CHAPTER 1. INTRODUCTION

Criticisms of the Braun-Blanquet (1928, 1951) approach to vegetation studies have mainly been concerned with two facets, namely,

i. minimum sampling unit area or quadrat size (Goodall 1961, Werger 1974); and

ii. observer bias, both in the sampling and classification phases (Goodall 1953, 1961; Poore 1956; Werger 1974).

In the southern African context, doubts on the relevancy of vegetation classifications can also be expressed: Is this the most cost-effective method of inventorizing and describing the variation in the vegetation resource? Is there a demand for classifications and how are they put to use?

Observer bias in the stratification, sampling or classification processes can affect repeatability and hence, the potential for prediction, of the results. This study is an attempt to overcome the criticisms and justify expanded use of the Braun-Blanquet approach in vegetation science, by reducing decision-making, and hence observer bias, through method refinement and increased application of computers. Objectivity in the basic processes of stratification, sampling and classification should thereby be increased.

1.1 *AIMS*

The aims of this study are threefold, namely, to:

i. reduce subjective decision-making in the stratification, sampling and classification processes for improved repeatability and predictability;

ii. reduce time spent on the stratification, sampling and classification processes through computer automation, where possible, for greater efficiency; and

iii. increase relevancy and significance of classifications by emphasizing possible classification derivatives.

1.2 *JUSTIFICATION*

Data collection in many scientific fields is a technical operation. That this is not so in the field of vegetation ecology can be attributed to the reliance placed on subjective decision-making. Reduction of subjective decision-making could ensure that the processes, up to and including classification, become technical. Research personnel could thus be freed to verify the adequacy, as well as improve the relevancy and significance of classifications, and increase areas covered. This should also provide greater scope for the employment of technicians.

In comparison with South Africa, with about 24 000 specific and infra-specific plant taxa (Gibbs Russell *et al.* 1985), the flora of Europe is relatively depauperized with about 15 000 to 17 000 specific and infra-specific plant taxa in an area more than eight times the size of South Africa (Polunin 1969). Application of the Braun-Blanquet methods in the depauperized European flora, in which the methods originated, can be relatively simple compared with South Africa, where natural vegetation still covers over 80%

