CHAPTER 3

STUDY AREA

3.1 Introduction

The distribution of savannas is correlated with many environmental factors, including geomorphology, climate, soils, vegetation, fauna and fire (Bourlière 1983; Cole 1986). Mopaneveld is no exception to the rule. The distribution of *Colophospermum mopane*, hence to a great extent the distribution of Mopaneveld (see section 2.2.1, Chapter 2) is principally influenced by moisture availability expressed through altitude, rainfall and soil texture (Mapaure 1994). The study area will therefore be discussed according to these determinants, although others will not be eluded, for it is rather a combination of factors than a specific set of conditions that influence the distribution of the Mopaneveld (Timberlake 1995).

In most environmental studies, scale is often the most hazardous factor to deal with. Considering the large geographical region of the Mopaneveld over its distribution range, the discussion on the environmental determinants is broad, rather than detailed.

3.2 Locality

For the purpose of this study, Mopaneveld is used to describe the demarcated areas on Figure 1, which was adapted from Mapaure (1994). Although the map of Mapaure (1994) follows the distribution of *Colophospermum mopane*-dominated vegetation types, it serves a good indication of the distribution of Mopaneveld.

The Mopaneveld lies across several political borders stretching from Mozambique and South Africa along the East Coast of Africa to Angola and Namibia along the dry West Coast, crossing areas of Zimbabwe, Zambia, Malawi and Botswana. The longitudinal boundaries of the study area lie between 11°00′ and 24°30′ E. Mopaneveld covers approximately 550 500 km^2 over its distribution range (Mapaure 1994).

Although the discussion of Mopaneveld vegetation (Chapter 2) and the discussion of environmental parameters (Chapter 3) follow the distribution of Mopaneveld over its entire distribution range, the study area applicable to vegetation analysis and synthesis (Chapter 4) were narrowed according to the availability of adequate phytosociological data.

3.3 Topography and Geomorphology

Mopaneveld is associated with large river valleys and their tributaries where it inhabits the deep, clayey to loamy clayey soils in the valley bottoms (Werger & Coetzee 1978; Cole 1986; Mapaure 1994). Well-known African features such as the Cunene, Chobe, Limpopo, Luangwa, Okavango, Shire and Zambezi Rivers dissect the study area. Physiographically the study area can be described as flat to undulating terrain with scattered inselbergs (koppies or rocky outcrops). On these steep-sloped inselbergs, *Colophospermum mopane* rarely forms the dominant species in the tree layer since it is usually confined to the deeper, more clayey soils (see Chapter 2).

The western limit of Mopaneveld stretches along the Chela escarpment in the North (Angola) and the Kaokoland escarpment in the South (Namibia). The Kalahari Basin in Botswana is in general level or slightly raised. The escarpment in Zimbabwe does not form a definite separation of Mopaneveld vegetation since the Mopaneveld in the Limpopo River Valley below the Zimbabwean escarpment leads Northeast (Figure 1). Further downstream of Lake Kariba (Zimbabwe), Mopaneveld however covers the slopes of the escarpment (Werger & Coetzee 1978). The topography along the Zambezi Valley varies from level (especially on the valley bottom) to slightly raised terrain, to an undulating landscape characterised by the alternate dominance of Mopaneveld and Miombo. The topography on the Kalahari sands is in general level. Mopaneveld in Zambia is characterised by a wide, flat-bottomed trough bounded by steep, dissected escarpments that rise from 700 m to 800 m above its floor (Werger & Coetzee 1978). Malawian Mopaneveld is not bounded by any escarpments, but occurs as isolated patches on broken topography. At its northern distribution limit in Malawi, Mopaneveld occurs on the flat to slightly raised valley floor of the Shire, whereas its southern limit in Malawi is associated with stony hills (Werger & Coetzee 1978). Landscapes in the Mopaneveld of Mozambique are not very diverse. A slightly undulating landscape is the predominant landscape type in this part of the study area. In South Africa Mopaneveld is characterised by level or slightly raised terrain along the Lebombo range in the northern Kruger National Park. The Mopaneveld in the northwestern parts of its range covers undulating landscapes with scattered rocky outcrops. The Soutpansberg forms a definite southern border of Mopaneveld in the northern parts of the country. The southern-most limit of Mopaneveld in South Africa is south of the Olifants River in the Kruger National Park (Gertenbach 1987).

