A BIORESOURCE CLASSIFICATION

FOR

KWAZULU-NATAL,

SOUTH AFRICA

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ABSTRACT

The classification of Bioresource Units (BRUs) was developed to provide a reconnaissance appraisal of the natural resources for both environmental impact assessments and the agricultural potential of KwaZulu-Natal. Storage of the Bioresource Programme in a geographical information system (GIS) facilitates usage.

Of the criteria used for the classification of BRUs, climate (rainfall and temperature in particular), was considered to be the most important factor. Other factors used were the soil association codes of the Land Types, plant indicator species and communities, and terrain type. The base map used for the study was the 1 : 50 000 topo-cadastral map on which the Land Types (LTs) were demarcated.

The result of the study was the mapping of 590 BRUs, each of which is sufficiently homogeneous in environmental factors (climate, soil association, vegetation type and terrain form), such that uniform land use practices, production techniques and levels, can be defined with a reasonable degree of accuracy. Ecotopes, based on LT information, were defined for each BRU. An ecotope is a class of land, defined according to soil characteristics, within which agricultural production will be uniform and will differ significantly between one ecotope and another. The ecotopes, both for cropping and veld, are not spatially defined, but expressed as percentages of the total area of the BRU. In the BRU inventory, crops suitable for the BRU and each ecotope, and the level of production (tons/ha/annum) in the case of crop ecotopes, are supplied at a stated level of management. In addition, it is possible to investigate the potential for 29 crops for which crop production models exist, and for any other crop providing its growth and site requirements, particularly climate and soil, are known. Additional crop production models will be developed, as the demand for this type of information is high. Veld management norms, such as grazing capacity, are supplied for the veld ecotopes.

On the completion of the classification of BRUs the decision was made to develop a third level of classification and the Bioresource Groups (BRGs) were mapped. In the classification of the BRUs 23 vegetation types had been identified and used as one of the criteria for BRU demarcation. By grouping all the BRUs with the same vegetation type, BRGs were defined. Each BRG, therefore, consists of a specific vegetation type containing one or more BRUs of the same vegetation type. The 23 BRGs are used mainly for regional and veld management planning.

The programme was designed for use by a wide range of people with individual skills and knowledge, and contains most of the information needed for land use planning. It is essential however, to be able to identify ecotopes in the field to effectively use the information at a detailed level for farm planning.

DECLARATION OF ORIGINALITY

I, Kelson Gerald Temple Camp, hereby declare that the research reported in this thesis is the result of my own investigations except where acknowledged, and has not, in its entirety or in part, been previously submitted to any University or Institution for degree purposes.

K G T CAMP

I, J R. King, chairperson of the Supervisory Committee, approve release of this thesis for examination.

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INTRODUCTION

In a report entitled "Report on the Agro-Ecological Zones Project - Vol 1 - Methodology and results for Africa" (FAO, 1978), the statement is made that, "to sustain the likely world population in the year 2 000, an increase of 60 percent in agricultural production will be required." When questioning the attainability of such a target, investigations by the FAO on the African continent south of the Sahara indicated that the maize potential for this area was 225 times greater than its then present production. This result was obtained by matching crop requirements to edaphic and climatic conditions, using the information then available. The great problem of the continuing degradation of the natural resources would also have to be faced, however, and it was apparent that countries would have to meet the challenge of achieving sustainable food production in the future. This can be done only by recognising the limits of the natural resources and matching the requirements of farm enterprises to these natural resources. With all forms of land use it is necessary to recognise the sensitivity of the natural resources and to plan development in order to avoid degradation.

It is, however, not only agriculture that has an impact on the natural resources, and Agenbach (1974) warned that land in the Republic of South Africa had become a scarce commodity. Continued uncontrolled development will result in yet more agricultural land being taken for non-agricultural purposes. Environmental impact assessments are therefore being called for in, for example, industrial, urban and infra-structural development projects. In these instances it is necessary to be aware of the many different ecosystems and to identify the most important and ecologically sensitive areas.