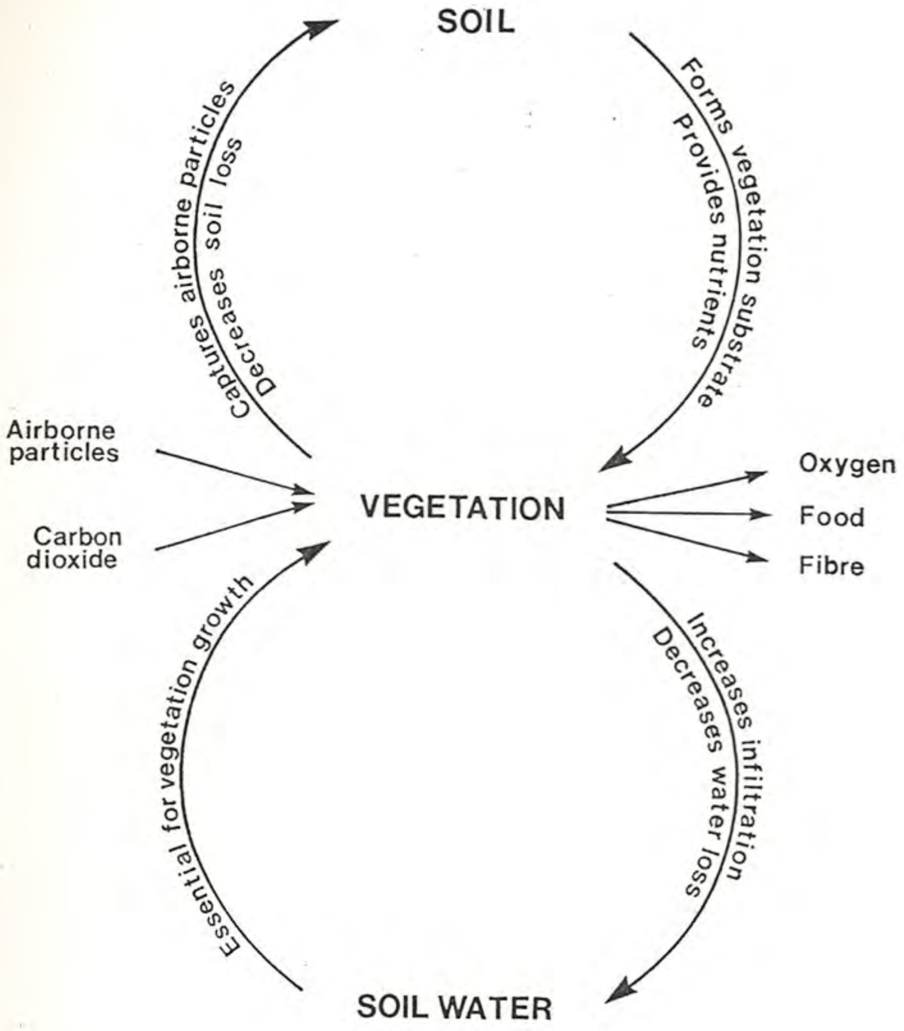

FIGURE 1.1. - A model of vegetation, soil and soil water interactions, illustrating the necessity for vegetation cover for soil and soil water conservation, as well as reducing airborne particles.

of the surface area (Rutherford & Westfall 1986) and consequent need for small-scale work is required. Furthermore, the largest areas of the Savanna, Nama-Karoo and Grassland Biomes occur on the interior plateau (Rutherford & Westfall 1986), with generally weak environmental gradients which can complicate understanding of floristic and environmental relationships, especially at small scales. This environmental and floristic complexity of the vegetation in South Africa, relative to Europe, can complicate subjective decision-making, especially for workers with insufficient experience in Braun-Blanquet methodology.

Why is it necessary to study vegetation at all? Is this a luxury that we cannot afford? Vegetation is essential to life. This resource is primarily responsible for oxygen production and removal of carbon dioxide and pollutants from the atmosphere. It is a primary food and fibre source. Vegetation cover conserves soil without which terrestrial plants would not grow. Vegetation can increase soil water through increased infiltration, decreased runoff and reduced evaporation through shading. Soil water is essential to plant growth and maintenance of the water supply in many streams. These relationships are illustrated in Figure 1.1. It is, furthermore, suggested that with conservation of vegetation, soil and primary water conservation is assured, as can be inferred from Figure 1.1. Therefore, costs can be saved and the total conservation effort could be made more effective by according vegetation conservation the highest priority of the natural resources.

But is classification of vegetation necessary in the study and conservation of vegetation? Not only vegetation studies and conservation efforts, but any form of land use, from policy determination to the execution thereof, must be related to appropriate areas. For example, areas of interest at national level will generally be larger than those of interest for individual farms. This difference in area can be related to scale where national scale is smaller than farm scale. Such areas should also relate to the purpose for which the area is intended. For example, a catchment area should not be based on a magisterial district.

The assumption that a plant community integrates the effects of its physical environment, thereby indicating natural classes for significant environmental continua in a given area is basic to the Braun-Blanquet method (Poore 1956; Mueller-Dombois & Ellenberg 1974; Werger 1974). This assumption has not been disproved. Plant communities can also be related to scale because they form hierarchies where smaller communities can be grouped to form larger plant communities. This implies that the environmental factors, which differentiate plant communities at different scales, are also related to scale. Areas, based on plant communities should, therefore, be suitable for many purposes and at various scales.

Classification of the vegetation of South Africa into appropriate areas or communities can be advantageous for many land use practices, but is essential for vegetation conservation and utilization management. Reducing the number of decisions required for the stratification, sampling and classification processes can not only improve the scientific validity of these processes, but can also facilitate these processes.

