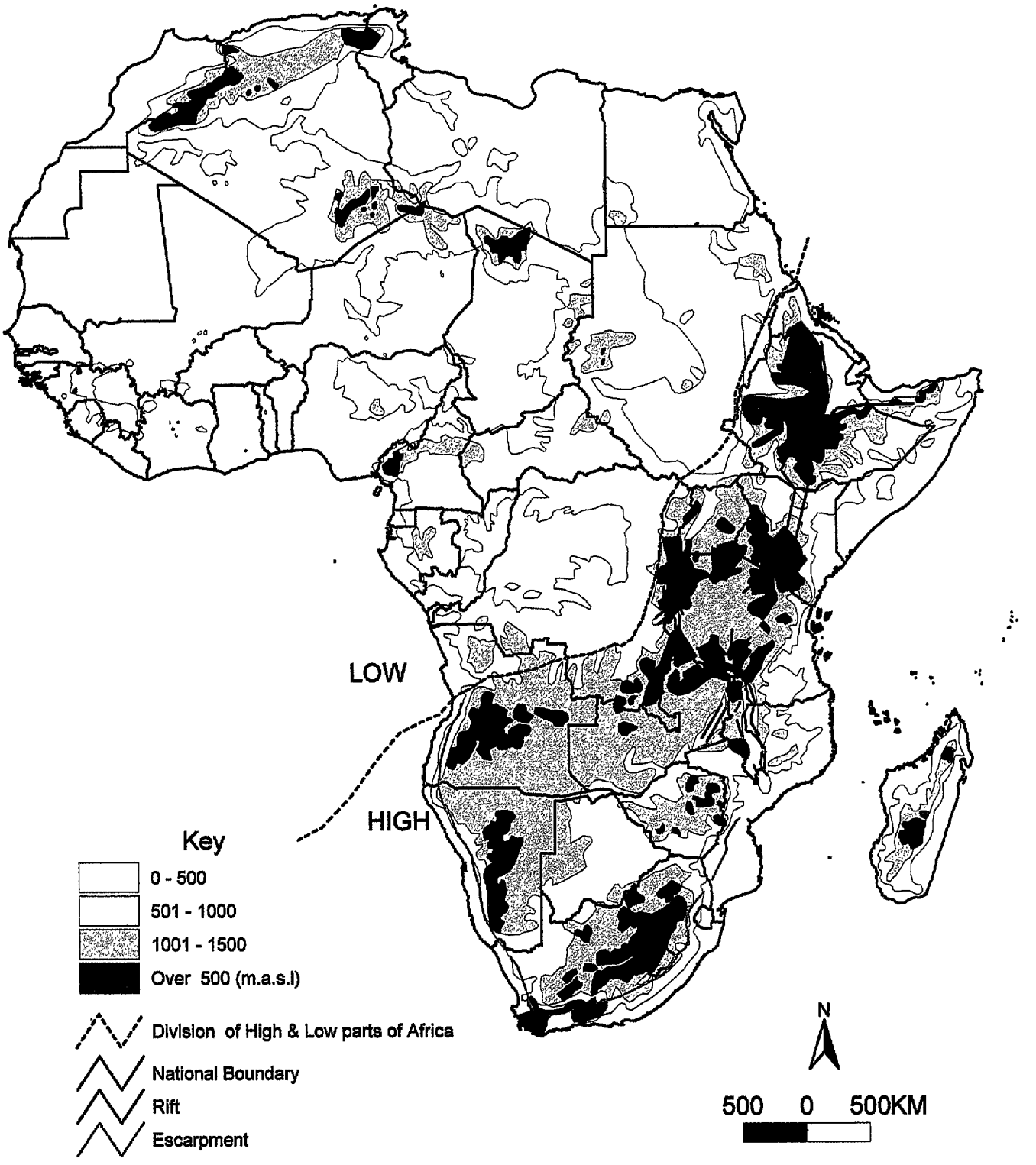


Fig. 2.1 African general topography, regions of high and low elevation, and major rifts

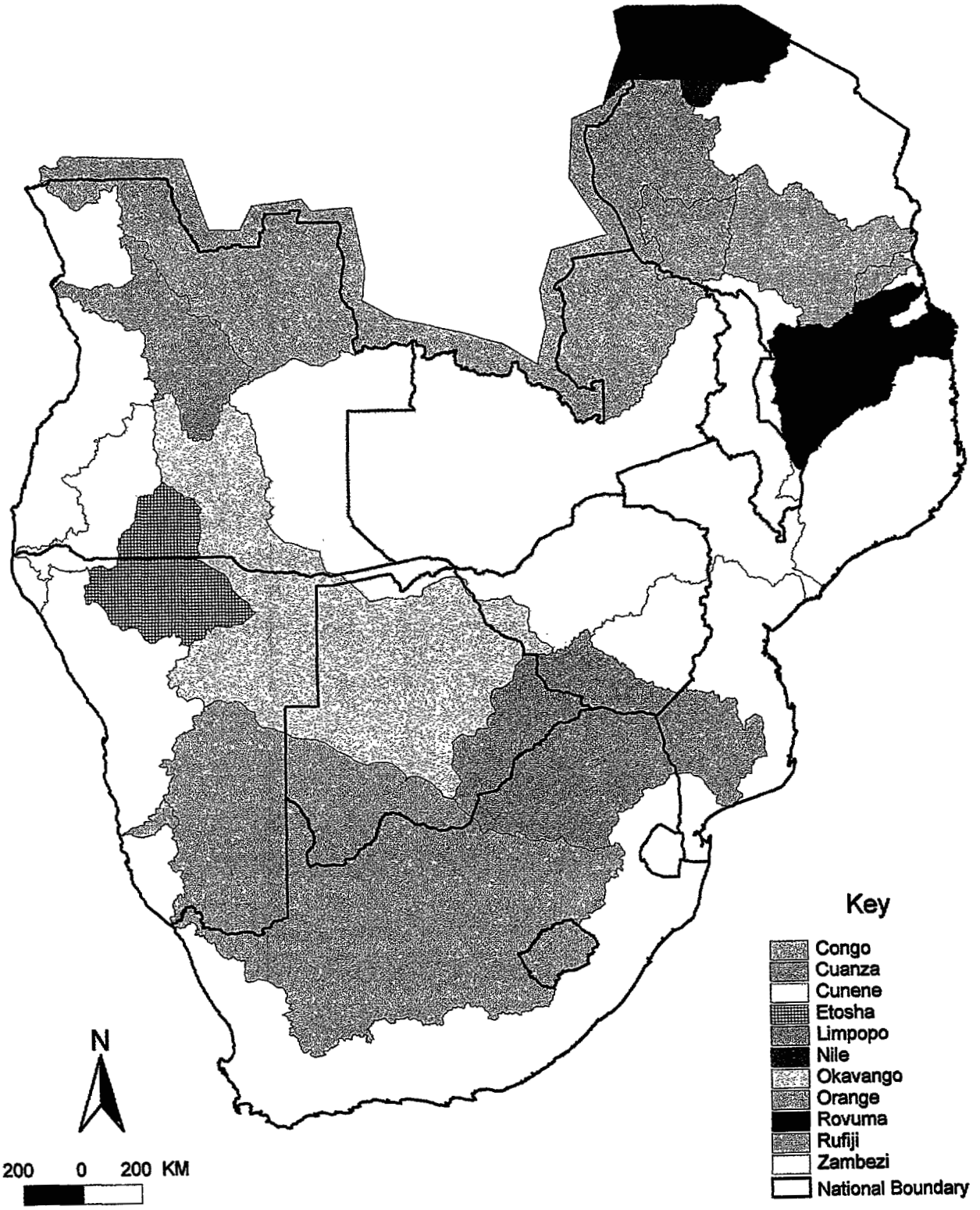


Fig. 2.2 Major drainage basins of southern Africa.

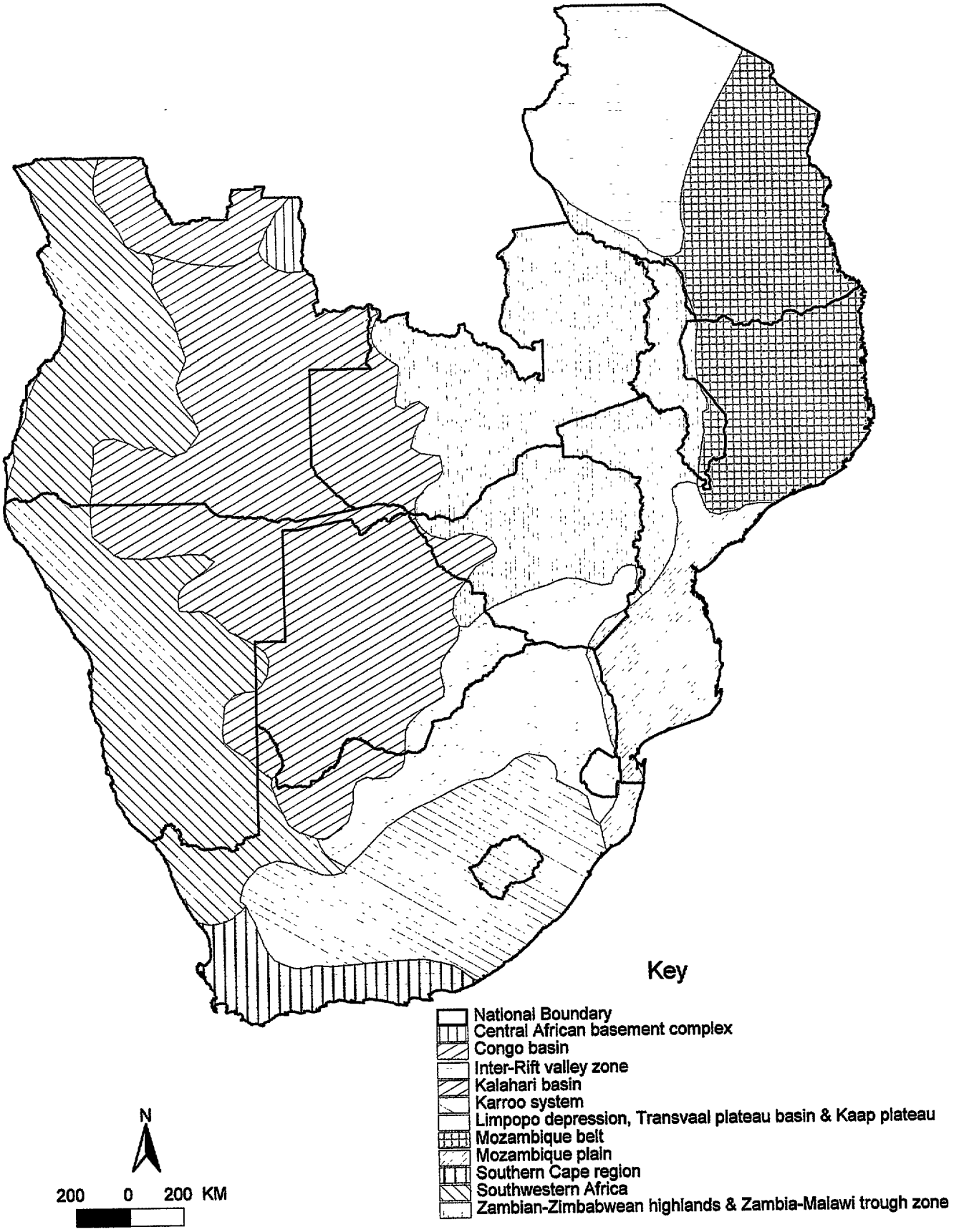


Fig. 2.3 Simplified geology map of southern Africa region (Adapted from FAO, 1977)

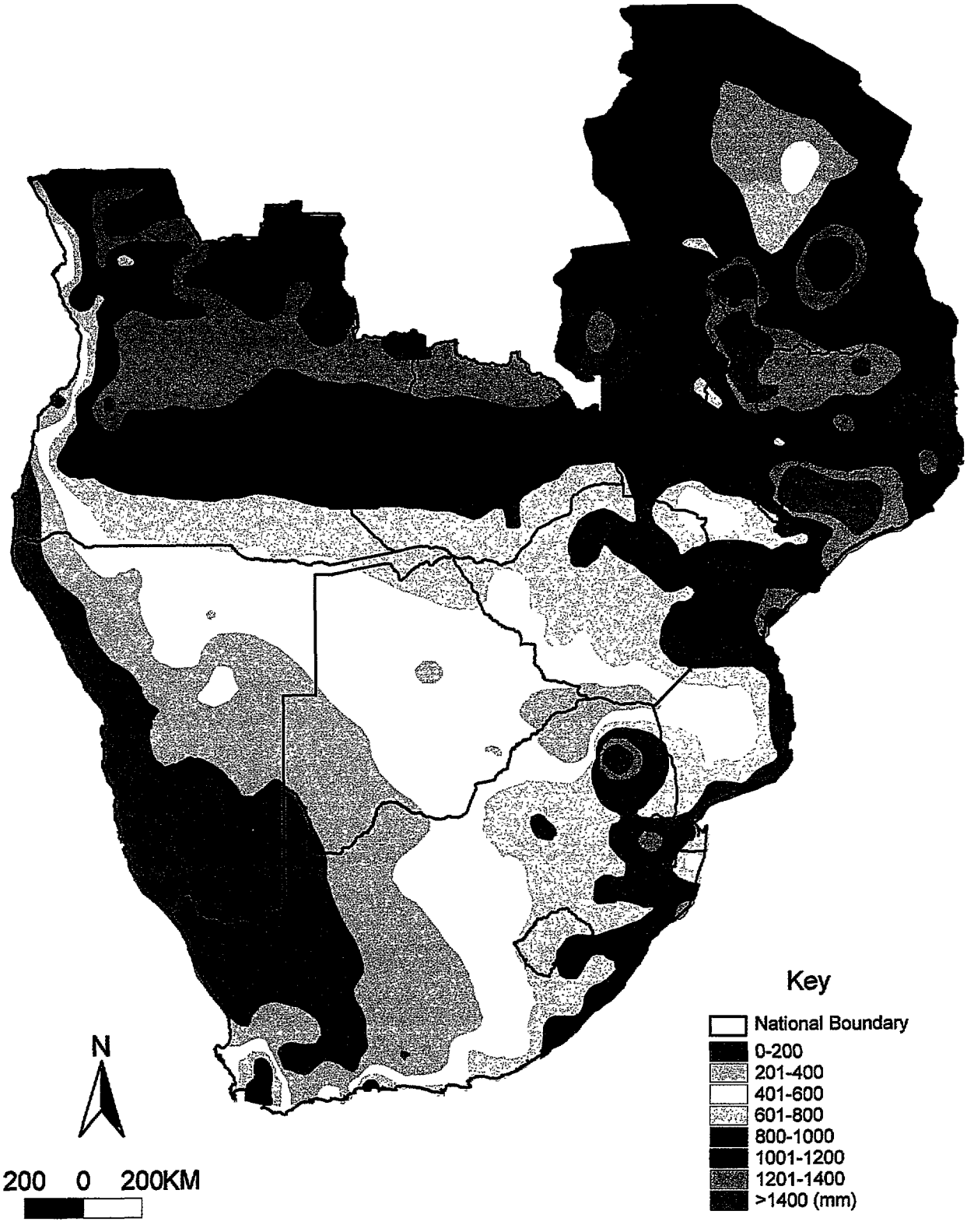


Fig. 2.4 Map of Mean Annual Rainfall in Southern Africa (WWF-SARPO derived from rainfall data from Hutchinson *et al*, 1996)

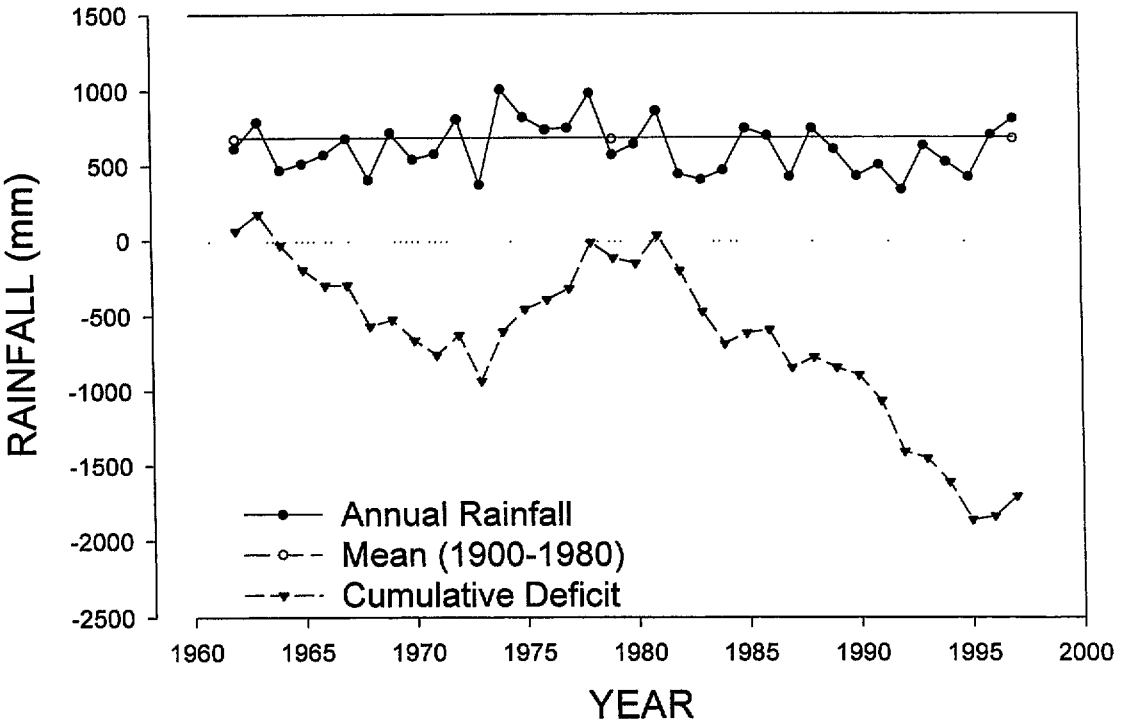


Fig. 2.5 Rainfall deficit graph for Zimbabwe

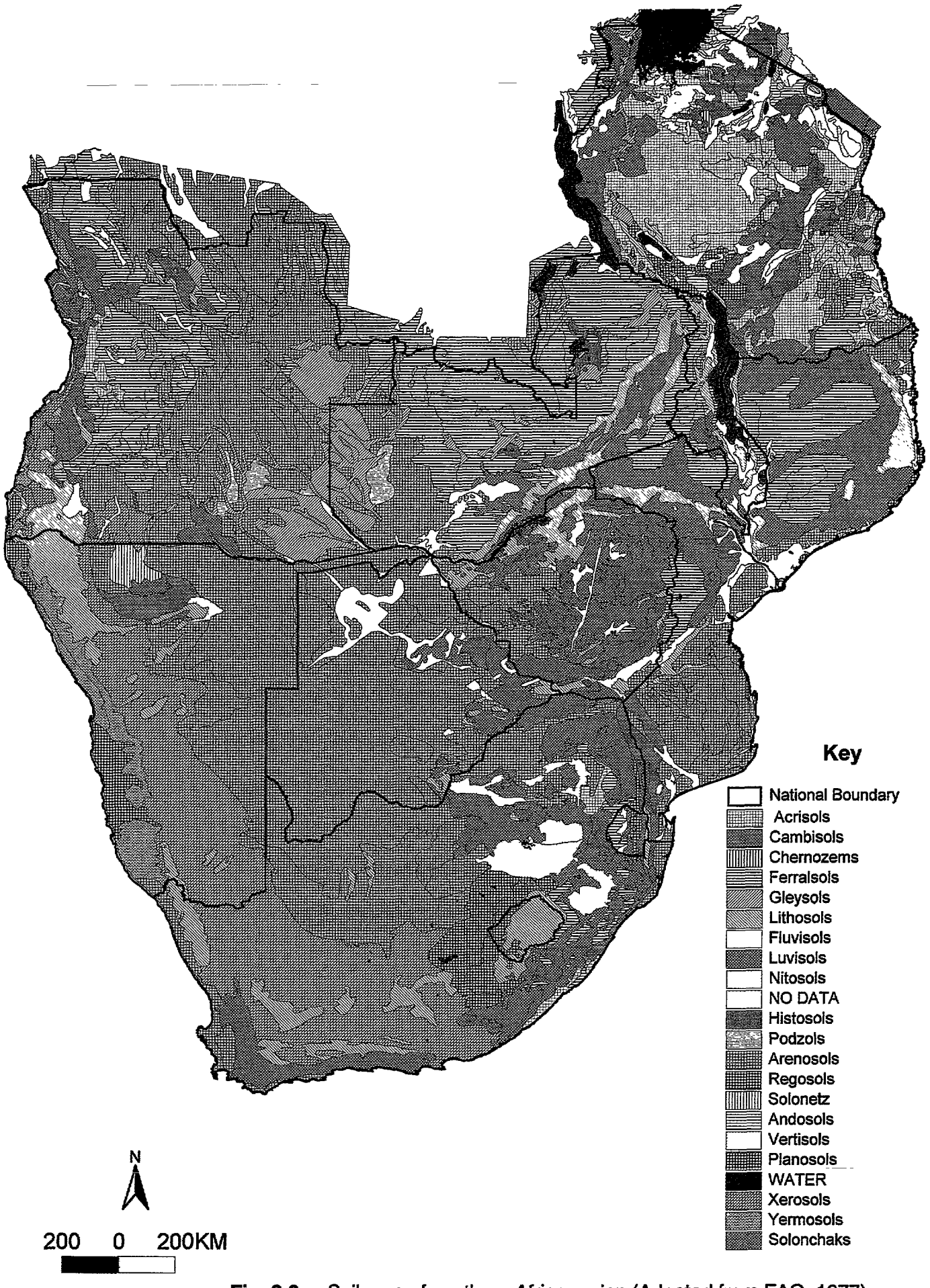


Fig. 2.6 Soil map of southern Africa region (Adapted from FAO, 1977)