In KwaZulu-Natal (KZN) the importance of the correct use of the natural resources to the overall economy of the Province cannot be over-emphasised. The degradation of the natural resources is a matter of grave concern and both increased demands for, and the economic pressures placed on, agriculture, indicate the urgent necessity to match crop and animal requirements with the production potential of the natural resources in order to protect land of high agricultural potential.

To achieve the necessary sound matching of agricultural production and other forms of land use with the natural resources, an inventory of the resources is necessary. One means of achieving this is by mapping the natural resources into ecological zones of reasonable homogeneity which could then be used to give an indication of the suitability of certain areas for growing specified crops and the levels of production that could be achieved, and a suitability for other forms of land use. With this need in mind, a joint meeting of two subcommittees of the Southern African Regional Commission for the Conservation and Utilisation of the Soil (SARCCUS), namely the subcommittee for Agrometeorology and Climatology and the subcommittee for Land-use Planning and Erosion Control, was held in Pretoria during July, 1979. All other committees of the body, notably the Standing Committee for Plant Production and the committees for Agrometeorology and for Veld and Pastures, were invited to participate in the identification of predictive growth parameters for major crops and the methodology for attaining norms. Meetings and workshops were held by the committees until finally, in April 1986, A B Bridgens, the Secretary-General of SARCCUS, presented an interim report on what had by then come to be known as the "SARCCUS Agro-ecological Zones Project".

The Republic of South Africa (RSA) consisted of seven different Regions under the control of the Department of Agriculture, of which Natal, later to become KwaZulu-Natal, was one. Because of the wide ecological diversity found in the Regions, each Region was given the responsibility for developing a methodology for defining agro-ecological zones (AEZs).

The diversity of natural resources in KZN is enormous, leading to wide variations in the type of farming and levels of agricultural production throughout the Province, so that to provide sound, ecologically-based development planning in agriculture, and other fields, is a major challenge. The work reported in this thesis was initiated in November, 1988, and reflects the endeavour to classify KZN into (AEZs).

In the classification of AEZs, the primary aim was to develop a natural resource mapping and land use appraisal system. Three levels were identified with the Bioresource Unit (BRU) being the primary unit.

The BRU is an area within which the environmental factors such as climate (rainfall, temperature and evaporation), soil type, vegetation and terrain type have a degree of homogeneity such that land use practices, farming enterprises, agricultural production and production techniques can be clearly defined. A total number of 590 BRUs were defined. There is, however, a wide range of soils within a BRU and site specific production can vary considerably. As a result ecotopes, to be found within a BRU, were identified.

An ecotope is a class of land defined in terms of soil (form, texture and depth) and soil surface characteristics (rockiness). The narrow range of soil variation results in uniformity in terms of the potential yield of each farming enterprise. A significant difference will be found in the natural resources of one ecotope and another, and there will be no significant advantage in further subdivision. Both crop and veld ecotopes were defined.

At this stage of classification it became apparent that the very large data base of the BRUs and ecotopes, while being invaluable for farm and site planning, required manipulation by a Geographic Information System for interpretation of land use over wider areas, or the Province as a whole. In the classification of the BRUs, vegetation types were used as one of the criteria for demarcation. By grouping all BRUs with the same vegetation type, a broader classification, known as Bioresource Groups (BRGs), was developed.

A BRG is a specific vegetation type controlled by an interplay of biotic factors such as soil and altitude and is formed by one BRU, or the grouping of BRUs, each of the same vegetation type. There are 23 BRGs in KZN. The BRG is a convenient unit for general planning and all veld management norms have been based on the BRGs.

The description of the classification process will follow the order of BRU, ecotopes and finally the BRG.

CHAPTER 1

A LITERATURE REVIEW OF AGRO-ECOLOGICAL STUDIES BOTH OUTSIDE AND INSIDE SOUTH AFRICA

Many agro-ecological studies have been carried out in various parts of the world as well as in southern Africa. Some of these studies, or surveys, are discussed in this section with reference being made to the role they played in the classification of the BRUs.