1.3 *HYPOTHESES*

i. That adjacent plant communities at a certain scale differ in above-ground phytomass causing variation in the spectral characteristics, of the plant communities. The spectral characteristics are those detectable with a multi-spectral scanner. These differences can be used to objectively delimit plant communities at the given scales.

ii. That the minimum sampling unit area for objective vegetation sampling is a function of scale, and vegetation structure. Vegetation structure, here, refers to plant size and spacing.

iii. That more than one solution is possible in the classification of a vegetation data set.

iv. That "noise" is a quantifiable attribute of a classified data set and is inversely proportional to pattern. "Noise" refers to outliers and the absence of species in a species-group in a classified data set.

1.5 *THESIS ARRANGEMENT*

Page numbering in this work is consecutive according to pages containing text or figures. Published articles are, therefore, renumbered accordingly. Tables and figures are numbered consecutively within each chapter, and are preceded by the chapter number, except in the case of published articles which retain the original numbering. A wide range of literature was consulted, but is not referred to, unless it contributed materially to the thesis. Literature cited in each chapter, including references of published articles included in the chapter, is referenced at the end of each chapter and a full literature list is referenced at the end of this work. Each computer program, relevant to the aims of this study is dealt with separately, but jointly form the PHYTOTAB-PC program package, except where otherwise indicated. Program listings are available by negotiation with the author.

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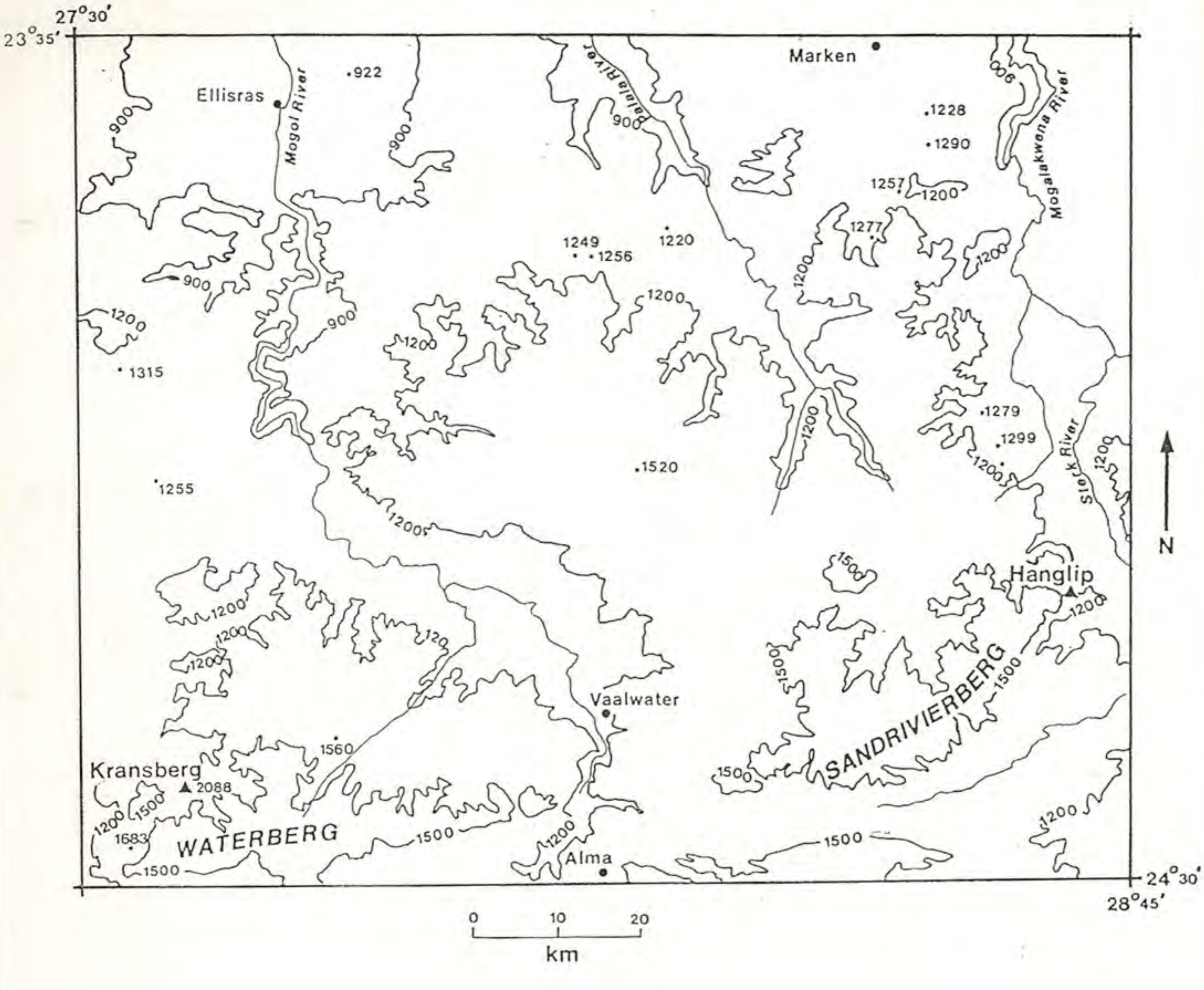
FIGURE 2.1 - The Transvaal Province, Republic of South Africa, showing the location of the main study area, in the north western sector of the province.