Apart from the large rivers (mentioned above) dissecting the study area, other conspicuous water bodies in the Mopaneveld include the Cuvelai Delta and Etosha Pan in Namibia, the Makgadikgadi Pan and the Okavango Delta in Botswana, Lake Kariba in Zimbabwe and Zambia and Lake Malawi in Malawi.

The study area varies greatly in terms of altitude, which ranges between 100 m to 1 000 m above sea level. Despite its wide range, altitude plays a major role in the distribution of the Mopaneveld (Mapaure 1994) since moisture availability is often expressed through altitude. Approximate altitudinal range for Mopaneveld in all different hosting African countries are summarised in Table 1.

3.4 Climate

3.4.1 Introduction

The central thesis for plant ecology is that climate exerts the dominant control on the distribution of the major vegetation types of the world. Within a vegetation type smaller-scale variations in distribution may be controlled by smaller-scale features of the environment, such as soil types, human activity or topography (Woodward 1986).

The Mopaneveld occurs in hot regions with a highly seasonal rainfall distribution. The warm, dry season lasts for five to eight months followed by the hot, wet season for the remainder of the year. Of all the factors involved, climate has a dominating influence on all other environmental factors and is therefore considered to be the most important from the point of view of their effect on plant-life (Rattray 1963). The understanding and recognition of climate variability in the Mopaneveld will provide in the understanding of ecosystem functioning.

3.4.2 Rainfall

In the savannas, high irradiance, heat and low humidity combine to create a high evaporative demand, which ensures that savannas are in net water deficit for most of the year, including much of the 'rainy season' (Scholes & Walker 1993). Considering this, rainfall is of utmost importance for the subsistence of Mopaneveld vegetation.

Rainfall patterns within the study area vary significantly. Mopaneveld is therefore regarded as a vegetation type which can tolerate the most extreme environmental, especially rainfall conditions. Approximate annual rainfall figures for Mopaneveld in all different hosting African countries are summarised in Table 1. Without considering the extremes, the general range of annual rainfall in which Mopaneveld predominate is approximately 250 mm – 400 mm. If an index of soil moisture availability could be examined for all areas hosting Mopaneveld, it is speculated that the range would not express such extremes as for annual rainfall. These speculations are based on the limited soil moisture availability in high rainfall areas of high rainfall intensities, heavy vertisols as well as fluvisols. Despite high annual rainfall, the vegetation in these areas are exposed to prolonged drought conditions due to low soil moisture availability as a result of high run-off or as a result of soil moisture retention by vertisols and fluvisols.

In the Luangwa Valley, Zambia, annual rainfall exceeds 800 mm. Nonetheless is the vegetation exposed to extremely hot and dry conditions during the period prior to rainfall events. Figure 10 represents a simplified explanation of a high rainfall area in Mopaneveld (Luangwa Valley, Zambia) which survive under low soil moisture availability for a significant time period.

3.4.3 Temperature

The whole study area has a fairly drawn-out warm summer, with a short mild to warm winter. January and February are generally the warmest months and July the coolest. Approximate mean temperature ranges for Mopaneveld in all different hosting African countries are summarised in Table 1. It is evident that Namibian Mopaneveld survives most extreme temperatures (12 – 31°C).

Temperature on its own is not a major determinant of vegetation patterns. In combination with annual rainfall and altitude it however has a profound influence on vegetation, also evident in the Mopaneveld. Periods of low rainfall conditions and high temperatures, such as illustrated in Figure 10 have a definite effect on vegetation. This phenomenon prevails especially in semi-arid savannas which consequently explains why non-equilibrium models are often used to explain vegetation change in these chapters (Chapter 7).