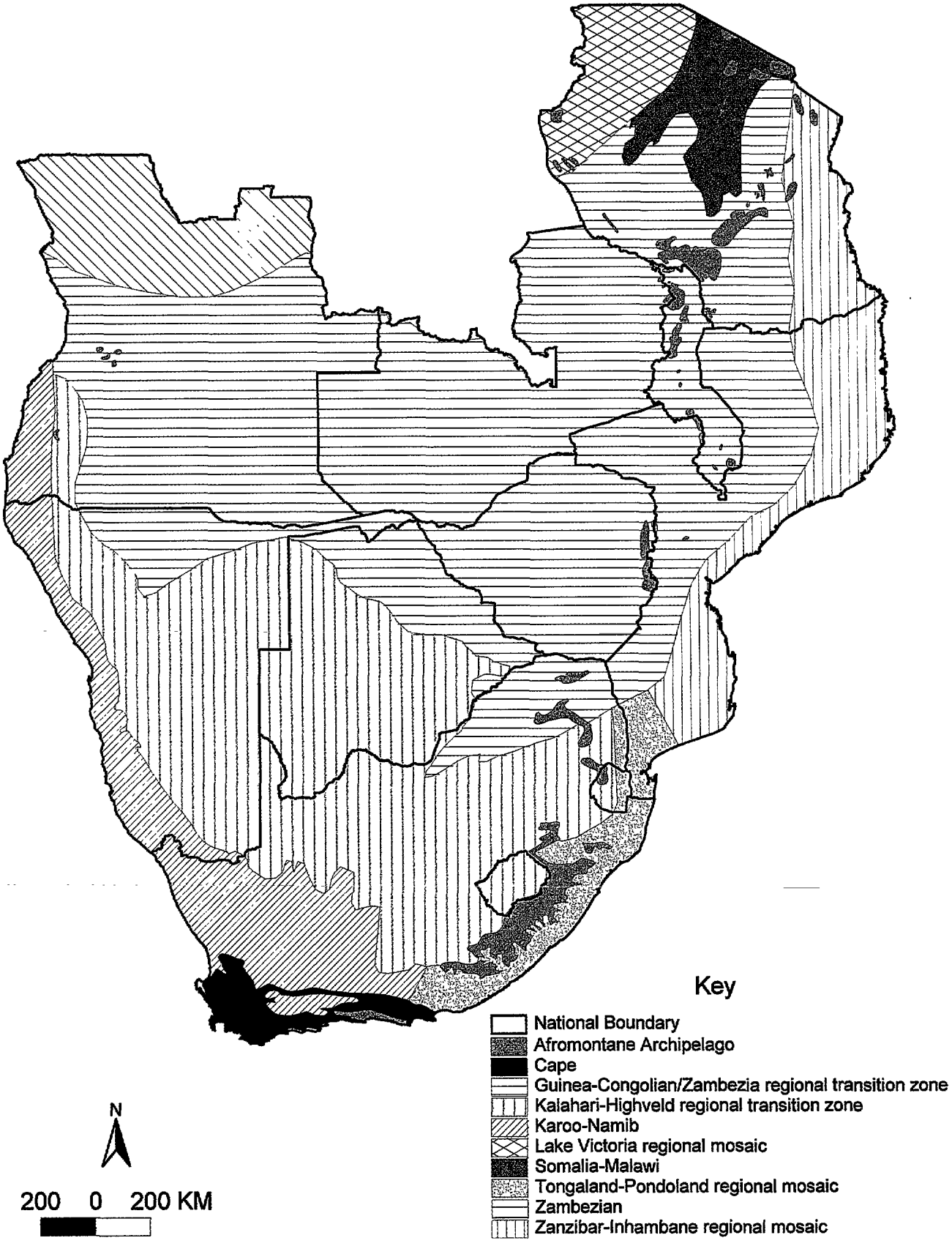


Fig. 2.7 Floristic regions of southern Africa and Afromontane Archipelago (Based on White, 1983)

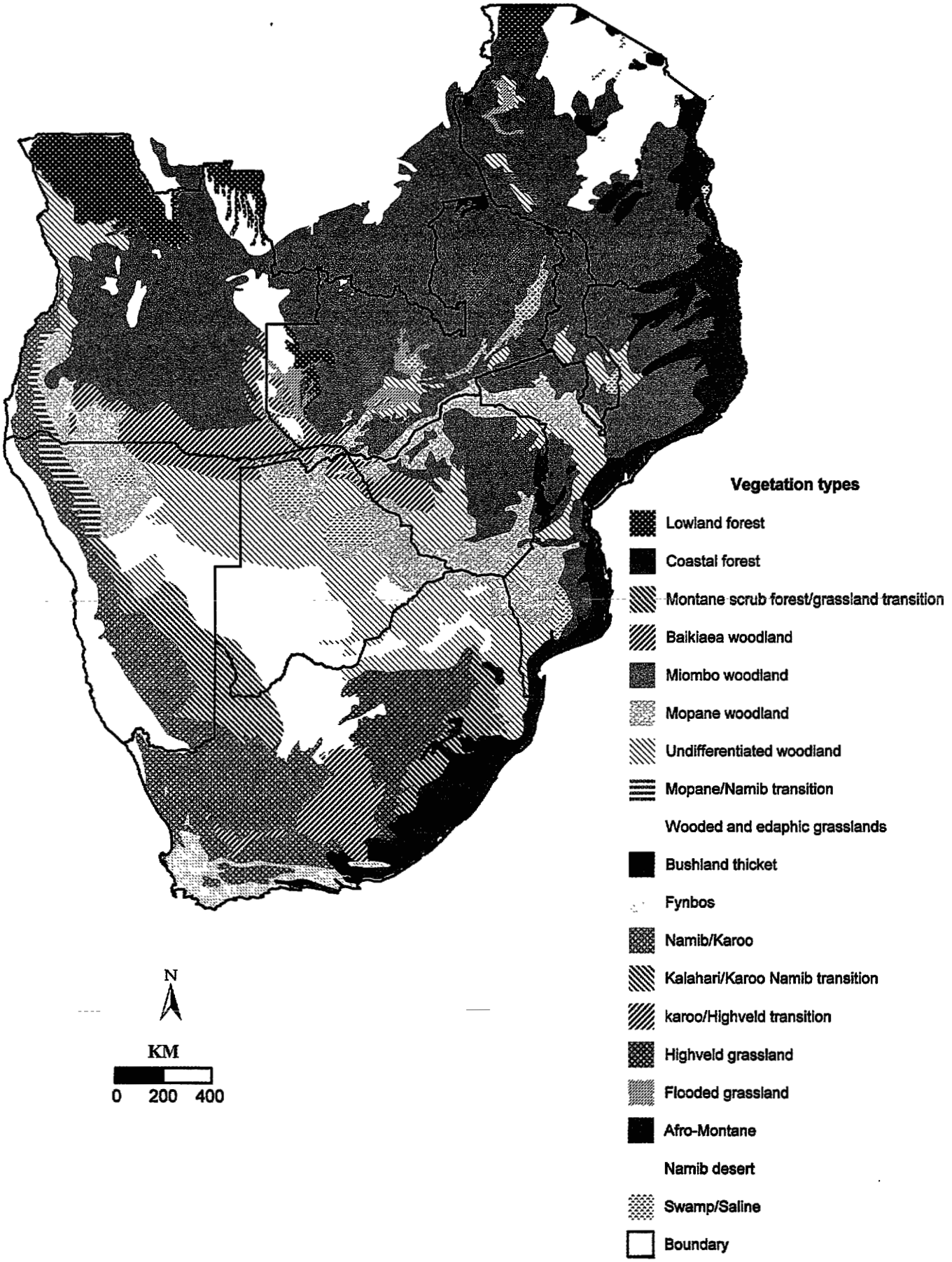
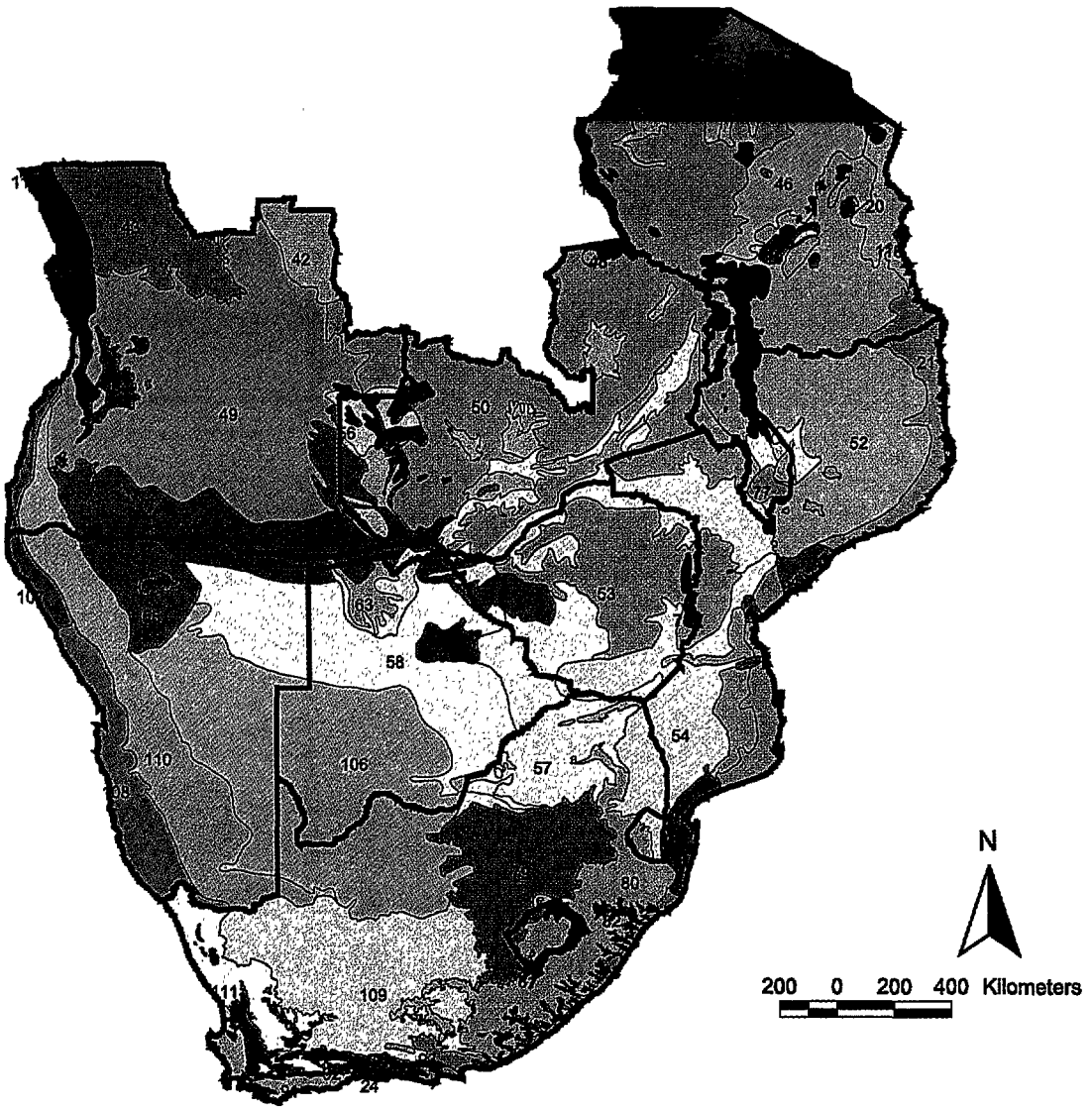


Fig. 2.8 Simplified Vegetation map of southern Africa (Adapted from White, 1983)



Key

- 17 Albertine Rift Montane Forest
- 18 East African Montane Forest
- 19 Eastern Arc Montane Forest
- 20 Northern Zanzibar-Inhambane Coastal Mosaic
- 21 Southern Zanzibar-Inhambane Coastal Mosaic
- 22 Maputaland Coastal Mosaic
- 23 KwaZulu-Cape Coastal Mosaic
- 24 Knysna-Amatole Montane Forest
- 32 Zambezian Cryptosepalum Dry Forest
- 41 Victoria Basin Forest-Savanna Mosaic
- 42 Southern Congolian Forest-Savanna Mosaic
- 43 Western Congolian Forest-Savanna Mosaic
- 45 Northern Acacia-Commiphora Bushland and Thicket
- 46 Southern Acacia-Commiphora Bushland and Thicket
- 47 Serengeti Volcanic Grassland
- 48 Itigi-Sumbu Thicket
- 49 Angolan Miombo Woodland
- 50 Central Zambezian Miombo Woodland
- 51 Zambezian Baikiaea Woodland
- 52 Eastern Miombo Woodland
- 53 Southern Miombo Woodland
- 54 Zambezian and Mopane Woodland
- 55 Angolan Mopane Woodland
- 56 Western Zambezian Grassland
- 57 Southern Africa Bushveld
- 58 Kalahari Acacia-Baikiaea Woodland
- 63 Zambezian Flooded Grassland
- 64 Zambezian Coastal Flooded Savanna
- 67 East African Halophytics
- 68 Etosha Pan Halophytics
- 69 Makgadikadi Pans Halophytics
- 74 East African Montane Moorland
- 76 Southern Rift Montane Forest
- 77 South Malawi Montane Forest-Grassland Mosaic
- 78 Eastern Zimbabwe Montane Forest-Grassland Mosaic
- 79 Highveld Grassland
- 80 Drakensberg Montane Grassland, Woodland and Forest
- 81 Drakensberg Alti-Montane Grassland
- 82 Maputaland-Pondoland Bushland and Thicket
- 83 Angolan Scarp Savanna and Woodland
- 84 Angolan Montane Forest-Grassland Mosaic
- 91 Lowland Fynbos and Renosterveld
- 92 Montane Fynbos and Renosterveld
- 93 Albany Thicket
- 106 Kalahari Xeric Savanna
- 107 Kaokoveld Desert
- 108 Namib Desert
- 109 Nama Karoo
- 110 Namibian Savanna Woodland
- 111 Succulent Karoo
- 116 Central African Mangroves
- 117 Southern African Mangroves
- 118 East African Mangroves
- 999 Water

Fig. 2.9 Ecoregions map for southern Africa (WWF Terrestrial Ecoregions of Africa [November, 1999]).