<u>Legend</u>
▲ Mountain peak
Contour interval: 300 m

FIGURE 2.2 - The physiography of the main study area in the north western Transvaal, showing the main drainage lines.

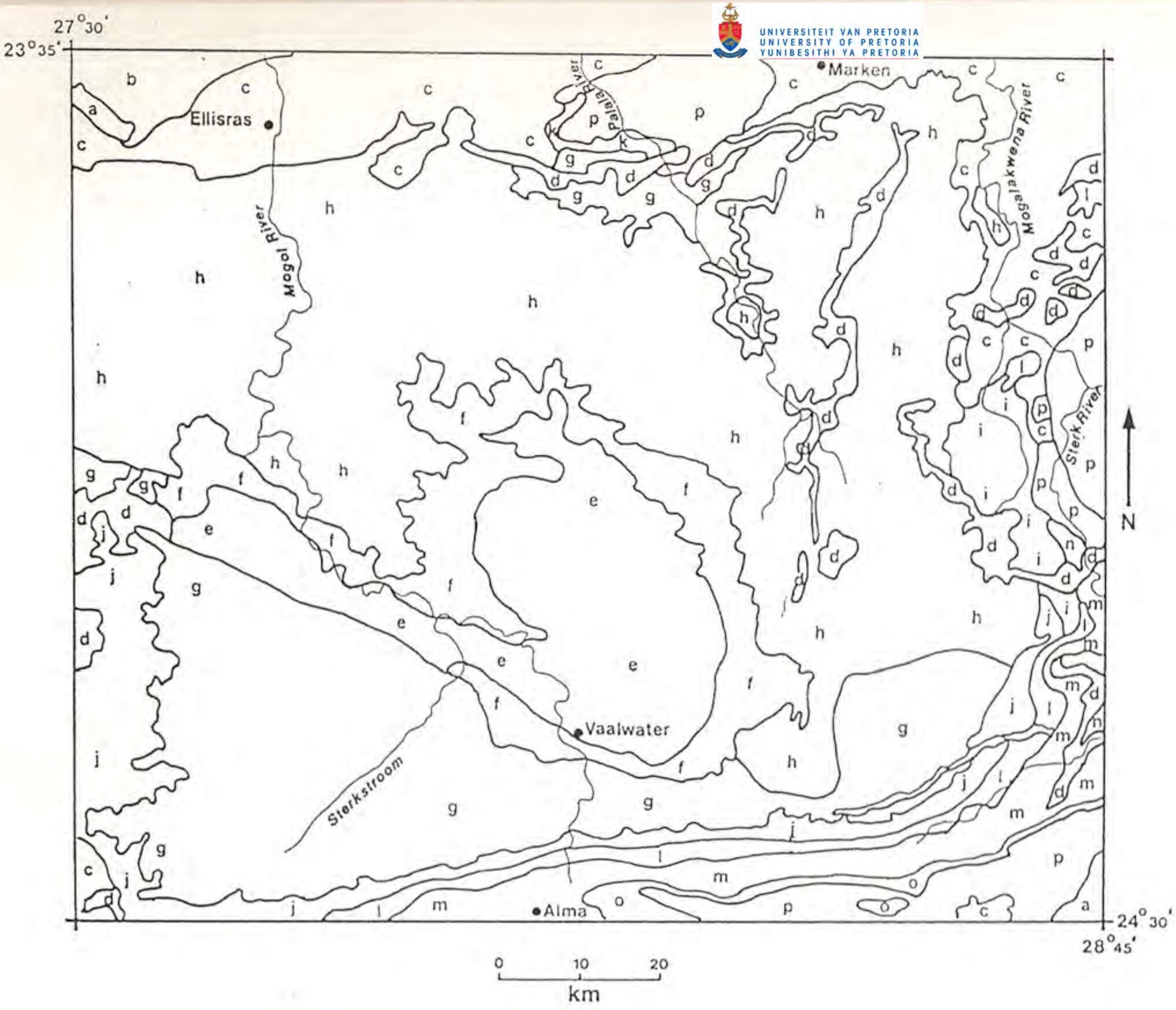
CHAPTER 2. STUDY AREAS

Two separate study areas were selected. The main study area is situated in the north-western Transvaal (Rutherford & Westfall 1984) between southern latitudes 23° 35' and 24° 30' and eastern longitudes 27° 30' and 28° 45' which include the major portion of Sour Bushveld (Acocks 1953, 1975, 1988) of the Transvaal Waterberg, north from Kransberg and Hanglip (Figure 2.1 & 2.2). In contrast to many vegetation studies the area is rectangular in shape which is intended to facilitate later integration of data. The area covers approximately 13 000 km^2 with dimensions of 100 x 130 km. Ellisras is the largest town, situated in the northwest of the study area (Figure 2.1).

The second study area is situated at the CSIR Division of Roads and Transport Technology, Silverton, Pretoria site. The study area comprises two 10 x 10 m plots ten metres apart in a visually homogeneous grassland with no observable variation in physiography, geology, soils, climate or biotic factors.

2.1 *PHYSIOGRAPHY*