Table 1 A summary of mean annual rainfall and temperature values as well as altitudinal range for the southern African Mopaneveld

Mopaneveld-hosting African country	**Mean annual rainfall (mm)**	**Mean temperature range (°C)**	**Altitudinal range (m)**
Angola	100 – 400	16 – 25	100 – 400
Botswana	400 – 600	13 – 30	800 – 900
Malawi	700 – 800	19 – 28	450 – 500
Mozambique	400 – 700	20 – 29	200 – 500
Namibia	100 – 550	12 – 31	150 – 1 000
South Africa	250 – 400	15 – 31	400 – 700
Zambia	700 – 1 000	14 – 30	400 – 800
Zimbabwe	500 – 700	16 – 30	400 – 950

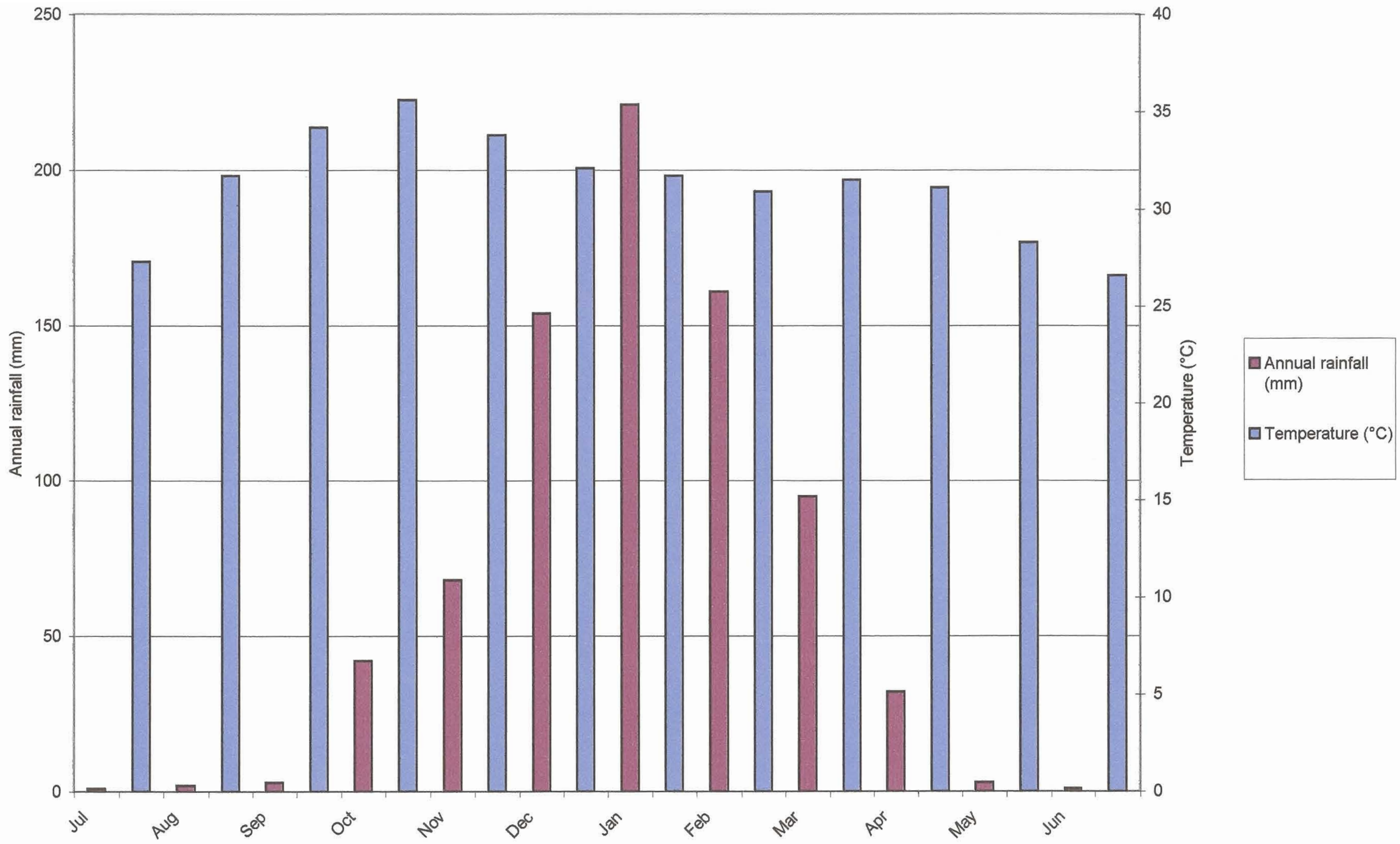

Figure 10 Monthly mean annual rainfall and mean temperature measures in Zambian Mopaneveld

3.5 Geology

The geology underlying southern African Mopaneveld is discussed only in broad terms since a detailed inventory of the complex geology over such a large area is beyond the scope of this study. A simplified geology map overlain by the distribution of *Colophospermum mopane* is presented in Figure 11 to illustrate variation in geological parent material in Mopaneveld.