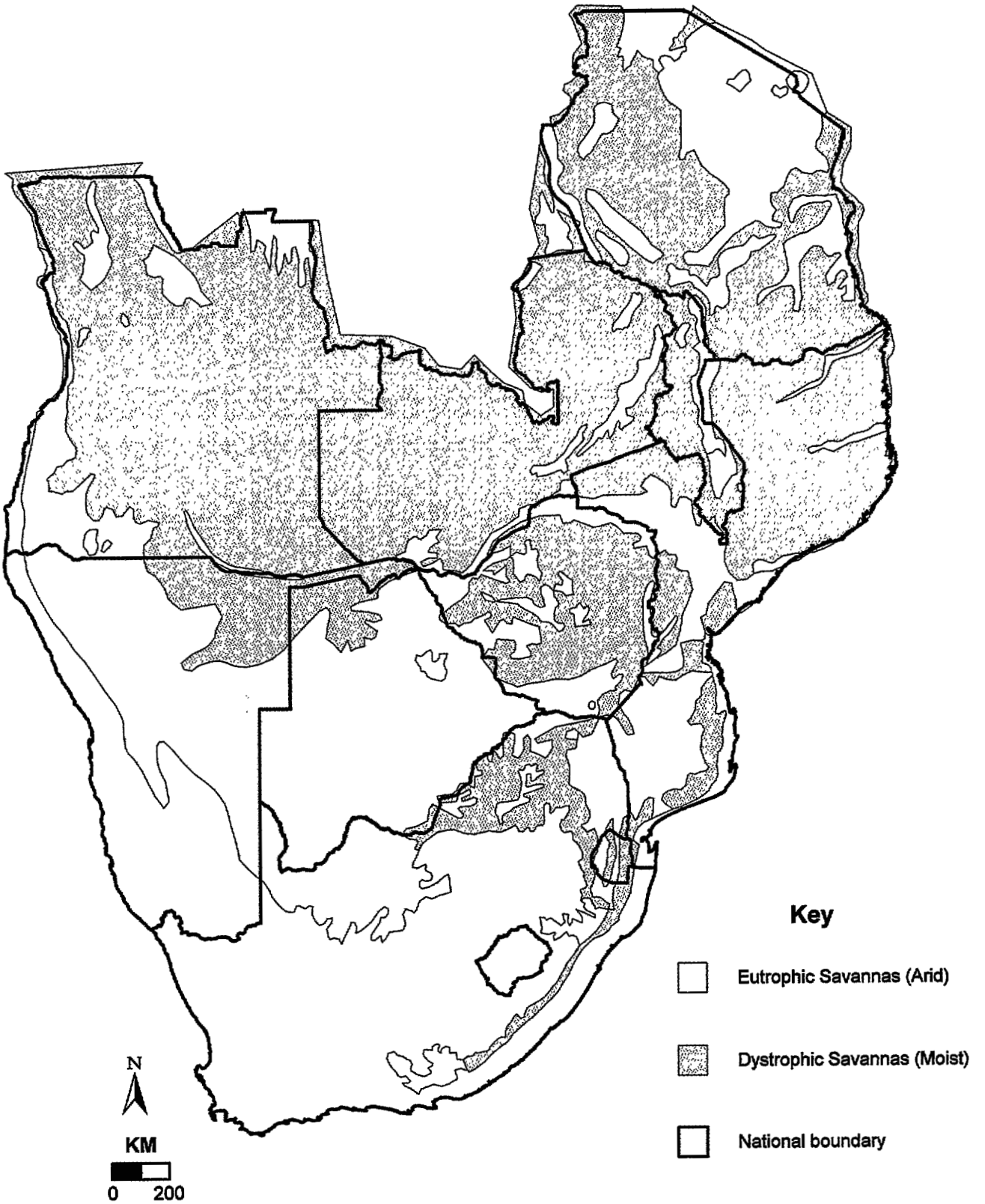


Fig. 2.10 Arid/Eutrophic and Moist/Dystrophic savannas of Southern Africa (Redrawn from Huntley, 1982)

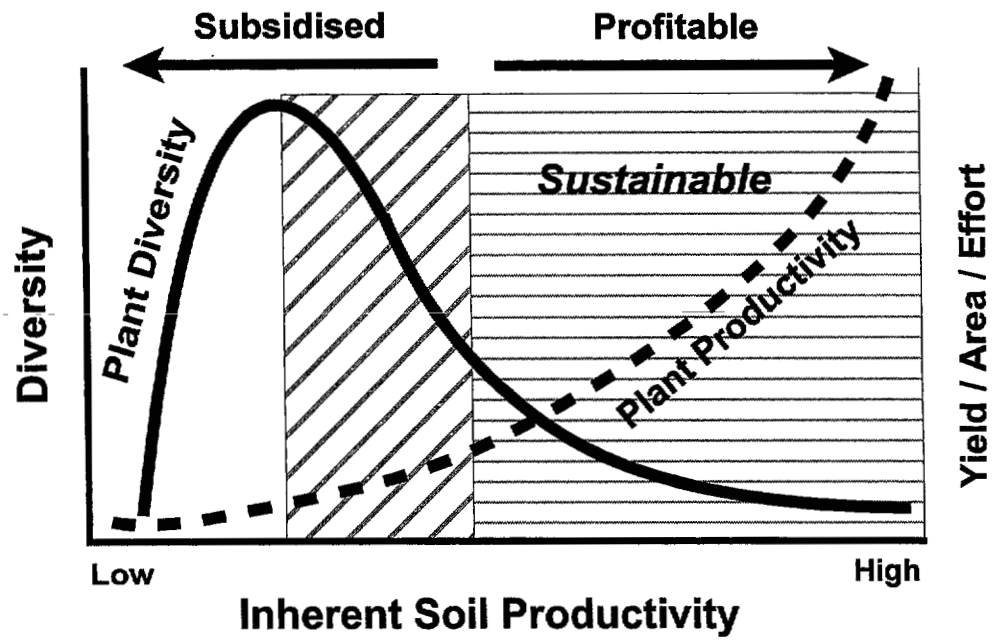
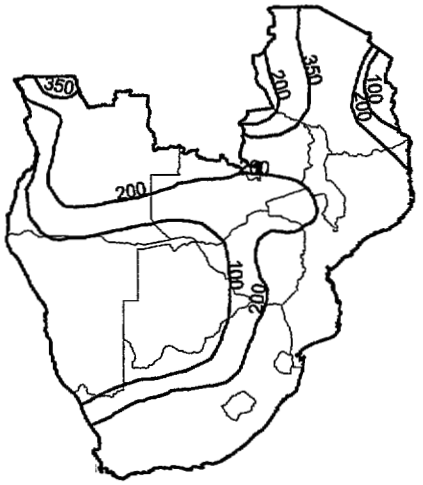
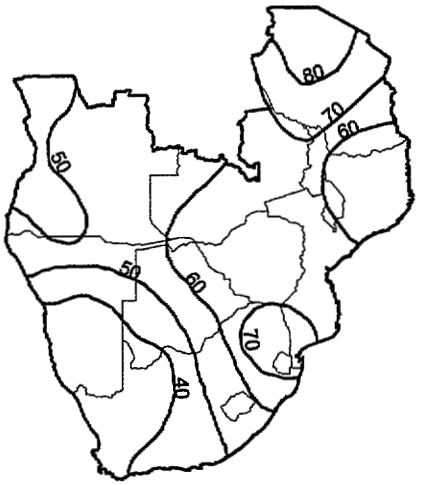


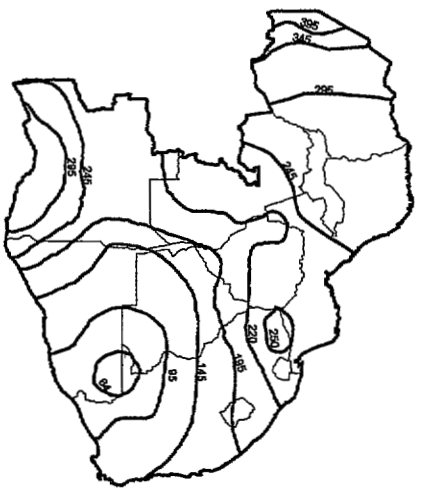
Fig. 2.11 Relationship between plant diversity and productivity illustrating the potentially greater negative effects on biodiversity of subsidizing agriculture on marginal lands compared with more productive lands (Redrawn from Huston, 1995).



Butterfly species richness



Mammals species richness



Passerine species richness

Non-passerine species richness

Plant species per 10 000 km2

Waterbirds species richness

Fig. 2.12 Distribution of species richness for selected taxa. Isolines represent number of species. (Data drawn from Carcasson 1964, MacKinnon and MacKinnon 1986, Crowe and Crowe , Turpie and Crowe 1994, Guillet and Crowe 1985, Groombridge 1992).

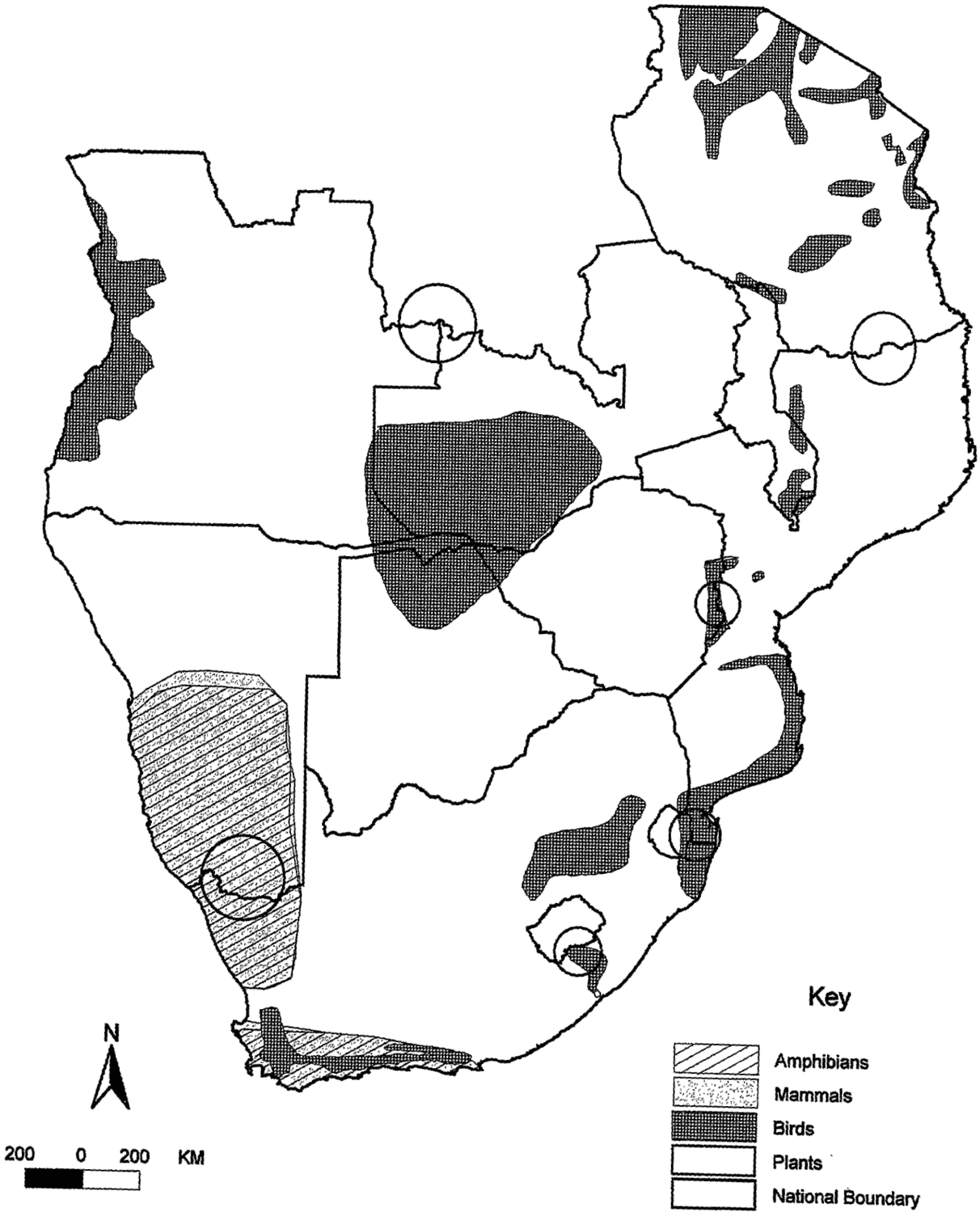


Fig. 2.13 Centers of endemism for mammals, birds, amphibians in southern Africa. Areas of plant endemism are shown *only* where they occur in transboundary areas (Based on Groombridge 1992 and Bibby *et al* 1992)

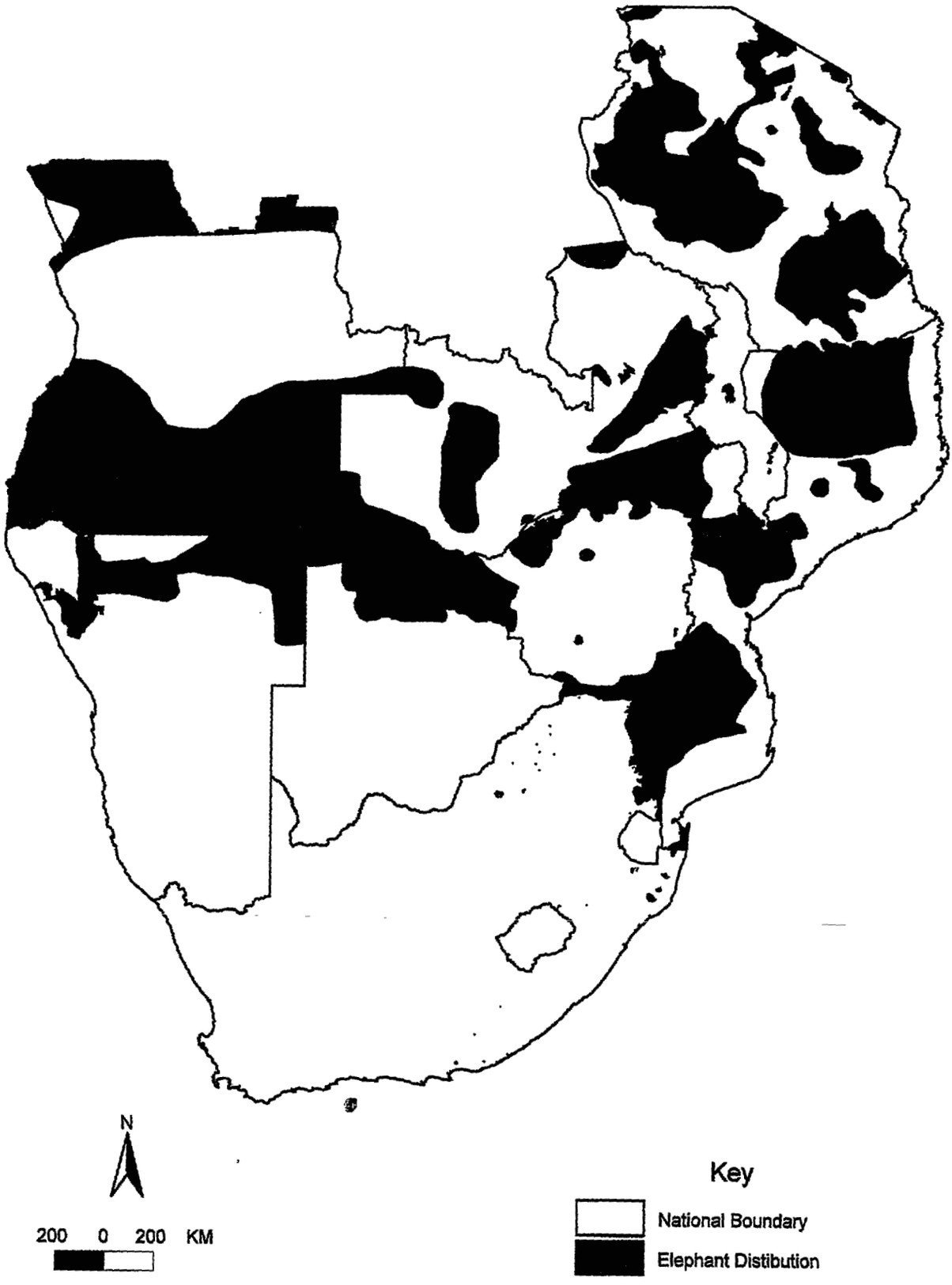


Fig. 2.14 Distribution of elephant in southern Africa (Redrawn from Said *et al*, 1995)

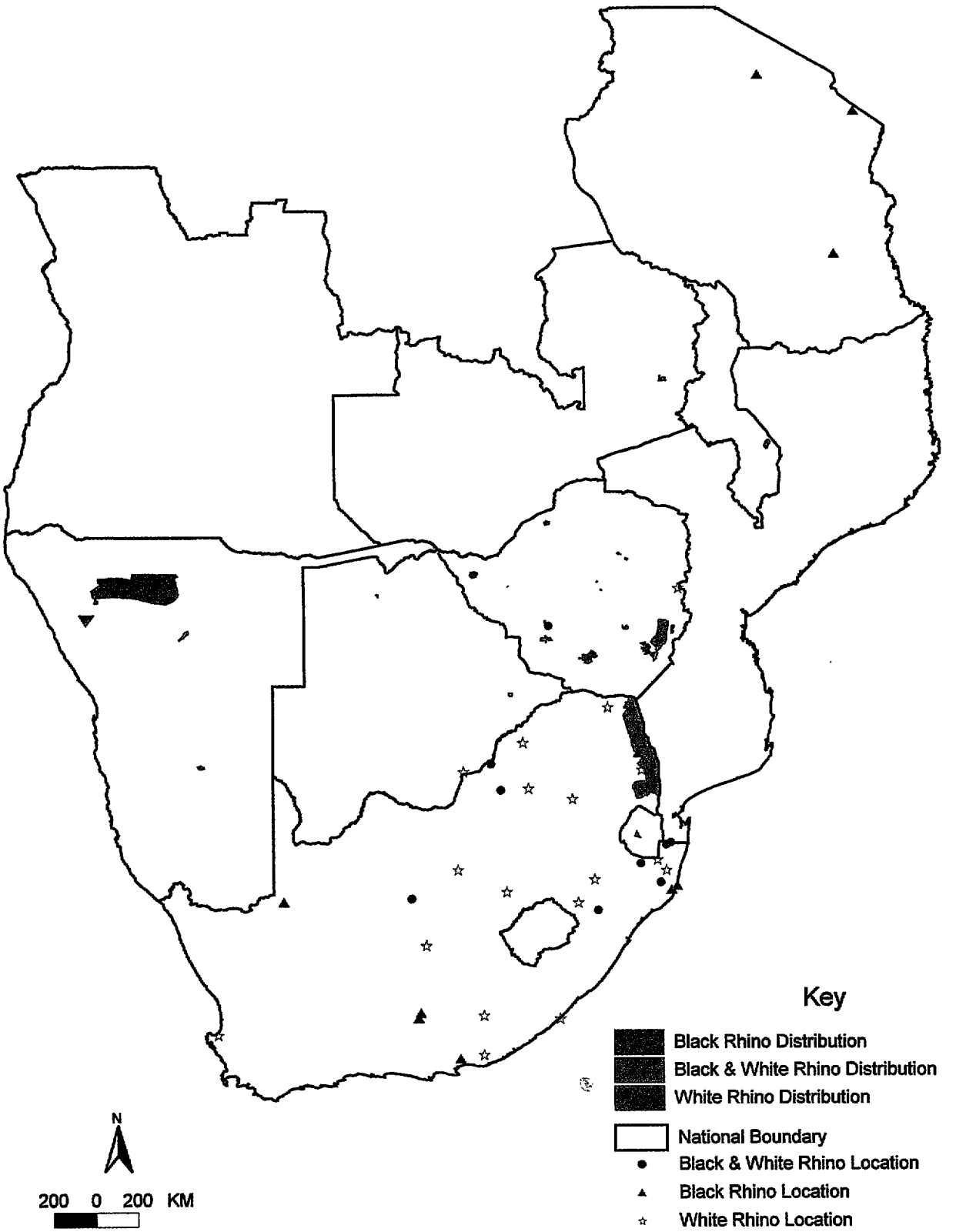


Fig. 2.15 Distribution of black and white rhino in southern Africa (Based on R. du Toit, pers.comm.1998).