The physiography of the main study area is extremely irregular, being mainly mountainous with the Waterberg and Sandriviersberg ranges in the south having altitudes of up to 2 088 m above mean sea level and decreasing in altitude northwards (Figure 2.2). Extensive plains at altitudes between 800 and 1 200 m above mean sea level occur in the far northwest of the study area. The main



LEGEND

	Formation and dominant lithology	
a		Basalt
b	Clarens	Sandstone, siltstone
c		Undifferentiated post-Waterberg
d		Diabase
e	Vaalwater	Sandstone, siltstone, shale
f	Cleremont	Sandstone, grit
h	Mogalakwena	Sandstone, grit
g	Sandriviersberg	Sandstone, grit
i	Makgabeng	Sandstone
j	Aasvoëlkop	Siltstone, mudstone, shale
k	Setlaole	Sandstone, grit
l	Skilpadkop	Sandstone, conglomerate
m	Alma	Sandstone, conglomerate
n	Sterkrivier	Sandstone, conglomerate
o	Swaershoek	Sandstone, conglomerate
p		Undifferentiated pre-Waterberg

FIGURE 2.3. - The geological formations in the main study area showing dominant surface lithology from Jansen (1982).

perennial rivers are the Mogol, Palala and Mogalakwena Rivers which drain northwards into the Limpopo River. Southward incisions by these drainage lines have formed extensive lower-lying floodplains within the mountain area.