The majority of geological substrates underlying the study area are from the Precambrian, dissected with various intrusive, extrusive and metamorphic rocks of undetermined nature and age. Small proportions of Mopaneveld cover recent deposits, such as the Kalahari Sand from the Quaternary (Figure 11). Limited areas of Mopaneveld are underlain by the Mesozoic of the Carboniferous, Jurassic to Triassic periods. Most of the Eastern Mopaneveld covers areas of alkaline black clay soils derived from Karoo (Triassic) basalt, granite and shale.

The lithology of the Mopaneveld can basically be divided into basic rocks, acidic rocks and recent deposits such as the Kalahari Sand. The difference between basic- and acidic rocks lies in their mineral content. Ultrabasic (ultramafic) rocks contain, for example, MgO, FeO and CaO, and acidic rocks contain mineral oxides such as SiO_2, K_2O and Na_2O (Krauskopf 1967). Basic rocks are usually referred to as basalt. Granite and shale are acidic rocks. Granite is known for its low mineral content and shale is formed from sediments derived from weathered rocks. Sediments derived from weathered rocks such as shale, cover about 70% of the world's surface lithology (Krauskopf 1967).

The geology of the South African Lowveld shows definite associations with vegetation distribution and therefore a simplified explanation of its geological history is included for possible reference to most parts of the Eastern Mopaneveld. Approximately 3 500 – 200 million years ago gabbro intruded granite and gneiss, which formed the major rocks of the Lowveld, as we know it today. Ecca-shales covered the granite-gneiss layer with gabbro intrusions after the marshy period. As Gondwanaland broke apart (200 milion years ago), volcanic rocks, first basalt then rhiolite, covered the earth's surface. The granite, gneiss and shale layers eventually ripped to expose a sequence, from West to East, of granite and gneiss, shale, basalt and rhiolite as the new continental coastline developed. After extended periods of wind and water erosion, the erosion-tolerant granite, gneiss and rhiolite remained to form the Eastern Escarpment and the Lebombo Mountain range respectively.

3.6 Soils

Soils are a distinct and important factor in plant ecology (Fraser *et al.* 1987). The close relationship between soils and vegetation is a useful aid in studying ecosystems (Witkowski & O'Connor 1996).

The scale of this study however does not allow a detailed soil inventory. More information on the relevant correlations between vegetation and soil is provided in the discussion of the different vegetation types (Results: Chapters 5 & 6) as well as the literature review on Mopaneveld vegetation (Chapter 2). General comments on the soils underlying the southern African Mopaneveld are provided in this section for sufficient background to understand the variation in vegetation types along the extensive Mopaneveld of southern Africa.

A variety of soils are found under savanna vegetation. This is attributed to the interaction of varied plant material with weathering regimes of different duration and intensities. The vegetation itself does not have a profound effect on pedogenesis in savannas, although there is often a close relationship between soil and vegetation type (Scholes & Walker 1993). The soils of dry savannas are base-rich, especially in the Mopaneveld where large areas are underlain by basic igneous rocks such as basalt, or fine-grained sediments such as shale or mudstone. High concentration of bases in dry savannas causes alkaline soils and the accumulation of free salts in the profile. Where the parent material is basalt or related basic lavas, vertic clayey soils occur (Scholes & Walker 1993).

Acid igneous parent materials such as granites result in a landscape with sandy, infertile uplands (typically *Combretum*-dominated vegetation) and clayey, fertile bottomlands, which are inhabited by *Colophospermum mopane*-dominated vegetation throughout large parts of the study area.

The relationship between geology, soils and plants are well stated by Fraser *et al.* (1987). The study was conducted in the Mooiplaas-Mahlangeni district in the Kruger National Park, South Afruca. These relationships are partially addressed in the discussion of the plant communities of the South African Lowveld Mopaneveld (Chapter 6).