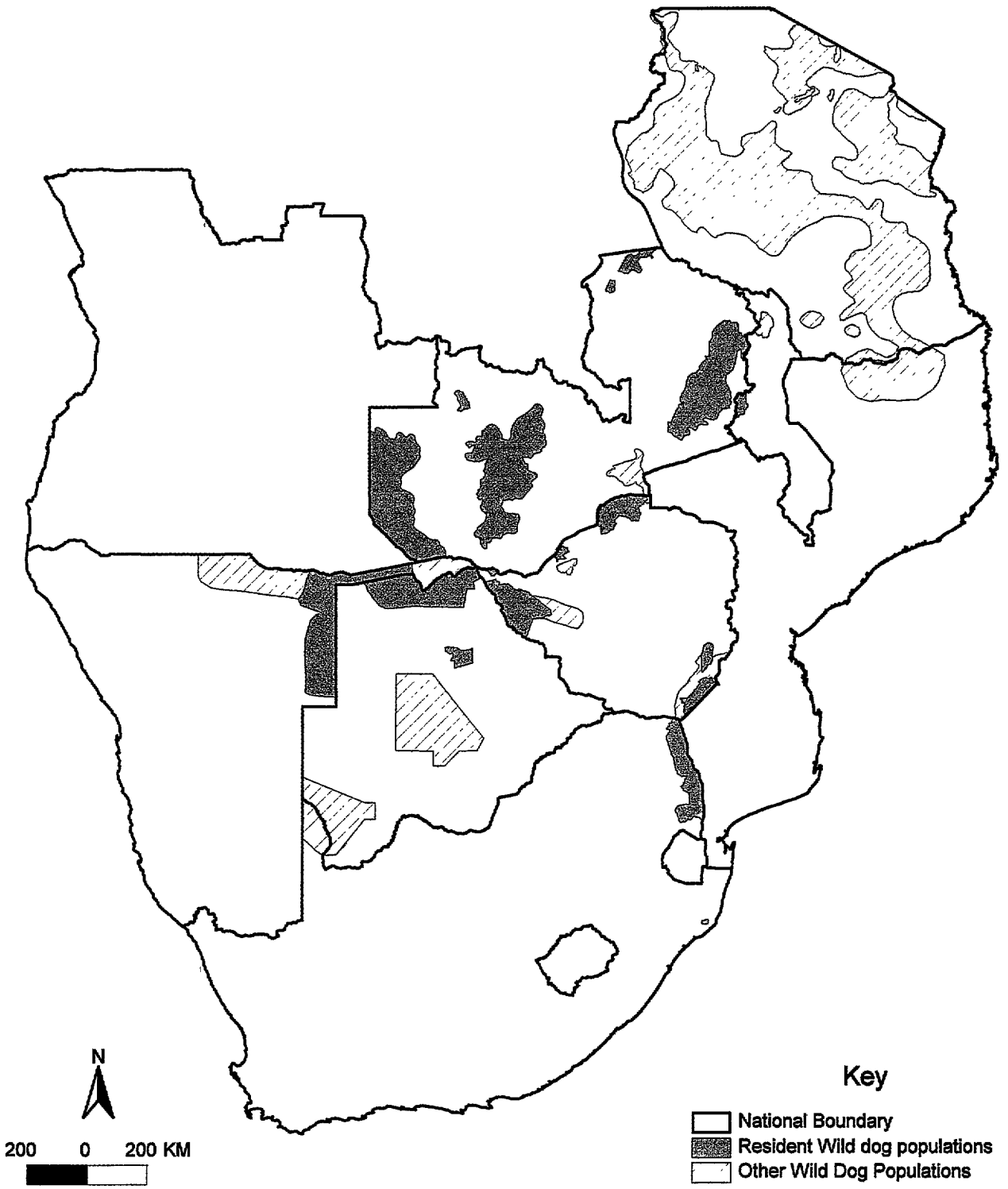


Fig. 2.16 Distribution of wild dog in southern Africa (Based on R. du Toit, pers.comm.1998, Kingdon 1977 for Tanzania).

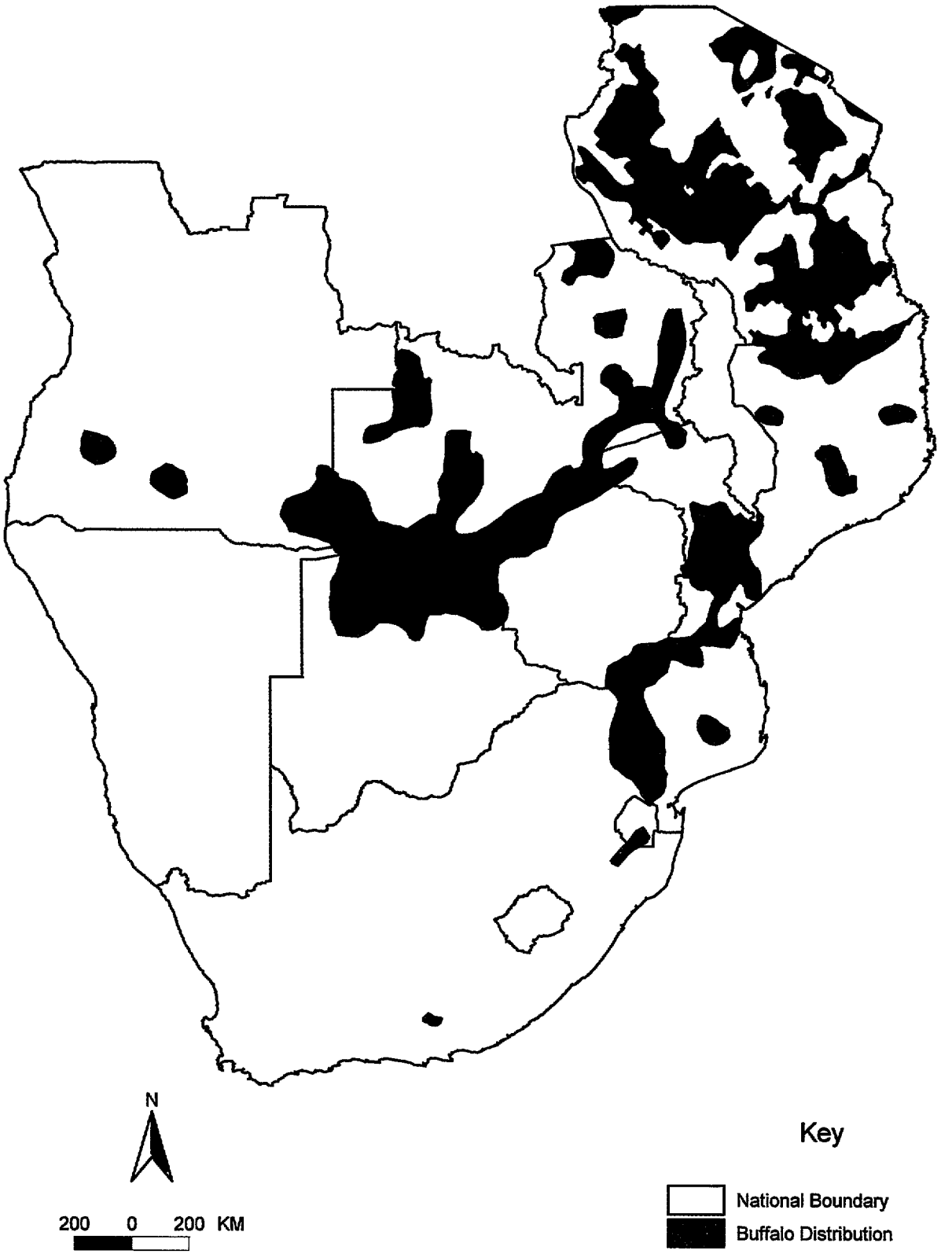


Fig. 2.17 Distribution of buffalo in southern Africa (From R. D. Taylor 1984; J Kingdon 1982 for Tanzania)

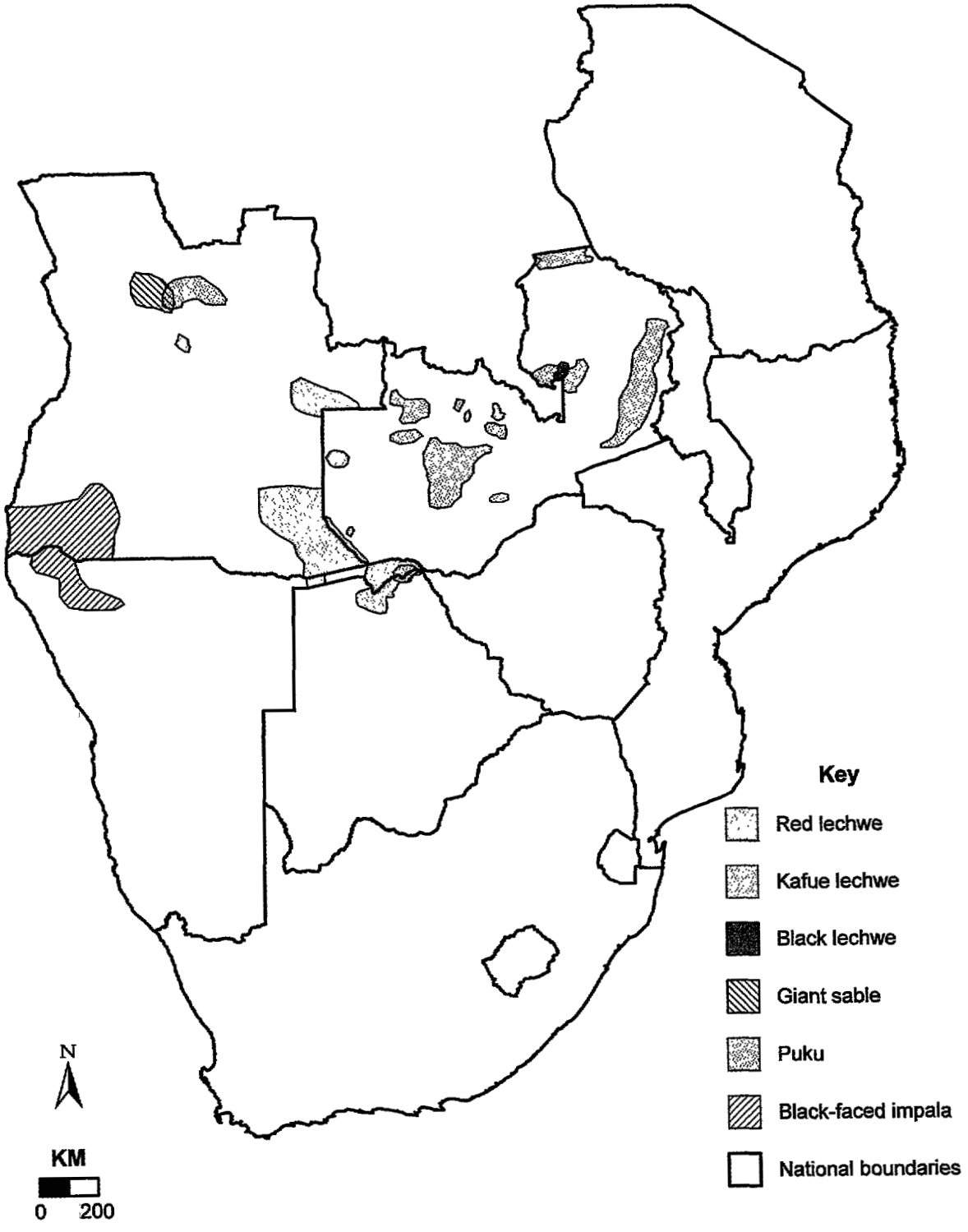


Fig. 2.18 Distribution of red, Kafue and black lechwe, giant sable, puku, and black faced impala in southern Africa (Sources: Ansell 1960, East 1989).

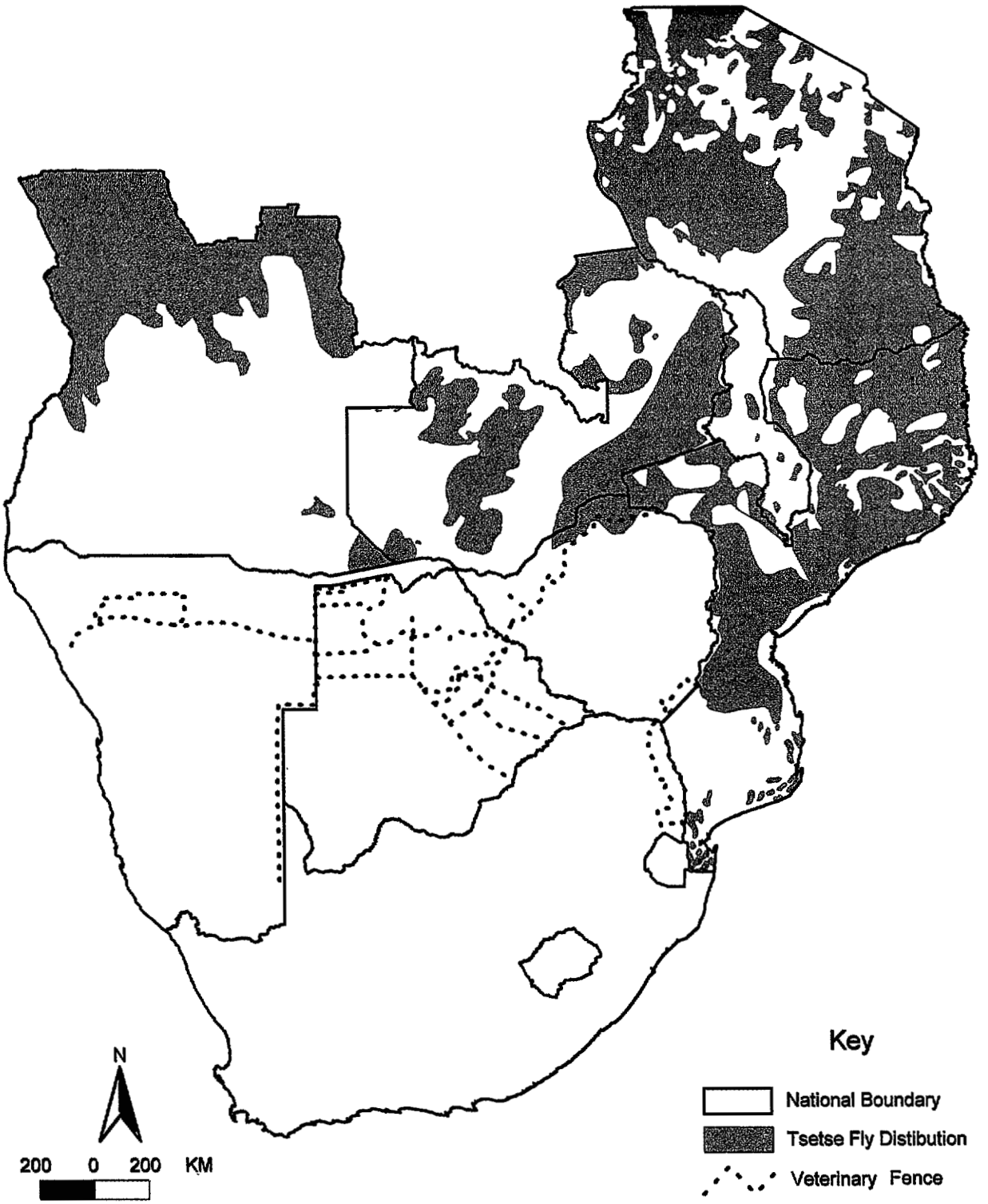


Fig. 2.19 Distribution of major veterinary disease control fences and tsetse fly in southern Africa (Sources: WWF-SARPO, Regional Tsetse & Trypanosomiasis Control Programme, Kingdon 1982)

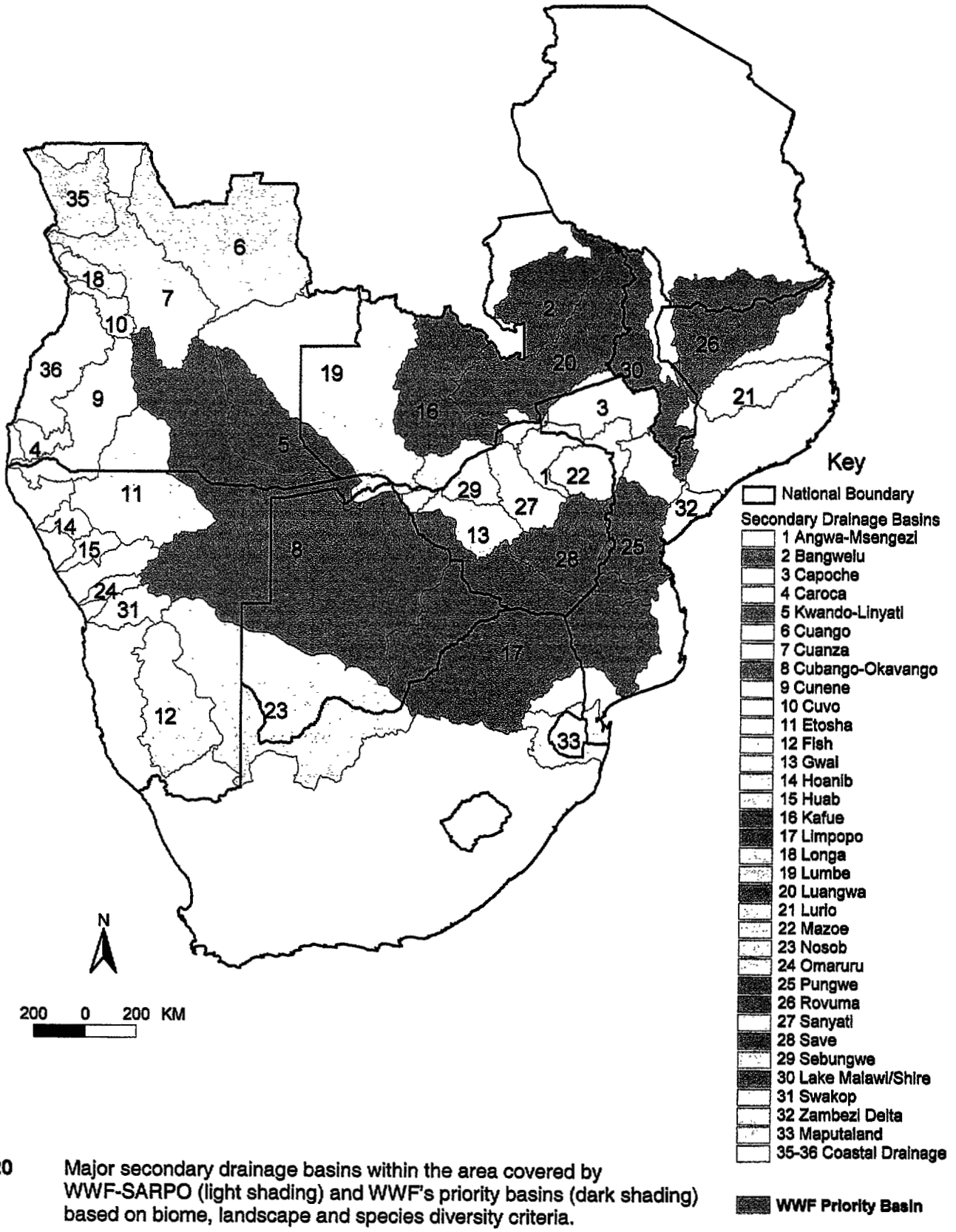


Fig. 2.20 Major secondary drainage basins within the area covered by WWF-SARPO (light shading) and WWF's priority basins (dark shading) based on biome, landscape and species diversity criteria.