2.2 *GEOLOGY*

The geology of the Waterberg area has been described by Jansen (1982). The main geological formations (Figure 2.3) in the east of the study area are the Aasvoëlkop Formation, with mainly siltstone, mudstone, shale and laharite and the Makgabeng Formation, with mainly sandstone. Both these formations are of the Matlabas Subgroup. The main formation in the south, is the Sandriviersberg Formation with mainly grit; in the north and west, the Mogalakwena Formation with mainly sandstone, grit and conglomerate; and in the central part of the study area, the Cleremont Formation with mainly sandstone and grit and the Vaalwater Formation with mainly sandstone, arkose, siltstone and shale. The lastmentioned four formations are of the Kransberg Subgroup. Both the subgroups are of the Waterberg Group and Mokolian Erathem, with ages from approximately 1 700 Ma to 1 300 Ma. The study area has very few known deposits of economic value but coal is mined in the Karoo sediments at the Grootgeluk Mine near Ellisras and iron ore is mined at Thabazimbi, both in close proximity to the study area.

2.3 *SOILS*

One of the most recent soil maps of the Republic of South Africa is the map of MacVicar (1973) where the entire study area is classified as being a Red-Yellow-Grey latosol plinthic catena with neutral sands/loams, yellow-grey dominant and much rocky land. The lack of differentiation of soil units within the study area can be attributed to the scale of 1: 2 500 000 at which this soil classification is mapped. Although the binomial and taxonomic soil classification systems for South Africa (MacVicar *et al.* 1977, 1991) provides for more detailed mapping of soils, the soils within the study area have not as yet been mapped using these systems. However, a comparison of floristic units with soil forms and series at a mapping scale of 1: 30 000, in a pilot project within a small part of the study area, often showed poor correlation (Westfall 1981). This poor correlation can be attributed to the limits set for the units of the soil classification not being necessarily the same as the limits influencing the vegetation. Furthermore, it was found that the recorded soil chemical properties were far less significant in differentiating natural vegetation, at this scale, than soil physical properties, in the area. Consequently, greater emphasis is placed on physical rather than chemical properties of the soil in the main study area.

2.4 *CLIMATE*

According to Köppen's classification (Schulze 1947) the main study area is classified as Cwa which describes a warm temperate climate with summer rainfall and a January mean temperature exceeding 22° C. The climate is continental with more than 85% of the mean annual rainfall falling in summer, from October to March (Schulze

1965). Precipitation is variable with mean annual rainfall varying from 650 to 900 mm in the mountainous areas and below 500 mm on the plains in the north of the study area. Precipitation data was obtained from the Weather Bureau, Private Bag X447, Pretoria, 0001, by request. The four hottest months of the year are November to February (Schulze 1965) which, because of predominantly summer rainfall, is the period when optimum plant growth should occur. The irregular topography of the study area would necessitate a very fine grid of climate stations to allow climatic correlation with vegetation at a scale of 1:250 000. The influence of climate on vegetation differentiation is, however, of prime importance in the study area (Westfall 1981). Because insufficient weather data are available from official and published sources, these data could be determined from farm records, where available and by interpolation and other indirect means.

2.5 *BIOTIC FACTORS*

Observations during the course of fieldwork indicate that in terms of area, veld grazing by cattle is the main land use practice in the main study area but the game on many farms also utilize the natural vegetation. Cultivation is mainly confined to the flatter areas where irrigation is possible, such as the floodplains of the Sterk, Palala and Mogol Rivers. Crops include maize, grain sorghum, tobacco and melons.