1.1 Agro-ecological studies outside the RSA

1.1.1 Rangeland Management and Ecology in East Africa (Pratt & Gwynne, 1977)

In a study of range classification in East Africa, Pratt & Gwynne (1977) stated that land can be classified in several ways depending on the nature of the land and the needs of development, and that when the East African Range Classification Committee was established in 1966, no standard approach had been developed. They mention that the trend had been towards definitions of range types based on grassland composition, but that a classification based on a few of the constituent grass species gave an incomplete idea of its character. The primary need in East Africa was for a system to assist in resource mapping and development planning which could give an indication of the ecological potential of the land and a description of the present vegetation. It was stressed that it was important to separate the description of land potential from the description of the present vegetation. Pratt & Gwynne (1977) stated that the former is relatively permanent, but may have to be inferred, while the present vegetation, which can be observed directly, may be changeable, such as when bush encroachment occurs through mismanagement.

Moisture availability was seen as the most potent environmental factor in East Africa and six eco-climatic zones were defined by moisture indices. These moisture indices were derived from monthly rainfall and evaporation data with the estimate of evaporation being based on measures of radiation, temperature, saturation deficit and wind speed. These were then weighted for altitude and latitude. The zone boundaries were mapped by ecological survey, using plant species and associations as indicators of climate. The six eco-climatic zones were also described in terms of their climax vegetation and land-use.

Two important features of this East African study were the use of climate as a dominant parameter in classifying agro-ecological zones and the warning that present vegetation, which can be changed, can be misleading. This stresses the importance of using climate and soils as the primary factors in recognising ecological zones. Soils classified according to a vertical sequence of diagnostic horizons remain unchanged except in the case of severe erosion. Vegetation does, however, play an important supporting role.

1.1.2 AEZ Workshop in Asia (FAO, 1991).

This workshop was sponsored by the Food and Agriculture Organisation (FAO) of the United Nations to bring together the different agencies in Asia which had been involved in the mapping of AEZs, with a view to discussing their various experiences and to familiarise themselves with the potentially major role which AEZ methods could play in planning environmentally sustainable development.

It was pointed out that neither general nor unique solutions had been developed that could handle all possible combinations of environment, social preference and production technology, and that national and sub-national adaptions and validation are essential ingredients of AEZ planning and implementation. It was stated that although Asia was probably the most AEZ-literate region in the world, a large variation in the range of expertise exists and it had become essential for communication between AEZ developers and users to be improved. In general these proceedings deal with the use of terminology and the comparison of results of AEZ classification by the participating nations.

1.1.3 Agro-ecological zoning - guidelines (FAO, 1996)

These guidelines express concern about the world's natural resources' ability to meet the needs of the growing population while essential resources are declining in both quantity and quality due to competition from industrial and urban demands.

The original AEZ project of the FAO was a land evaluation excercise at a continental scale and land was characterised by quantified information on climate, soils and other physical factors used to predict potential productivity for certain crops according to their specific environmental and management needs. Later the FAO developed a methodology based on the use of computers in a geographic information system. This involved a combination of layers of spatial information to define the AEZs, providing a framework for the appraisal and planning of natural resources. It is stressed that computers are not essential to an AEZ study and that many successful applications exist where convential cartography was used.

The scale used in the FAO method varied according to the planning level. For national and sub-national purposes a scale of 1 : 2 000 000 was used for AEZs and 1 : 1 000 000 for agricultural development planning. A scale of 1 : 50 000 was used for decentralised district agricultural development planning and the largest scale used was 1 : 10 000 for support to farm planning and development in village communities.

Examples of what the FAO term "advanced applications" include:

- potential land productivity;
- estimation of arable areas;
- population supporting capacity;
- land use planning;
- land degradation risk management;
- livestock forage balance assessment;
- land management;
- agro-ecological characterisation for research planning;
- agricultural technology transfer;

agricultural inputs recommendations;
farming systems analysis and development;
environmental impact assessment;
monitoring land resources development; and
assessment of impact of climatic change.

The FAO defined an AEZ as a land resource mapping unit, defined in terms of climate, landform, soils, and land cover, as well as having a specific range of potentials and constraints for land use. The essential elements used in defining an AEZ are the growing period, temperature regime and soil mapping unit.