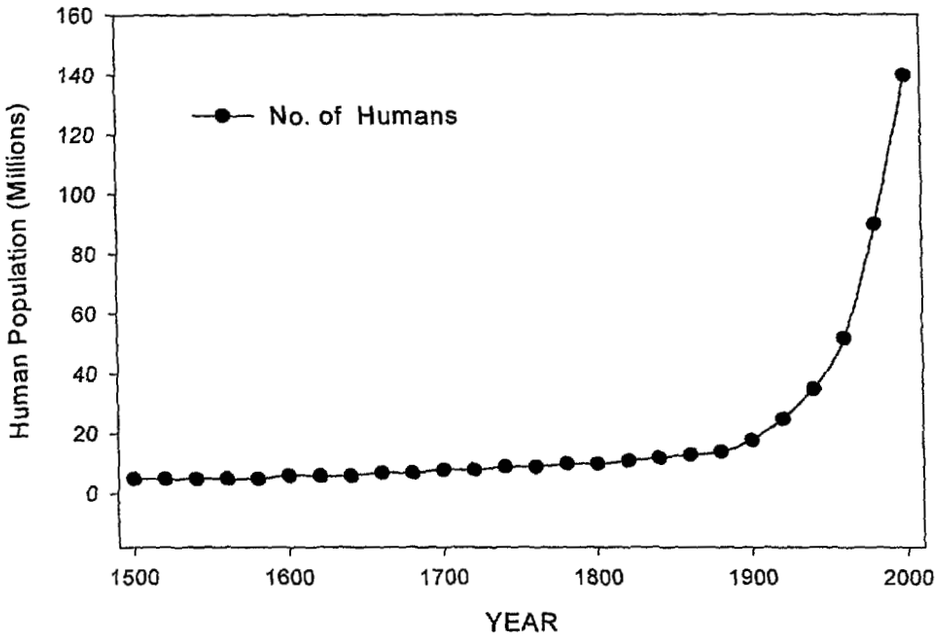


Fig. 3.1 Human population growth in southern Africa since c. 1500 AD. (Based on data from McEvedy 1980, and more recent regional data such as in Table 3.3)

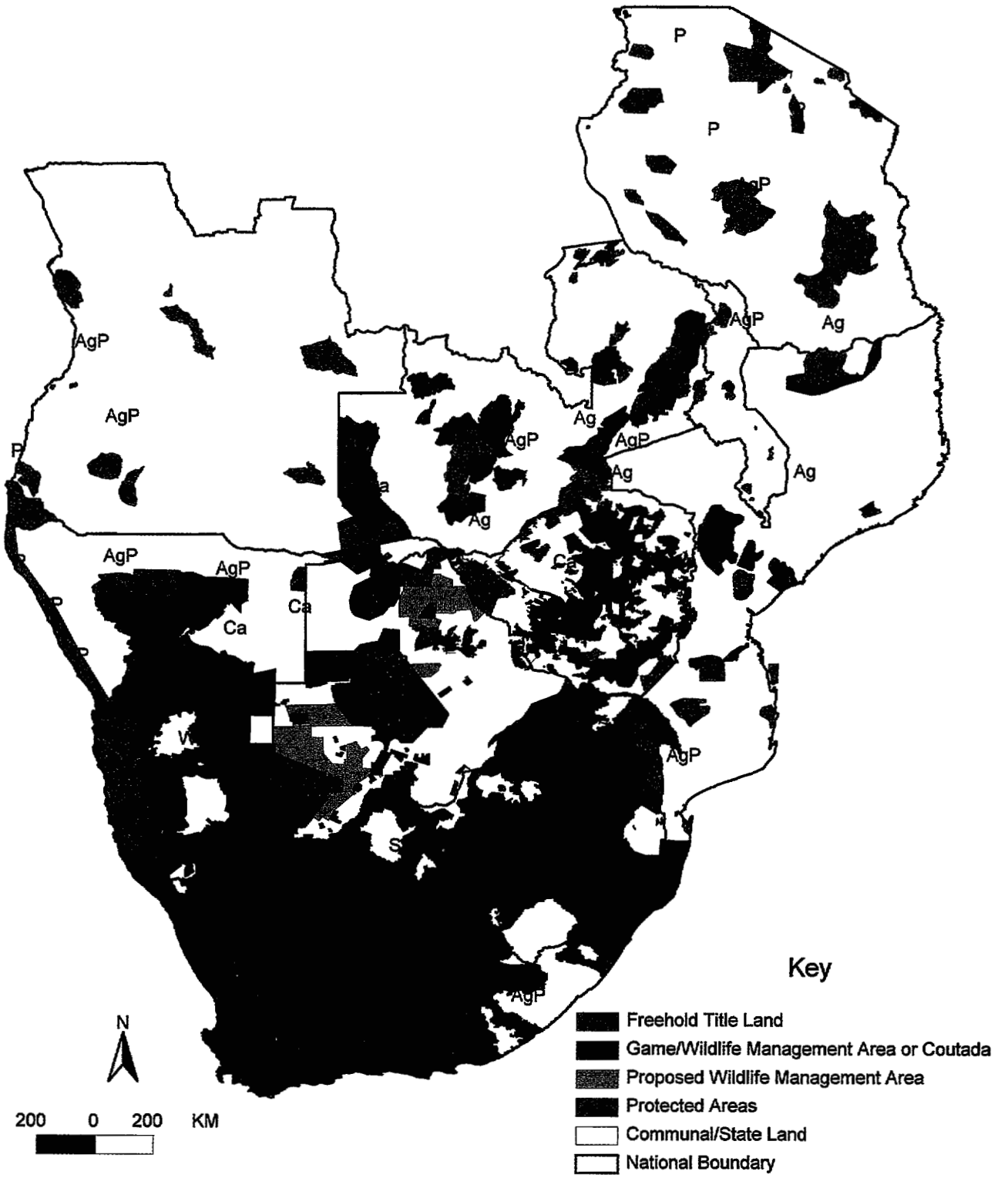


Fig. 3.2 Map of land tenure and distribution of extensive landuses in southern Africa (Redrawn from Cumming and Bond 1991). AgP = Agro-pastoral; Ca = Cattle ranching; P = Traditional pastoral systems: S = Sheep farming; W = Wildlife ranching).

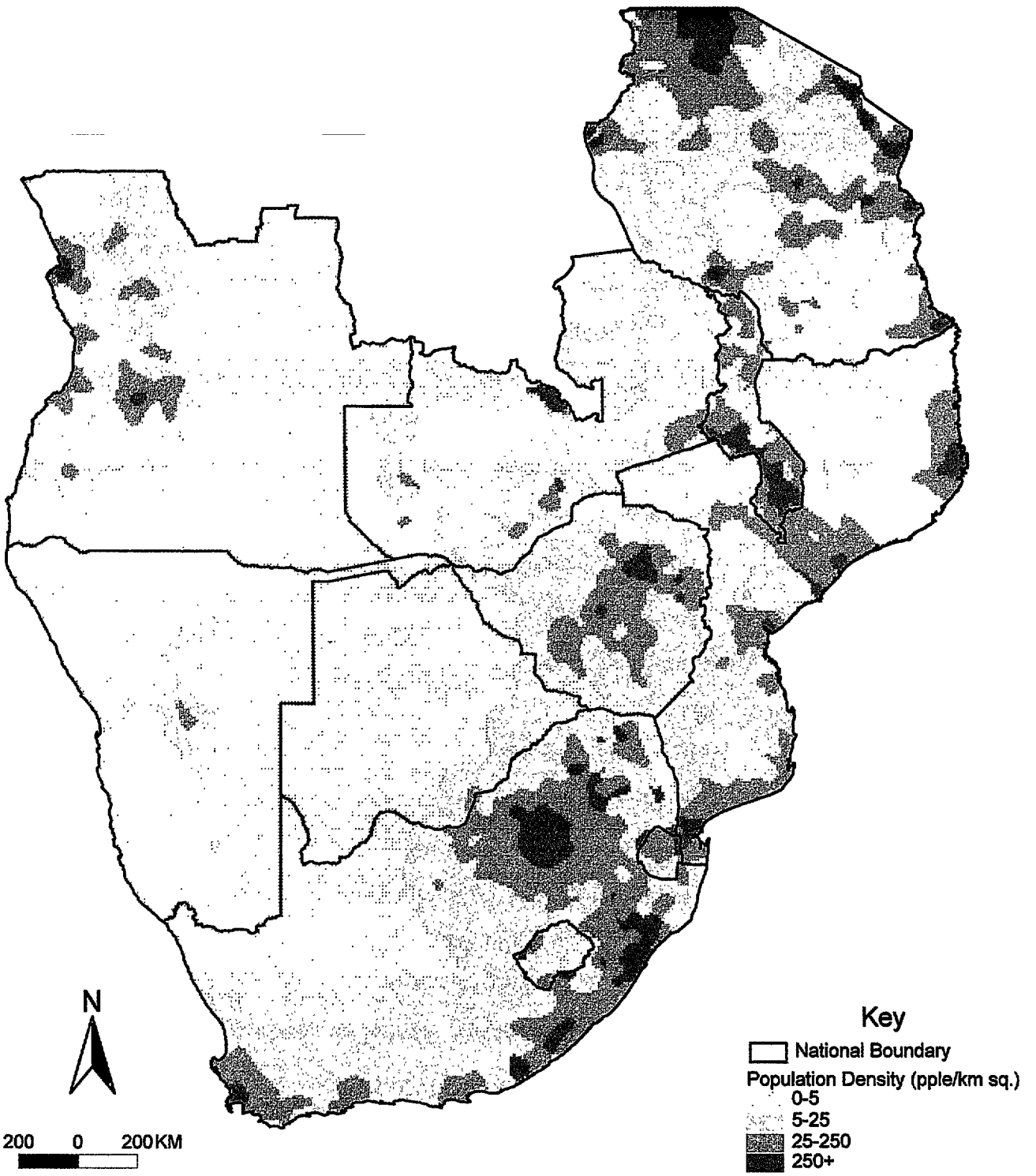


Fig. 3.3 Human population densities in southern Africa (Adapted from Diechmann 1994)

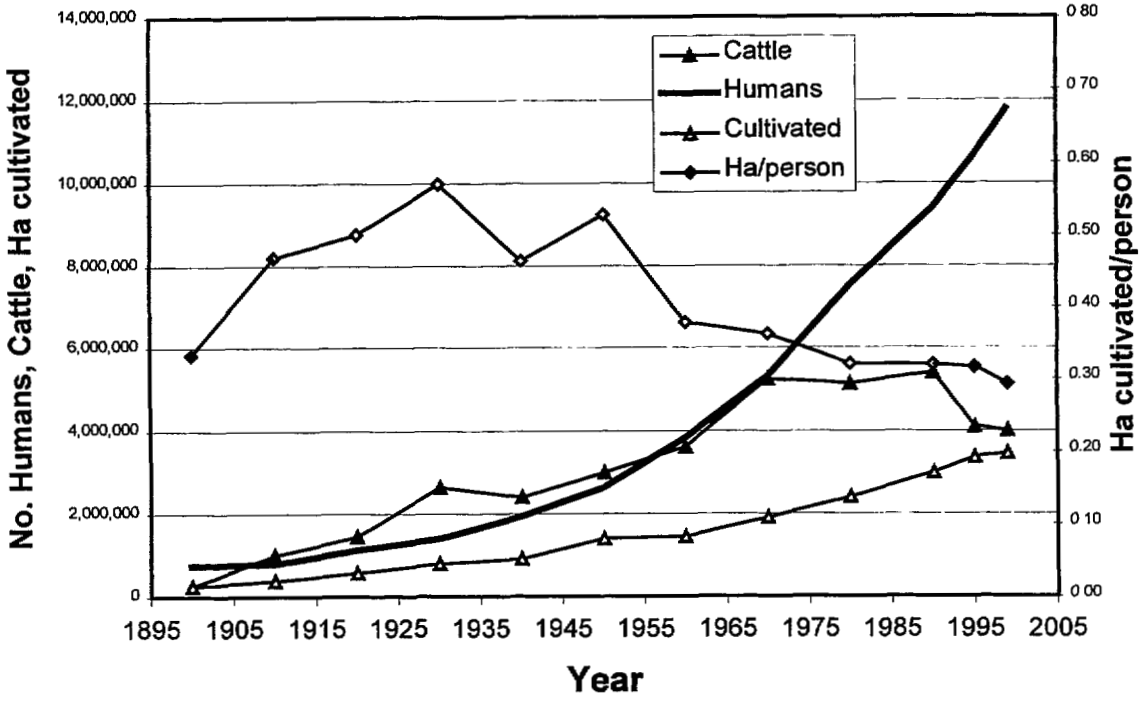


Fig. 3.4 Population trends, livestock and land cultivated in Zimbabwe from 1900 to 1995 (Updated from Murphree and Cumming 1993)

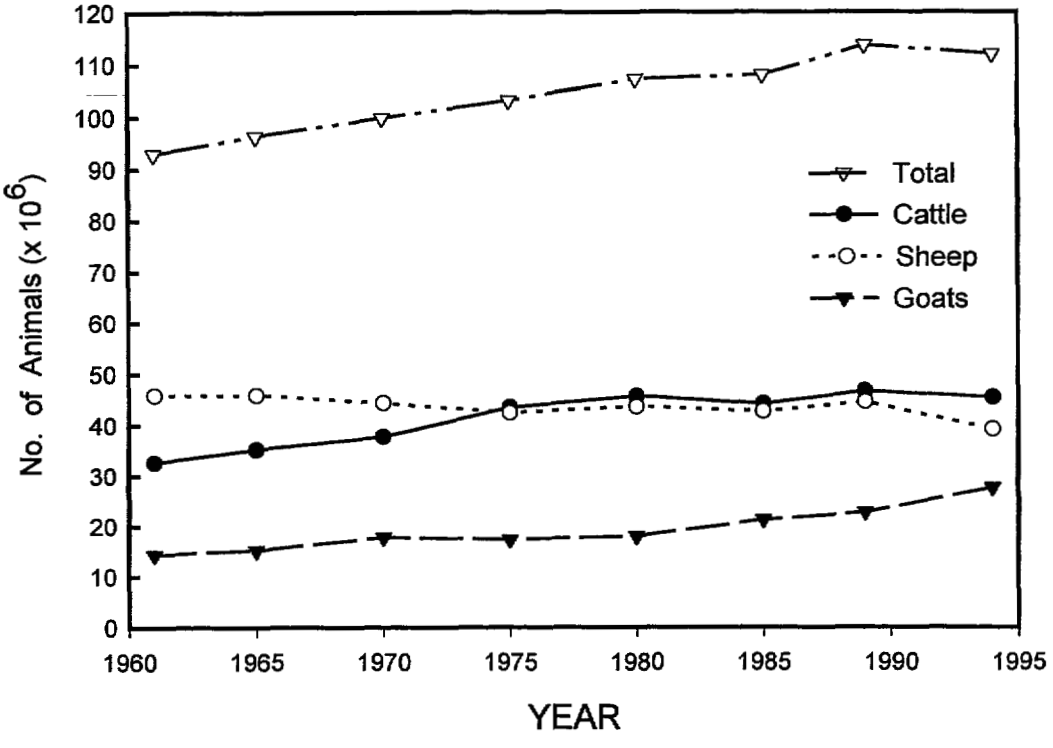


Fig. 3.5 Trends in Livestock numbers in southern Africa (Updated from Cumming 1991).

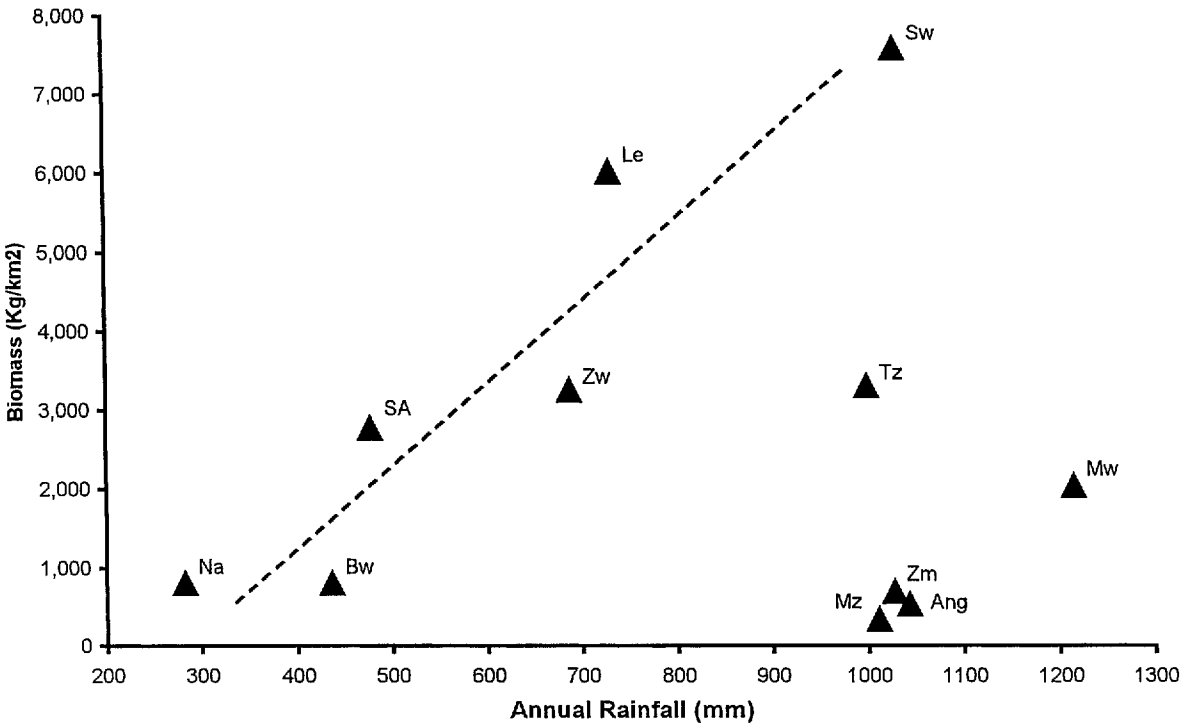


Fig. 3.6 Rainfall and livestock biomass densities in southern Africa (Updated from Cumming 1991)

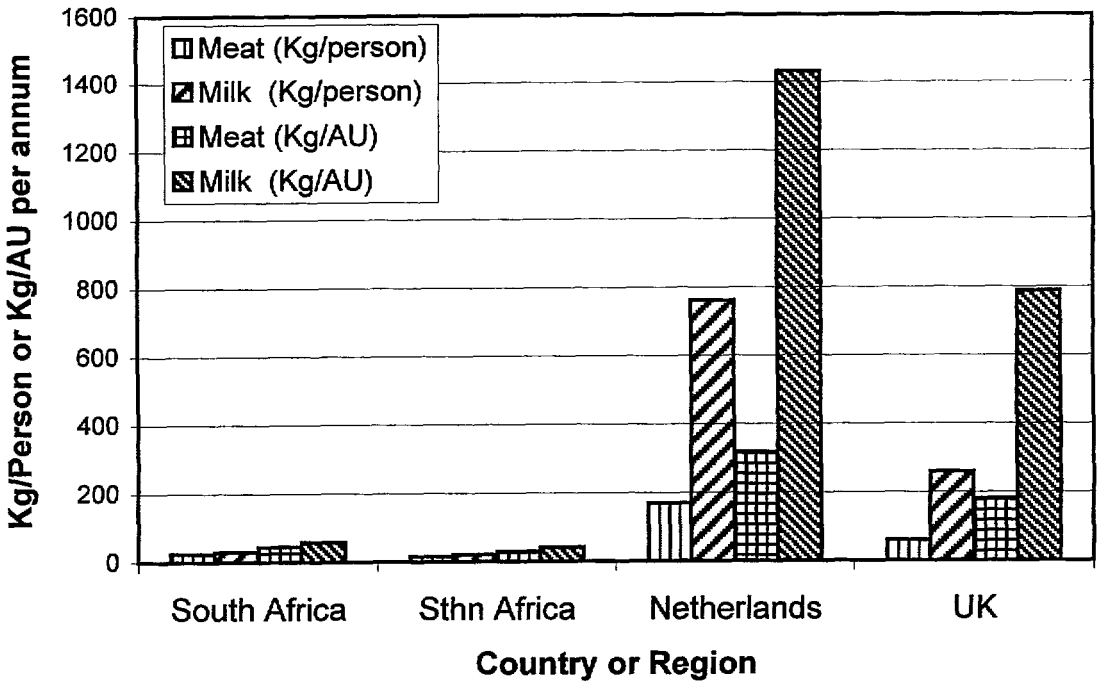


Fig. 3.7 Animal production levels in southern Africa and Europe (From Cumming and Bond 1991)