Observations also indicate that a dramatic human population increase is taking place at Ellisras with its newly developed

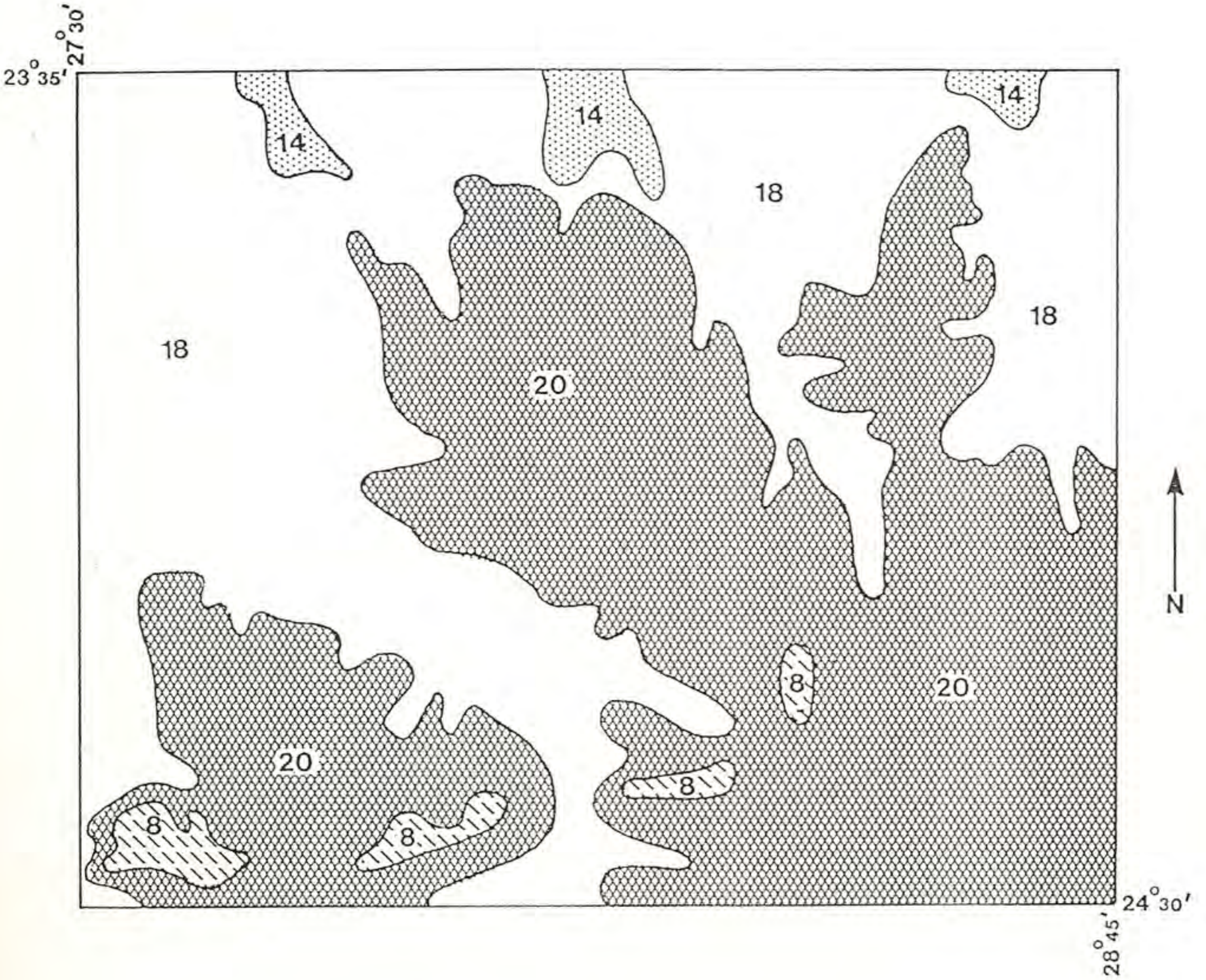


FIGURE 2.4. - The Veld Types (Acocks, 1953, 1975, 1988) of the main study area in the north-western Transvaal. 8, North-Eastern Mountain Sourveld; 14, Arid Sweet Bushveld; 18, Mixed Bushveld; 20, Sour-Bushveld.

coalfields and the construction of the Matimba power station. The relatively unspoilt, scenic grandeur of the Waterberg with the Kransberg massif considered to be amongst the best rock-climbing facilities in the Transvaal, according to members of both the Transvaal and Northern Transvaal Mountain Clubs; the many game and private nature reserves; the new Kransberg National Park and the proximity of the Waterberg to the Pretoria-Witwatersrand complex can combine to lure increasing numbers of visitors and increase development and human exploitation of the environment. Although the study area could be considered underutilized in terms of agricultural production, its potential could be drastically reduced by the effects of a large human population increase.