The growing period provides a way of including seasonality in land resource appraisal. Thermal regime is used and refers to the amount of heat available for plant growth during the growing period and is usually defined by the average daily temperature during the growing period.

The soil mapping unit was taken from small-scale soil maps on which the mapping units rarely comprised single soils, but rather consisted of a dominant soil with minor associated soils.

1.1.4 Interim Report on the Southern African Regional Commission for the Conservation and Utilisation of the Soil (SARCCUS) Agro-ecological Zones Project (Scotney, 1987)

In this study, which was carried out partially in the RSA, the Subcommittee for Land-use Planning and Erosion Control (LUPEC) of SARCCUS defined an AEZ as:

"a discrete area of land, delineated preferably at a scale of 1:250 000, in which the environmental conditions (such as soil, slopes, landforms and climate) are sufficiently similar to permit uniform recommendations of land-use and farm management practices to be made, to provide a framework in which an adaptive agricultural research program can be carried out, and to enable land-use planners to make correct decisions."

Scotney (1987) reported that consensus had been reached on the most important criteria to use in the mapping of agro-ecological zones in southern Africa and these were summarised as follows:

Climate

Rainfall:	Including mean and median rainfall, length of growing period, pentades and decades analysis, mean monthly rainfall, probability of 80% rainfall and intensity and erosivity of rainfall
Temperature:	Monthly means of daily maximum and minimum, mean first and last dates of frost and heat units
Other:	A-pan evaporation, frequency and intensity of hail, radiation and hours of sunshine, speed and direction of wind.

Soils — A soil association map was essential which would show:

dominant soil types, average profile texture, average effective depths, specific profile morphology, especially plinthite, E-horizons and gleyed horizons (MacVicar *et al.*, 1977).

Vegetation — As a product of the environment, vegetation was not an obligatory criterion, but was considered an important feature of indicator significance.

As in the East African study, climate and soils played the dominant role in classification, with vegetation playing a supporting role.

1.2 Agro-ecological studies within South Africa

Agro-ecological zones, described as Reasonably Homogeneous Farming Areas (RHFAs), have been defined in various areas of South Africa. A study of these produced nothing substantial in the way of development for the BRUs and will therefore not be discussed.

1.3 Agro-ecological studies in KwaZulu-Natal

Many ecological and agro-ecological studies have been undertaken in KwaZulu-Natal including those of Bews & Aitken (1923), Pentz (1945), West (1951), Scott (1952), Acocks (1953), Killick (1958), Edwards (1967), Moll (1971) and Phillips (1973). Despite these studies, a clear process of defining detailed and critical parameters for identifying broad ecological units has yet to be developed. Gross parameters, which can be more finely defined with increasing knowledge, were therefore used to demarcate units in the Bioresource Programme. As Phillips (1973) stated, ".....it is more helpful to the cause of scientific development to be reasonably venturesome than to shelter unimaginatively behind imperfection in our knowledge." He therefore recommended that gross parameters regarding climate, soil, physiography and vegetation, i.e., indicators of the ecosystems, be used for the demarcation of units of land systems.

1.3.1 An Agro-ecological Survey of Natal (Pentz, 1945)

The prime concern of Pentz was the problem of soil and veld deterioration and soil erosion in South Africa. He identified several causes for this situation including the application of incorrect farming systems and stated that "the development of systems of farming for the production of various commodities in areas potentially suited to their continued production, demands what may be termed regional planning in agriculture. This can be done only on the basis of what is known as an agro-ecological survey of each area." To achieve this a knowledge of vegetation, soil, and climatic conditions (including rainfall distribution, summer and winter temperatures, altitude and topography) was essential. This knowledge had to be related to the requirements for different types of stock, crops, pastures and timber. His methodology differed from that later used by Scotney (1970) and Pratt & Gwynne (1977) in that he started with the classification of farming regions.

Farming regions were classified into three main categories, viz., extensive, semi-intensive and intensive, but some crops could grow in any of the zones under artificial conditions such as irrigation. He classified natural environmental conditions as climate, vegetation, soils and topography.