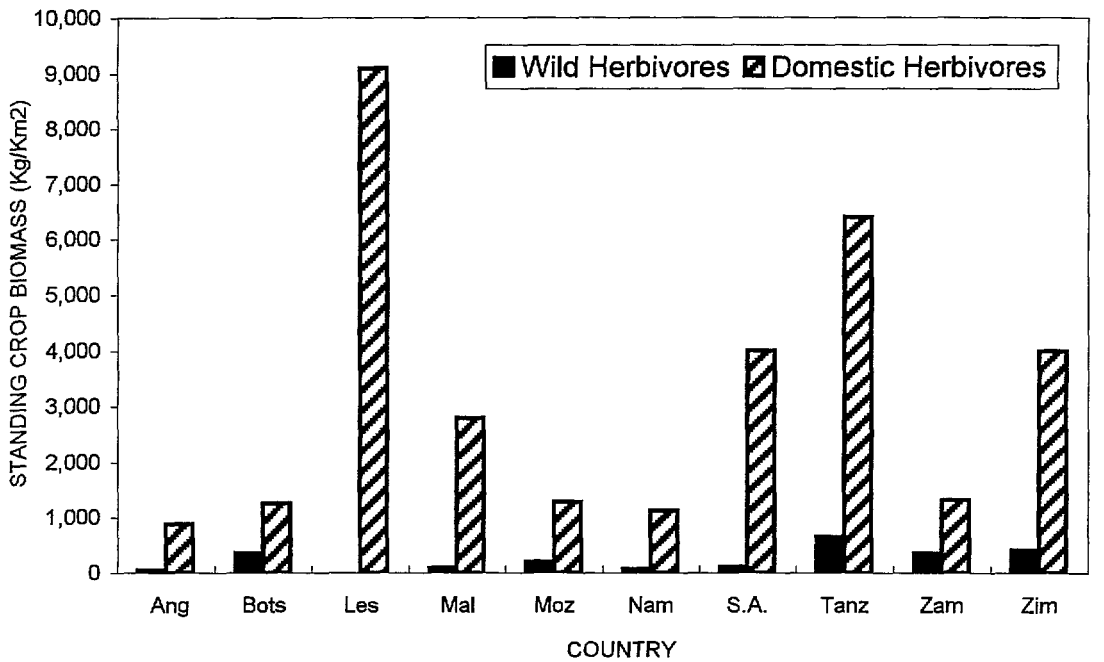


Fig. 3.8 Comparison of standing crop biomass of domestic livestock and wild herbivores in southern African countries (From Cumming and Bond, 1991)

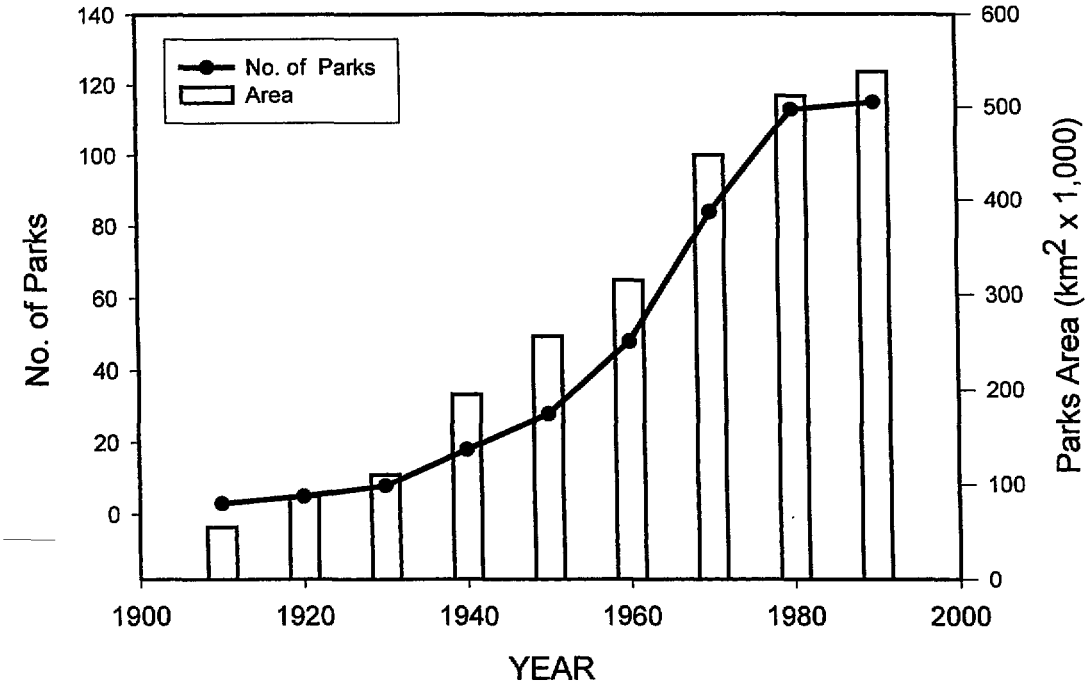


Fig. 3.9 Growth of protected areas in southern Africa 1900-1997 (Redrawn and updated from Cumming 1990).

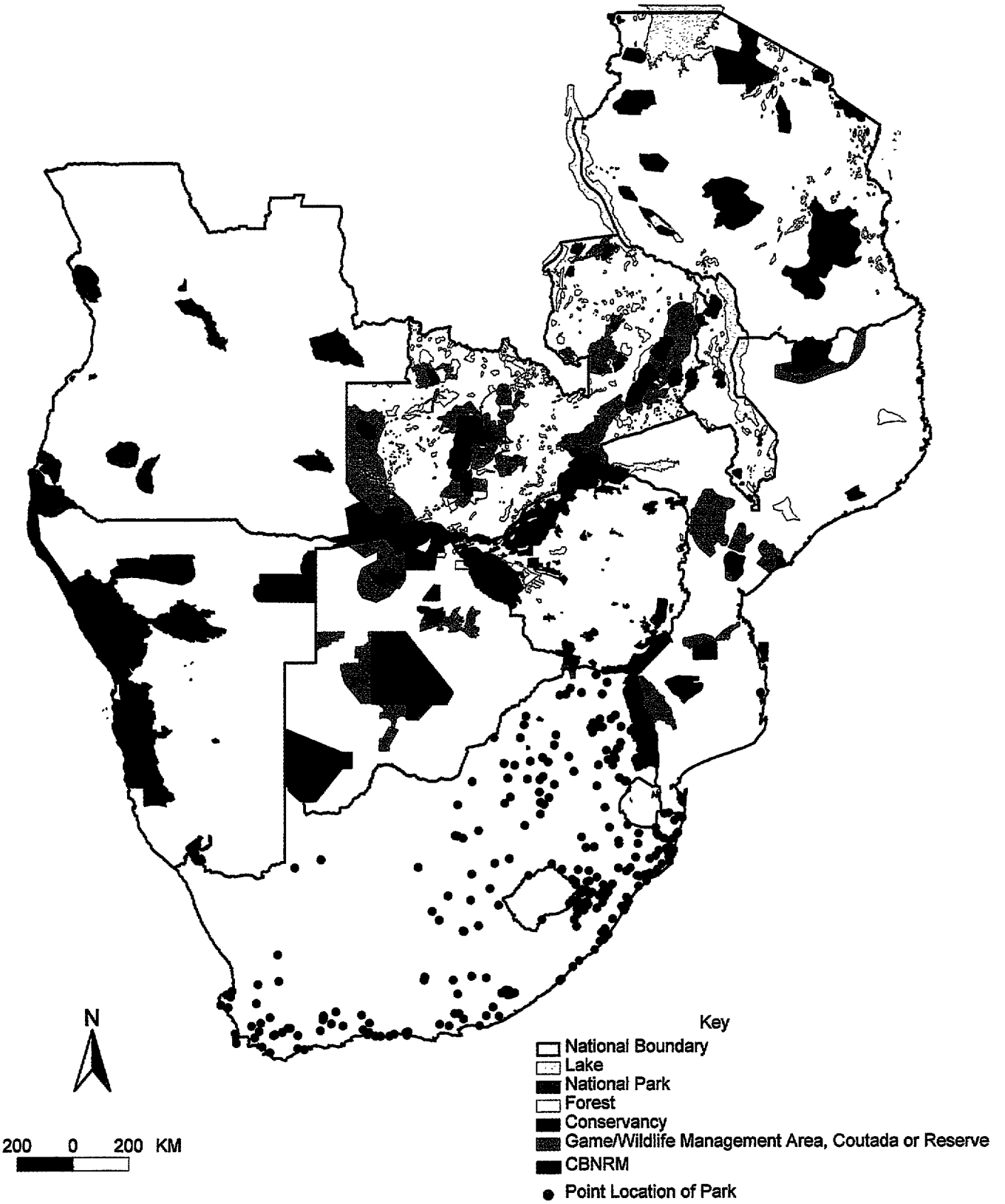


Fig. 3.10 Protected Areas and wildlife areas in southern Africa (WWF-SARPO, compiled from various sources).

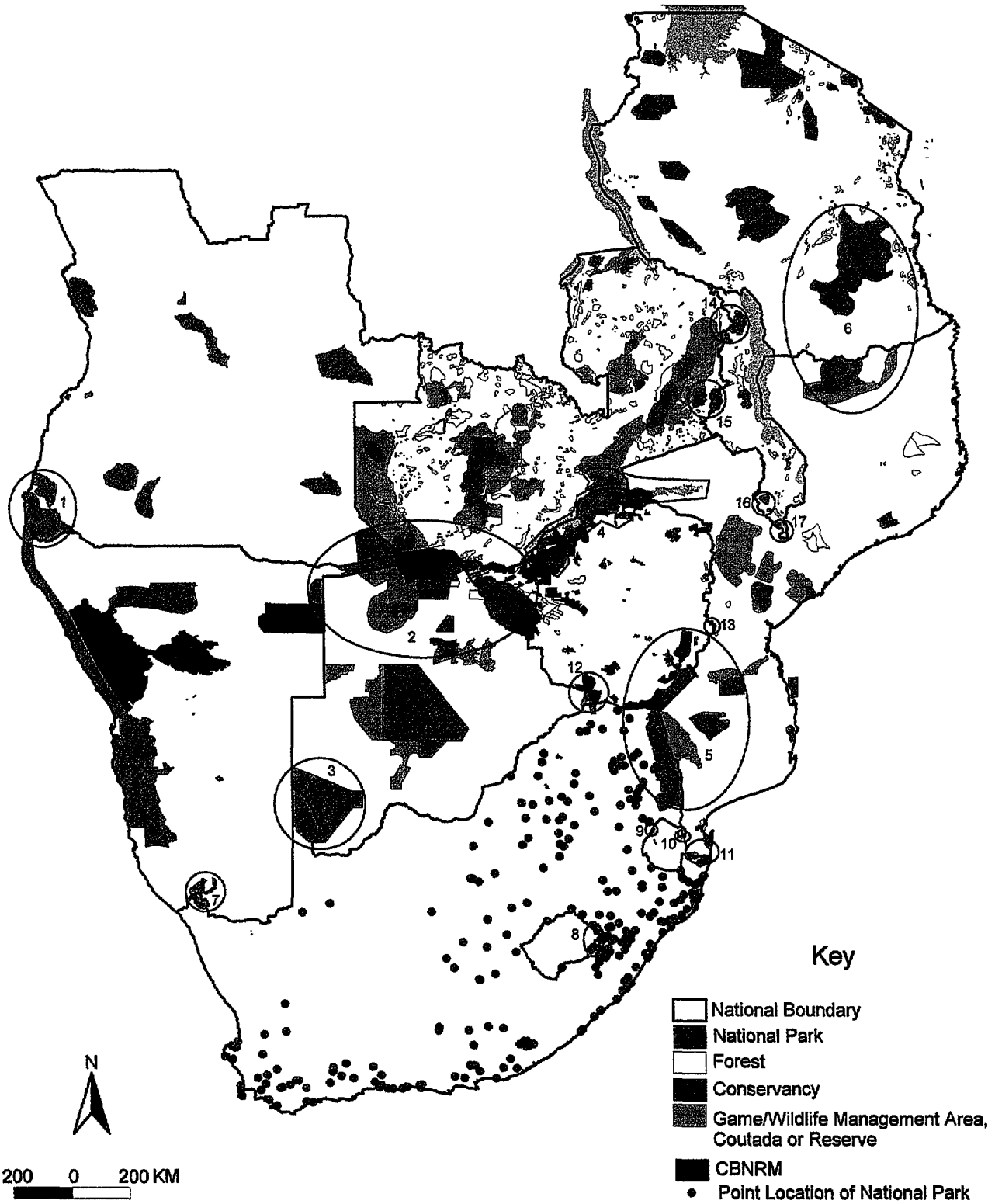


Fig. 3.11 Potential TBNRM areas in southern Africa (WWF-SARPO, compiled from various sources)(lakes and marine areas not included). 1 Iona/Skeleton Coast; 2 Okavango/Caprivi-/Chobe/Hwange; 3 Kgalagadi; 4 Mana/Zambezi/Cahora Bassa; 5 Kruger/Zinave /Banhine -/Gonarezhou; 6 Niassa/Selous; 7 Ais Ais/Richtersveld; 8 Drakensberg/Maloti; 9 Malolotja; 10 Maputo/Mlawula 11 Ndumu/Tembe/Maputo; 12 Tuli block; 13 Chimanimani; 14 Nyika/Nyika; 15 Kasungu/Lukusuzi; 16 Lengwe; 17 Mwabvi

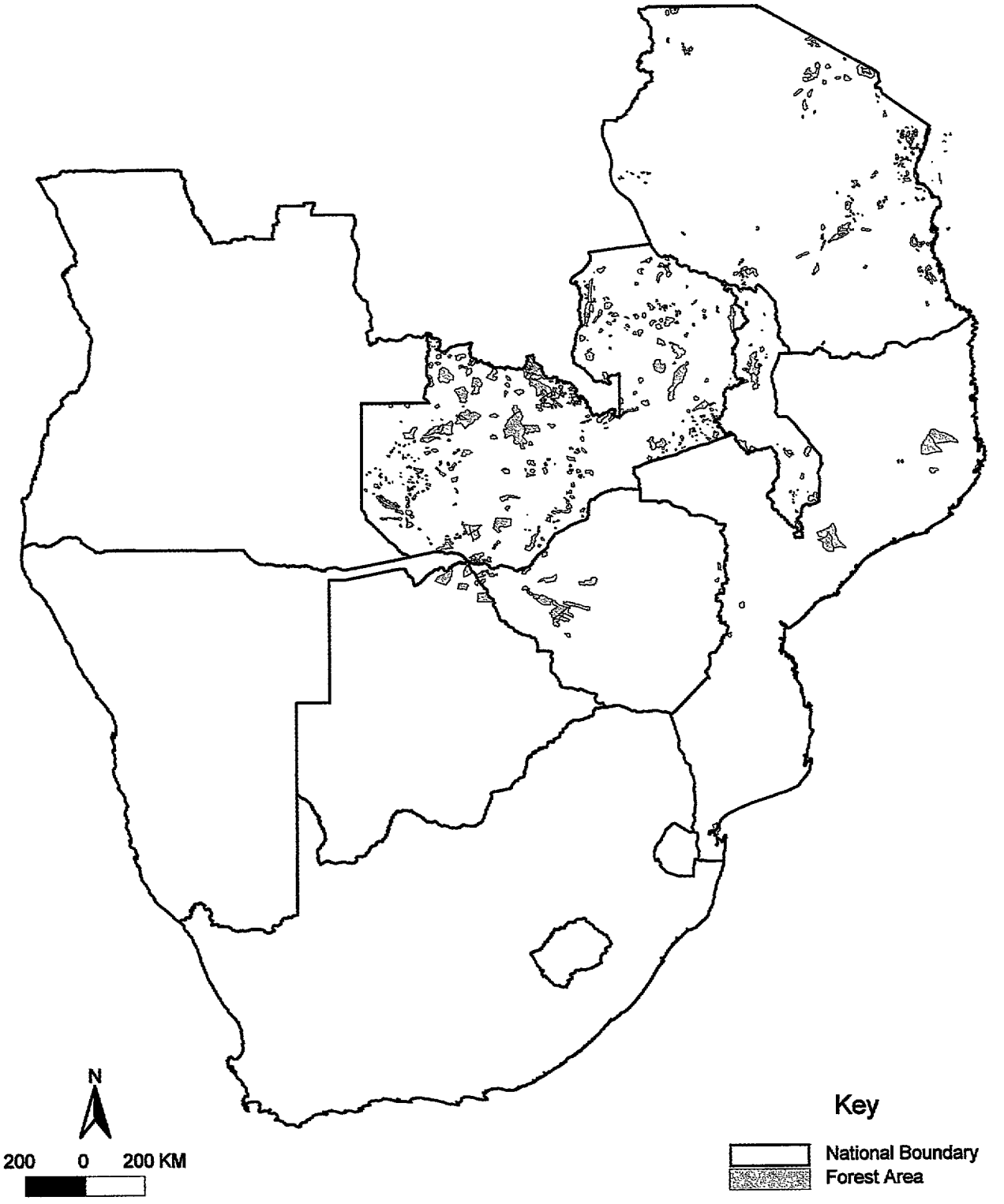


Fig. 3.12 Designated Forestry Areas in Southern Africa (WWF-SARPO, compiled from various sources)