The following Veld Types (Acocks 1953, 1975, 1988) are represented in the study area and the percentage of the study area covered, is indicated in brackets: Sour Bushveld (53%); Mixed Bushveld (43%); Arid Sweet Bushveld (2%); and North-Eastern Mountain Sourveld (2%) (Figure 2.4). The Sour Bushveld is found in the mountainous areas with Mixed Bushveld on the plains adjacent to the mountains and on the floodplains. Arid Sweet Bushveld is limited to the floodplains of the Mogol, Palala and Sterk Rivers in the north. Outliers of North-Eastern Mountain Sourveld are found only above 1 500 m altitude.

2.6 *PREVIOUS RESEARCH*

Early scientific interest in the vegetation of South Africa emphasized showy plants and plants of nutritional and medicinal value

(Werger 1978). Interest in the geographic distribution of plants, in South Africa and world-wide, developed during the nineteenth century because of the descriptions of travellers such as Lichtenstein (1811, 1812) and Burchell (1822, 1824). In subsequent descriptive phytogeographic divisions of southern Africa, based mainly on observations and experience, the Transvaal Waterberg was placed in the: Regnum Mesembryanthemorum (Schouw 1823); Kalahari Region (Grisebach 1872); Highveld Region (Rehmann 1880); Palaeotropic Dry Region (Engler 1882); Kalahari Region (Bolus 1886); and the Highveld Region (Marloth 1908).

During the first two decades of the twentieth century, botanists such as Schönland, Marloth, Phillips, Burtt-Davy and Bews published checklists of plant species and ecological notes for various areas in South Africa (Schönland 1922). Bews, who worked mainly in Natal also studied the succession of plants in South Africa (Bews 1916) and describes the grasslands of South Africa (Bews 1918), where the Transvaal formed part of the Eastern Grassland Region. Guidelines for future surveys, including codes for habitat factors and plant physiognomy, were suggested and checklists and plant succession were emphasized. The works of Bews (1916) and Clements (1916) on plant succession greatly influenced vegetation surveys in South Africa for the next four decades.

During this time the Transvaal Waterberg was described as being part of the: Kalahari Park and Bush Province (Pole Evans 1922); Evergreen and Deciduous Tree and Bush variation of Parkland (Pole Evans 1936) and Small Tree Savanna variation of the Bush Veld

Savanna (Adamson 1938). More recent, small-scale work, describing the vegetation of southern Africa includes that of: Eyre (1963), Meester (1965), Werger (1978), and White (1981). Although the descriptions of these vegetation types indicate a lack of conformity, the major vegetation units of Adamson (1938) correspond most closely with the Biomes of southern Africa (Rutherford & Westfall 1986) where the Waterberg area forms part of the Savanna Biome.

More detailed vegetation studies, with the purpose of improving agriculture subsequently played a greater role. Irvine (1941) classified the vegetation of the northern Transvaal into veld types, based on grazing potential and Acocks (1953, 1975, 1988) relied largely on these data for his classification of veld types, in this area. The vegetation of the Kransberg block in the south west of the study area was described by Coetzee *et al.* (1981) without formal sampling and Westfall (1981) studied the farm Groothoek, also in the south west of the study area, at a detailed scale, using the phytosociological approach.

Although Acocks (1953, 1975, 1988) *inter alia*, adopted a floristic sampling approach it was only with Werger (1973) and subsequent workers that the formal Braun-Blanquet methods of floristic sampling and classification were introduced to South Africa.

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