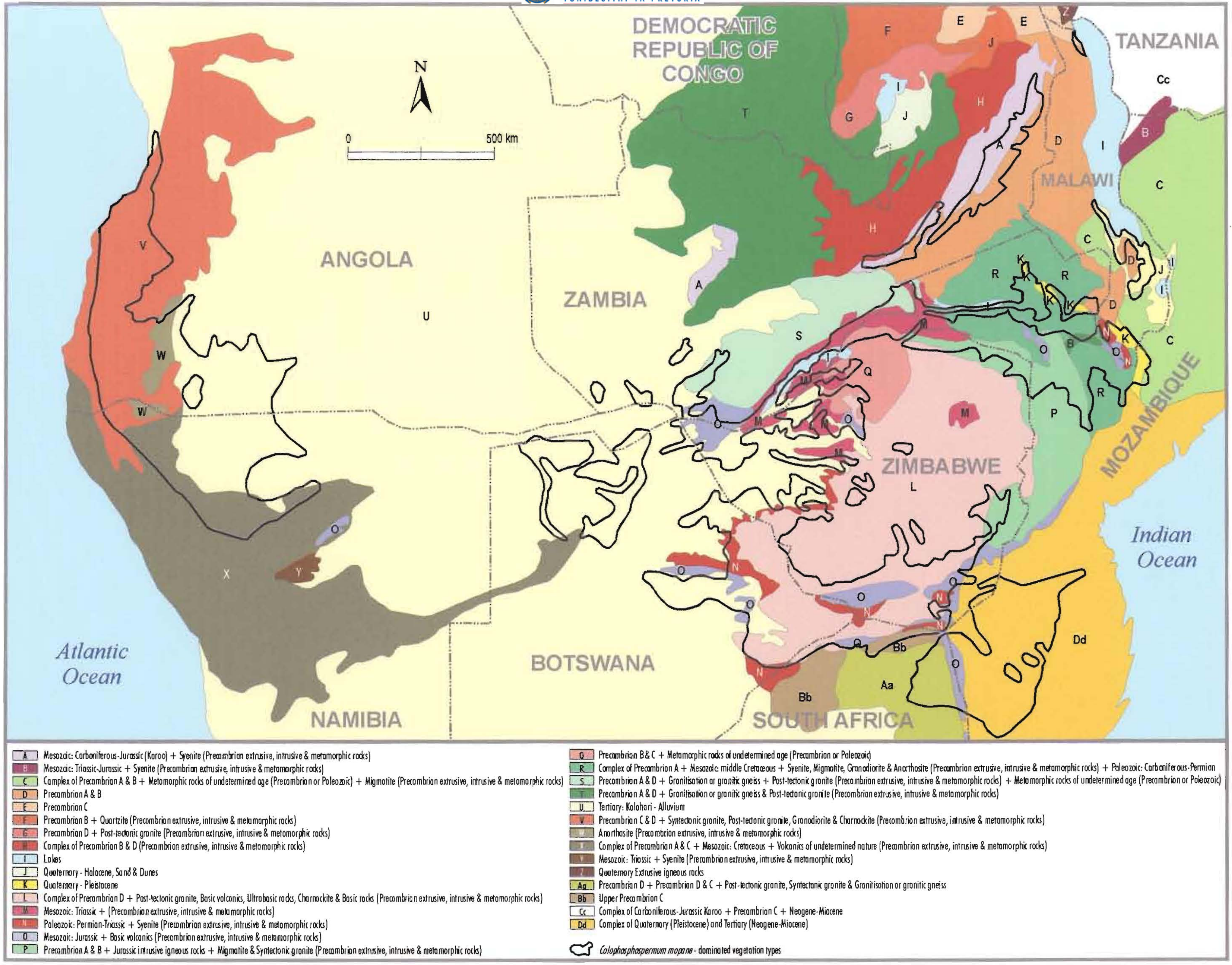

Figure 11 Distribution of *Colophospermum mopane*-dominated vegetation types along geological substrates (distribution of *C.mopane* adapted from Mapaure, 1994).