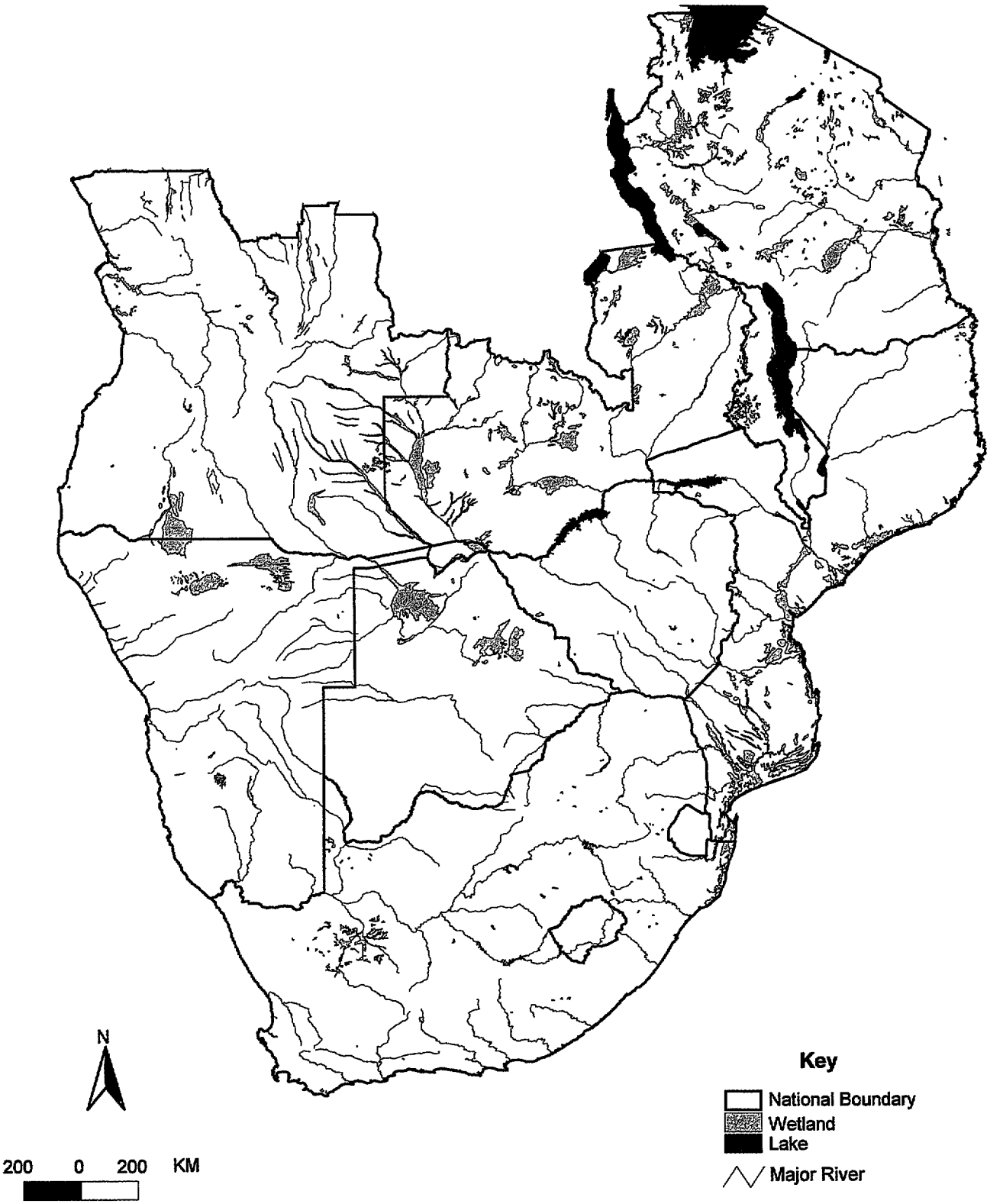


Fig. 3.13 Major lakes, rivers and wetlands in southern Africa (Source: WCMC ADS)

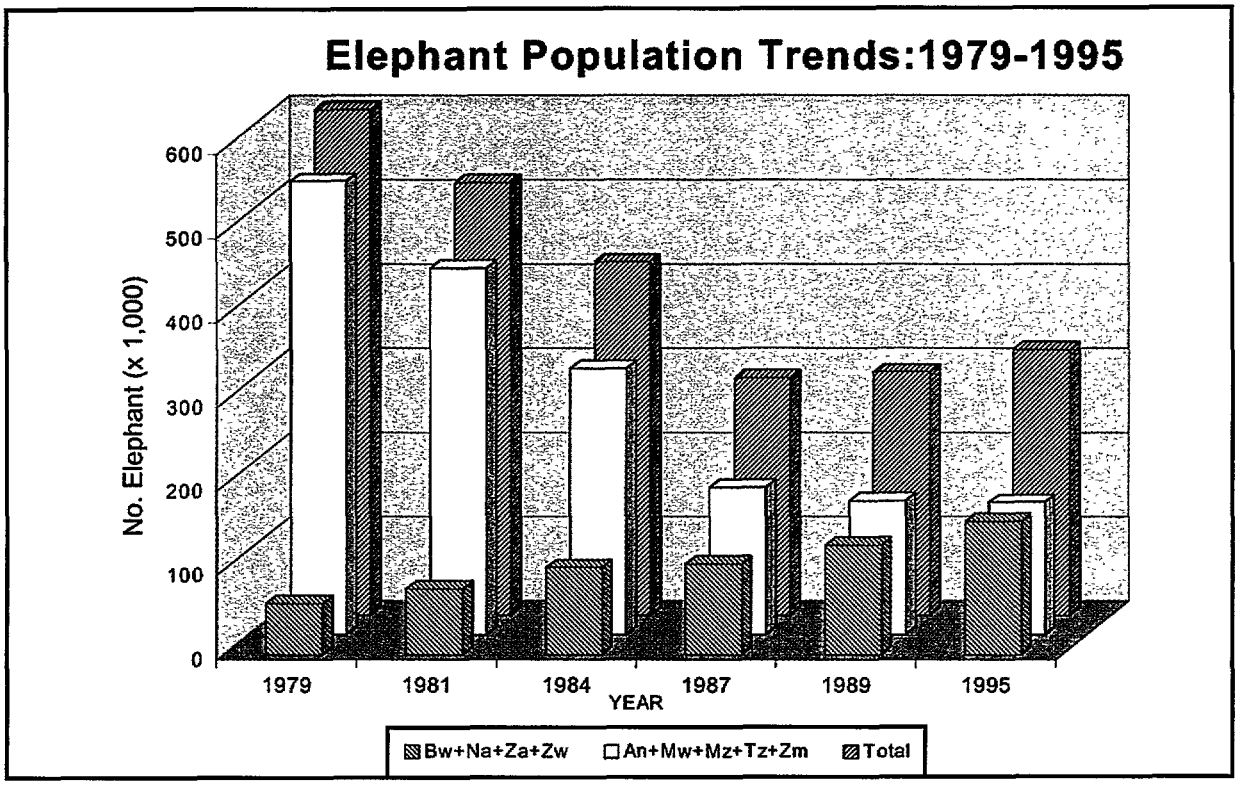


Fig. 3.14 Trends in elephant numbers in southern Africa: 1979-1995. (Based on IUCN/SSC African Elephant and Rhino Specialist Group reports)

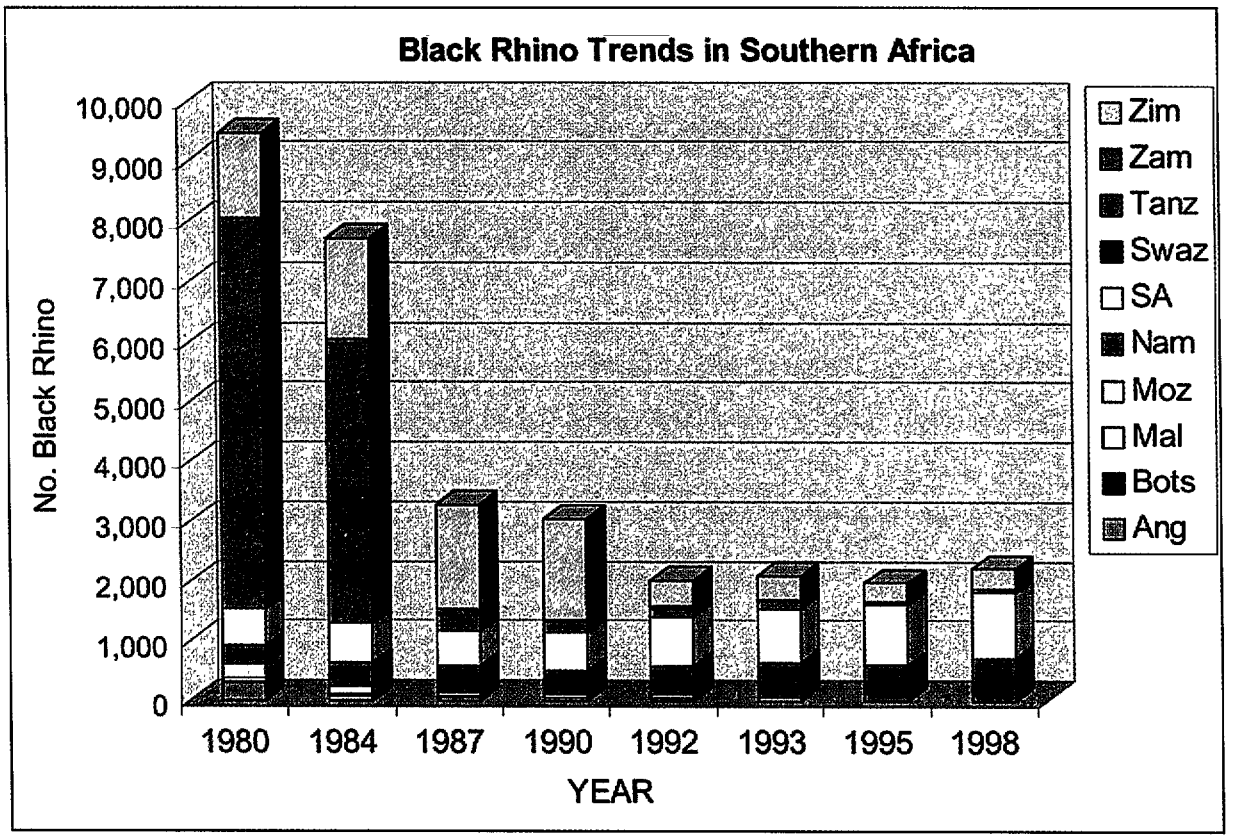


Fig. 3.15 Trends in black rhino numbers in southern Africa: 1980-1998. (Based on IUCN/SSC African Elephant and Rhino Specialist Group reports)

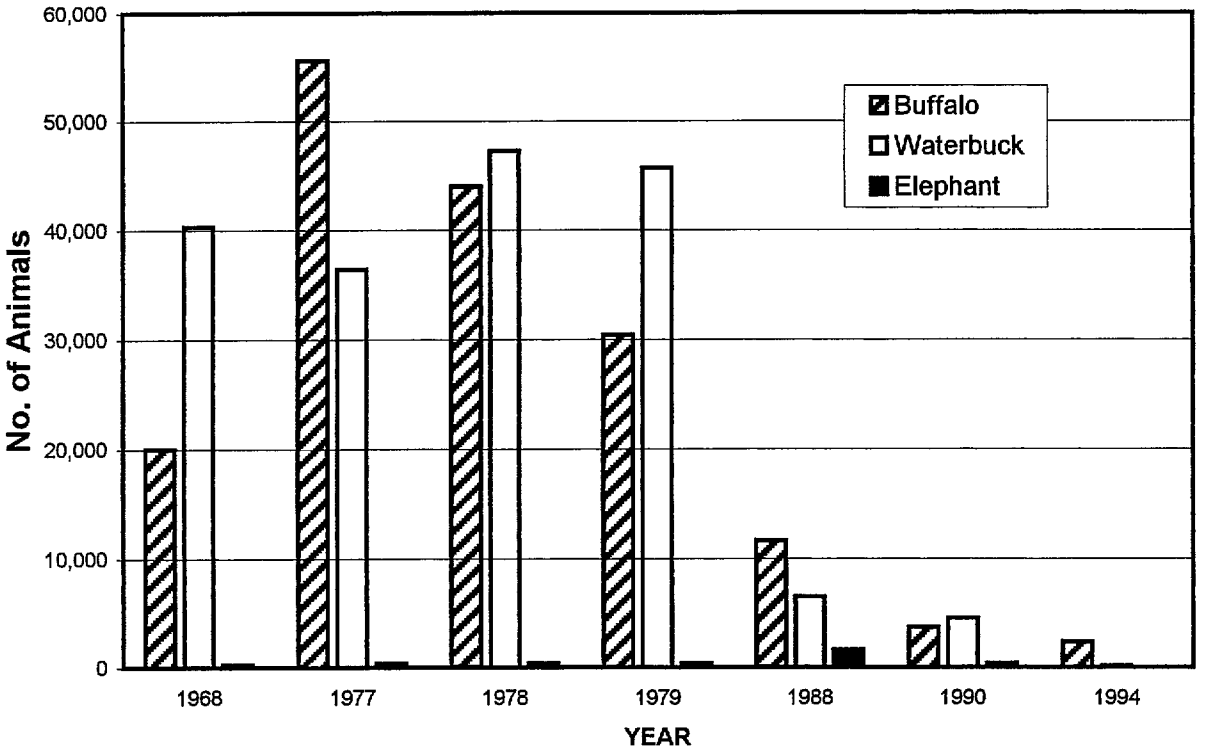


Fig. 3.16 Trends in dominant ungulate populations in Marromeu Game Reserve, Mozambique, between 1972 and 1994. (From Cumming, *et al* 1994)

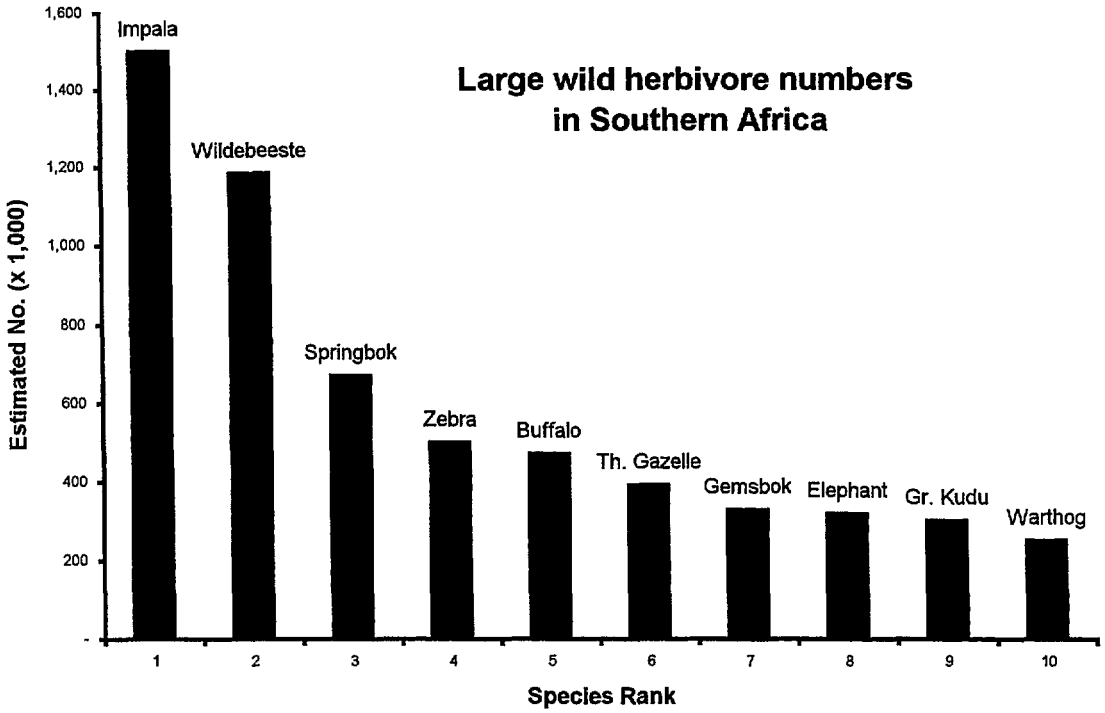
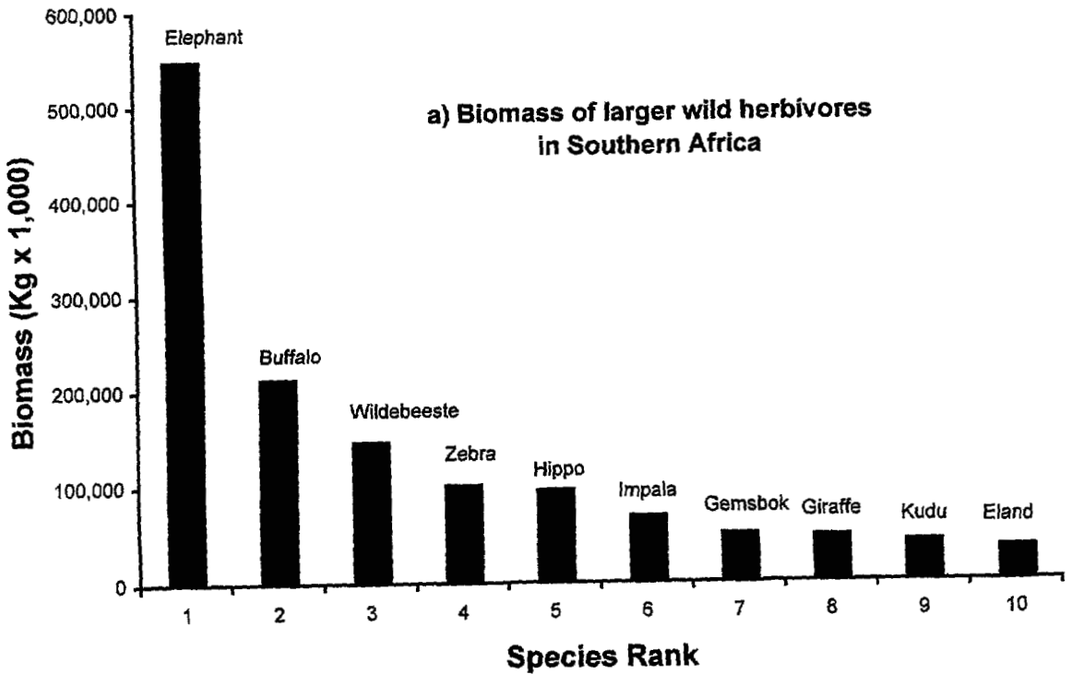


Fig. 3.17 Estimated numbers of the 10 most numerous ungulates in southern Africa (Based on data in East, 1989)



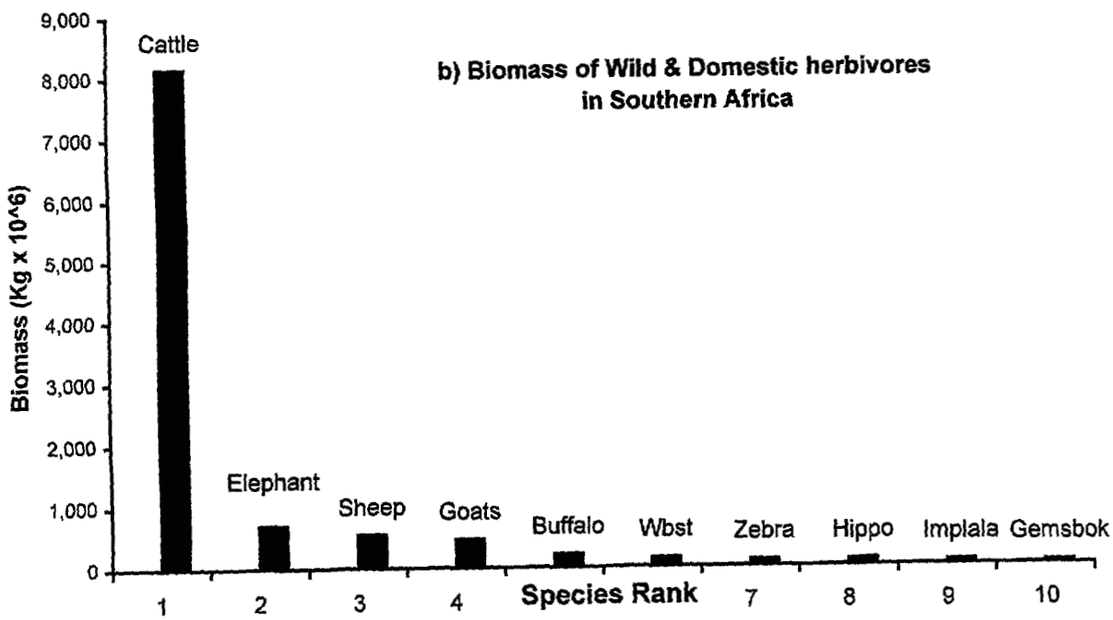


Fig. 3.18 Biomass of 15 dominant ungulates (i.e. in terms of biomass) in southern Africa

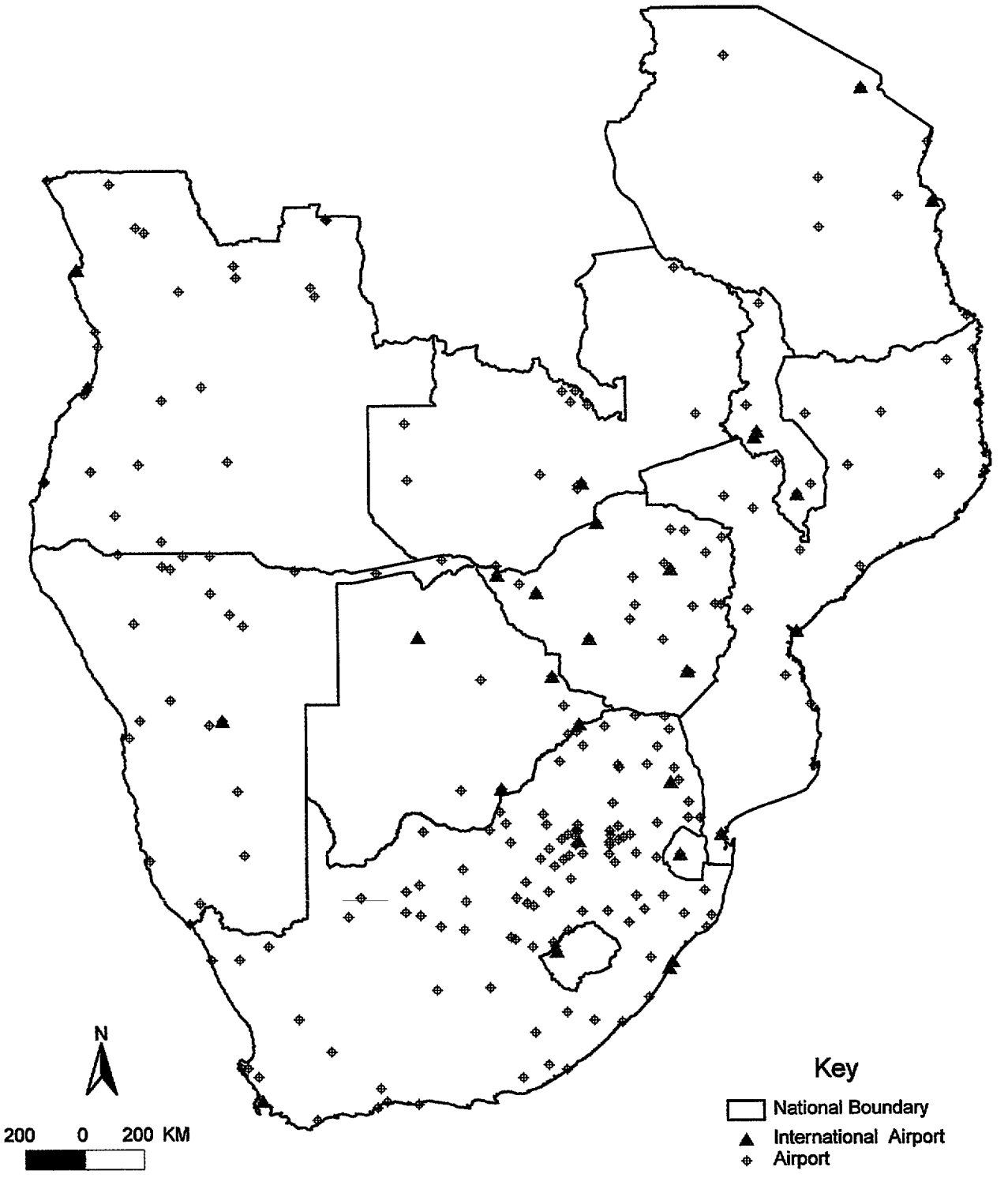


Fig. 3.19 International Airports in the region (Source: WCMC ADS)

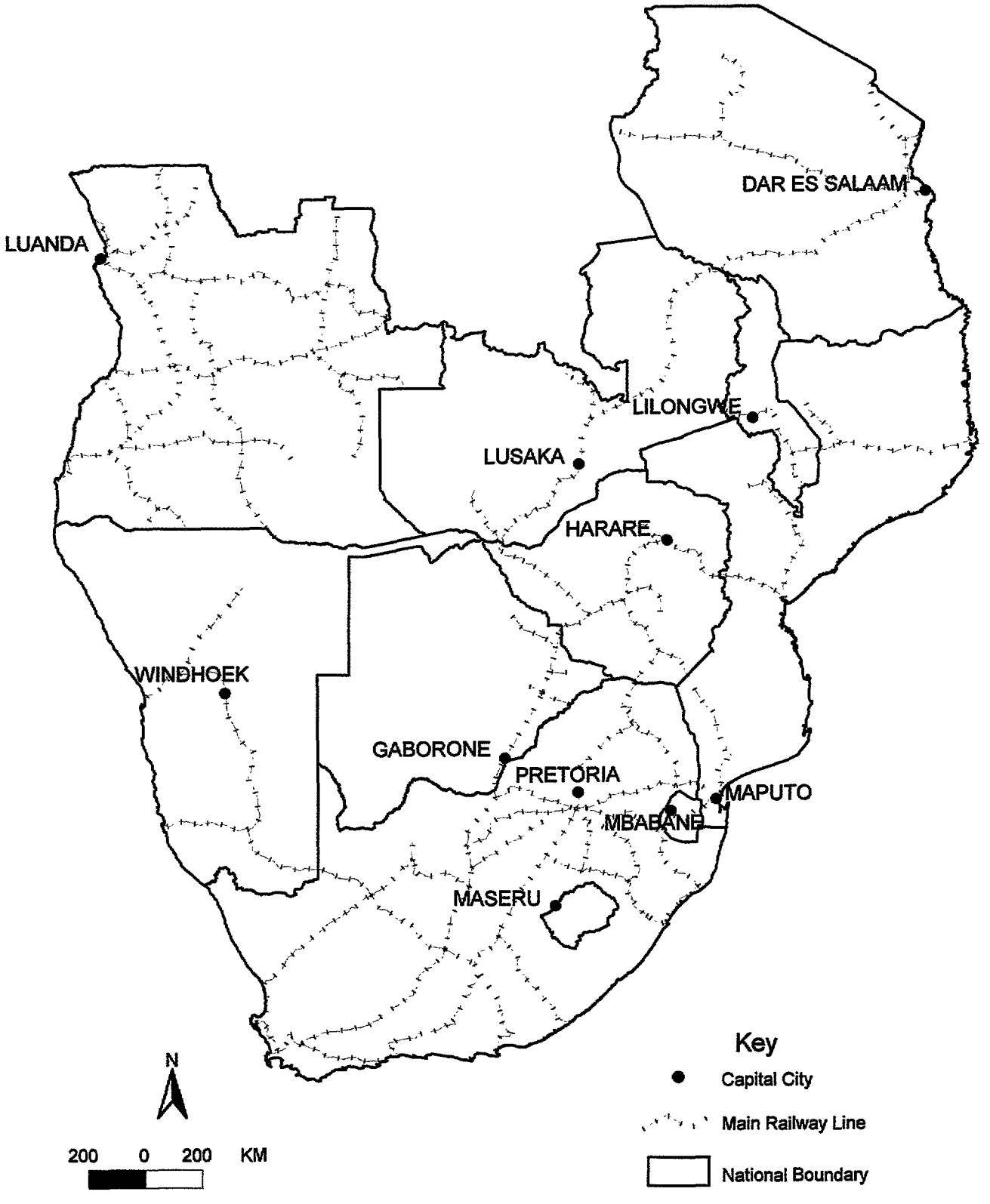


Fig. 3.20 Major Railways in the Region (Source: WCMC ADS)

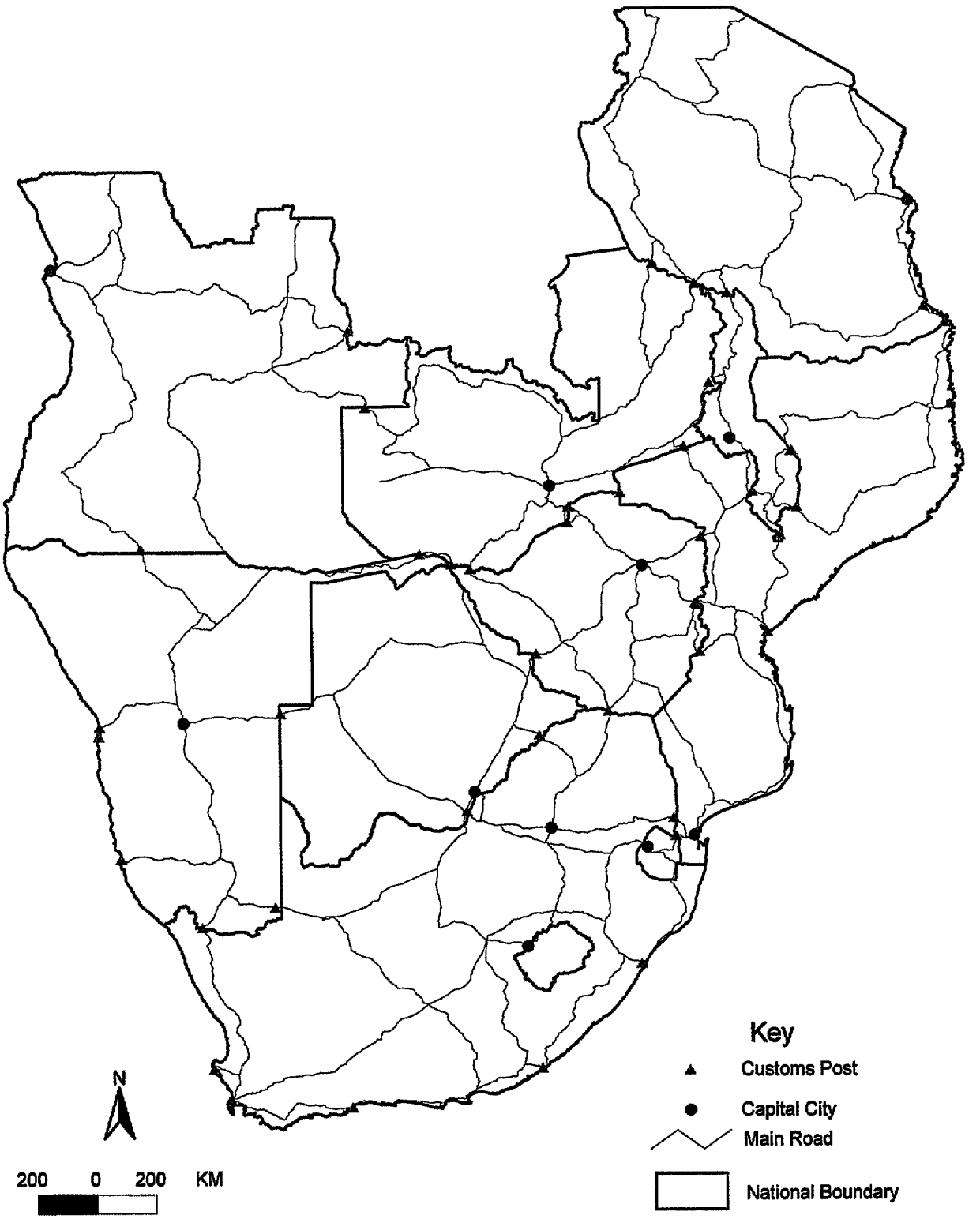


Fig. 3.21 Major Roads and Customs ports in the region (Source: WCMC ADS and WWF-SARPO)

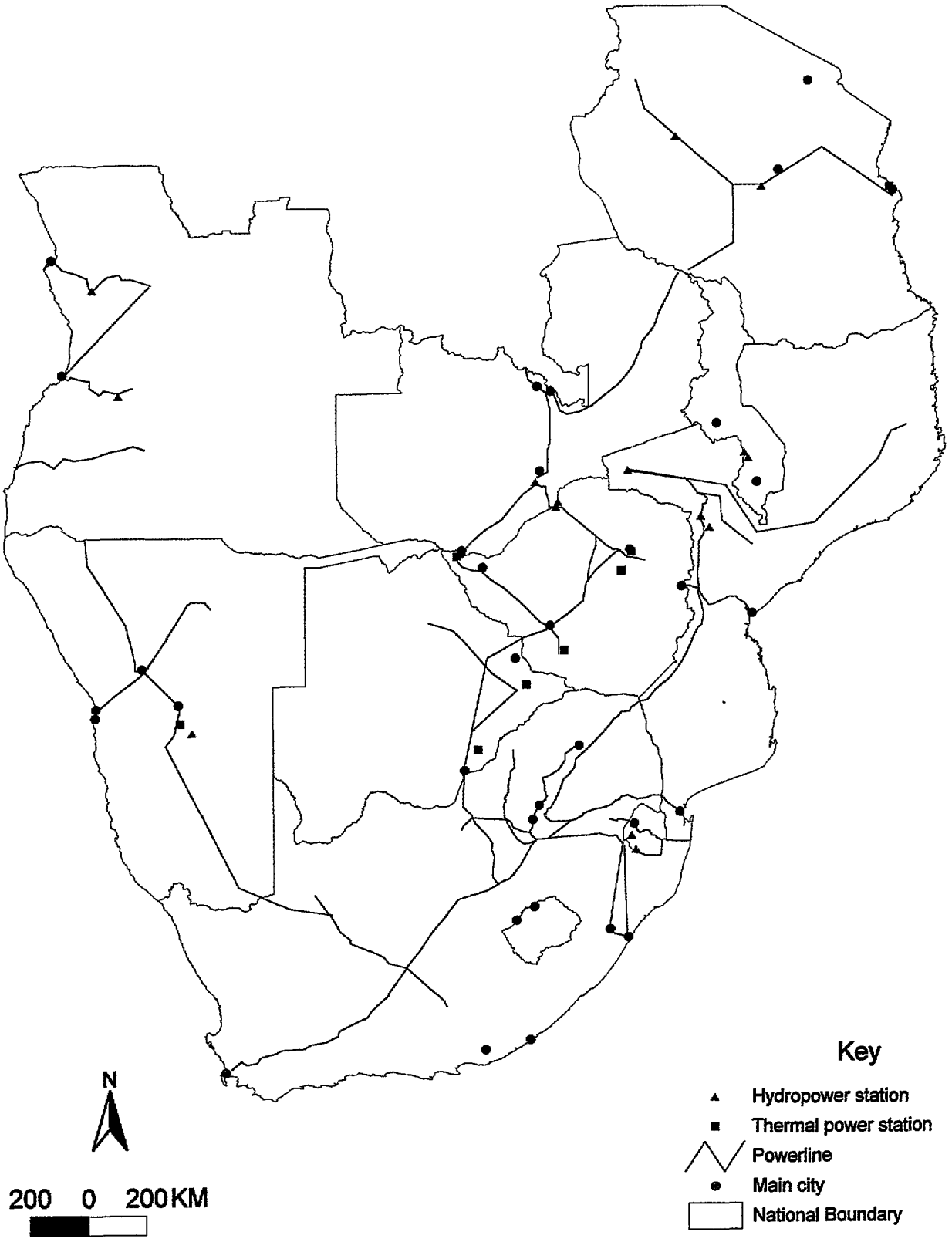


Fig. 3.22 Major Energy (Coal and Hydroelectric) sites and deposits of coal, gas and oil

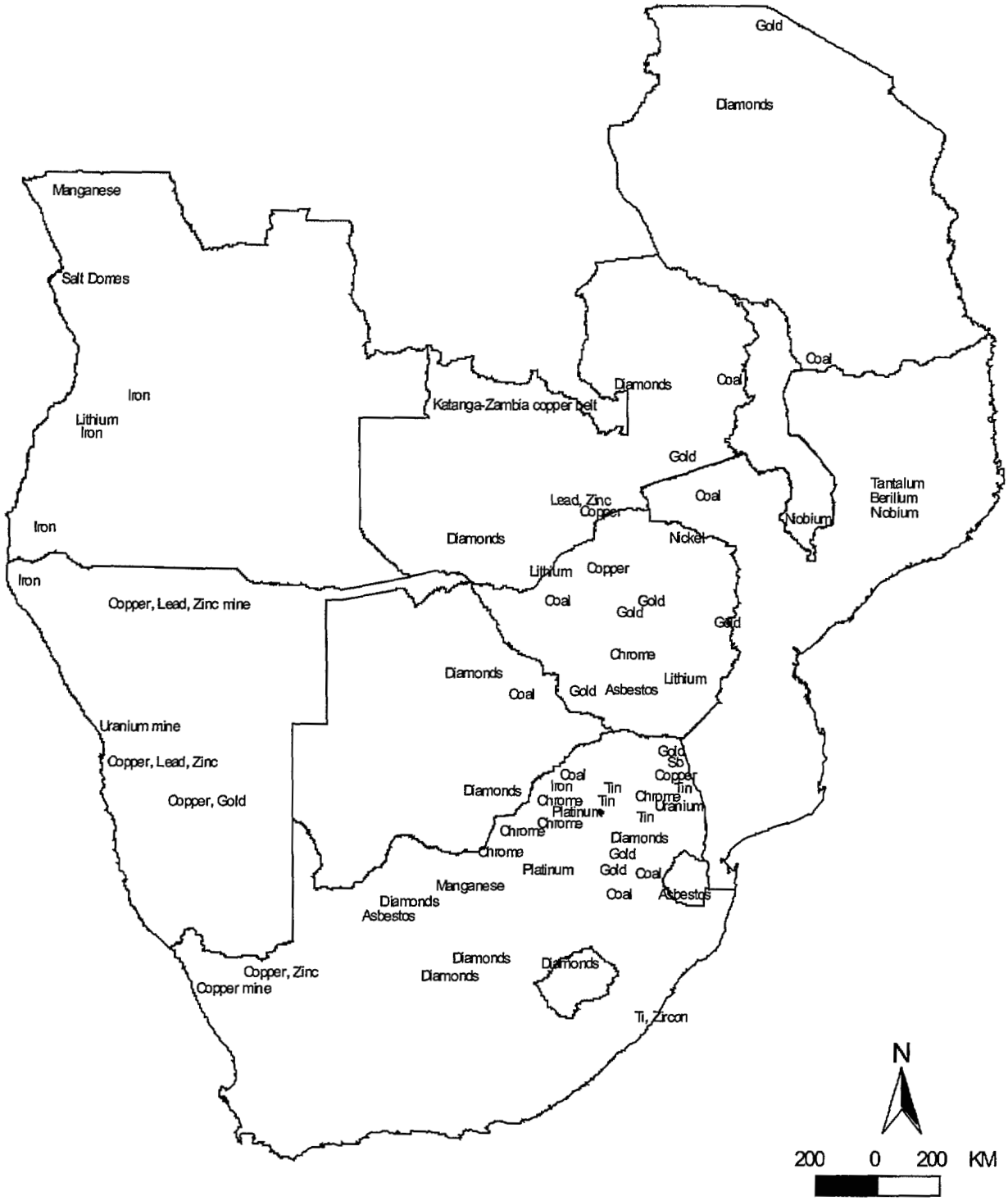


Fig. 3.23 Distribution of valuable mineral deposits/mines in the region (Based on Derry 1976)