These were sub-divided as follows:

Climate:	high rainfall, variable rainfall and low rainfall.
Vegetation:	bush, forest, grassland, and karoo.
Soils:	arable and non-arable.
Topography:	open, rolling, and broken

Pentz then classified farming enterprises which were suitable for the farming regions and environmental conditions as indicated in Table 1.1.

Table 1.1 : The classification of farming enterprises according to farming regions and environmental conditions (Pentz, 1945).

Farming regions	Climate, vegetation, soils, topography	Farming enterprises
Intensive:	high rainfall	beef breeding
	bush, forest, grassland	dairy
	arable	fat lamb
	open and rolling	timber
		fodder crops (no irrigation)
		cash crops (no irrigation)
Semi-intensive	variable rainfall	fattening steers
	bush, forest, grassland	dairy
	arable	fodder crops (irrigation)
	open, rolling, broken	cash crops (irrigation)
Extensive	low rainfall	beef ranching
	bush, forest, grassland, karoo	beef breeding
	non-arable	fodder crops (irrigation)
	open, rolling, broken	cash crops (irrigation)

Pentz divided the vegetation regions (bush, forest, grassland, karoo) into vegetation types and these in turn, into veld types. Those of relevance to KZN are given in Table 1.2.

Table 1.2 : Vegetation regions, vegetation types and veld types (Pentz, 1945)

Vegetation regions	Vegetation types	Veld types
Bush and forest	high forest	subtropical forest
	bush	temperate forest
	bushveld	littoral bush
		scrub bush
Grassland	high rainfall grassland	highland sourveld
	low rainfall grassland	tall grassveld
		sour sandveld

To map the agro-ecological zones, Pentz divided the Province into eight vegetation types within the three farming regions, providing altitude and rainfall ranges for each vegetation type (Table 1.3).

Table 1.3 : Agro-ecological zones within farming regions and their altitude and rainfall ranges (Pentz, 1945)

Farming region	Altitude range	Rainfall range
Intensive		
Coastal Evergreen Bush	30 - 457 m	no figures provided
Highland Sourveld	1 372 - 1 830 m	875 - 1 250 mm
Temperate Forest (Ngongoni)	914 - 1 219 m	750 - 1 125 mm
Temperate Forest - (broken Ngongoni)	No figures provided	no figures provided
Semi-intensive		
Tall Grass Veld	1 067 - 1 372 m	750 mm average
Open Bush Sandy Country	610 - 914 m	500 - 750 mm
Extensive		
Dry Thorn or Bush Veld	< 914 m	low and erratic
Sandy Sourveld	914 - 1 219 m	625 - 875 mm

A marked similarity occurs between the parameters of the farming regions, or ecological zones, of Pentz (1945), the veld types of Acocks (1953) and the Bioclimatic Groups of Phillips (1973).

1.3.2 Veld Types of South Africa (Acocks, 1953)

Acocks' "Veld Types of South Africa" has proved to be the most important work dealing with the vegetation of this country and had a major influence when determining parameters for the BRUs. Of particular value has been the veld type descriptions and species composition, and the physiographic regions he defined. A problem experienced when using his maps for reference work in the field was that the vegetation boundaries had been drawn on a 1 : 1 500 000 scale map and were difficult to place with accuracy in the field.

1.3.3 A Plant Ecology Survey of the Tugela River Basin (Edwards, 1967)

Edwards' "Plant Ecology of the Tugela Basin" provides a detailed description of the vegetation communities of the Tugela Basin and provided a particularly accurate map. The ecological zones are clearly defined and reference to land use and current conservation status provided an excellent insight into procedures to follow when defining AEZs. Plant indicator species are defined for the different vegetation types and these species greatly assist in identifying the types. The fact that the Tugela Basin originates at the top of the Drakensberg and ends at the sea, means that a good cross-section of the conditions in KZN is covered. This study provides an excellent basis for further studies of ecological units in the Province.

1.3.4 The Agricultural and Related Development of the Tugela Basin and its Influent Surrounds (Phillips, 1973)

The "Bioclimatic Groups of Natal", which were developed by Phillips as part of this study of the Tugela Basin, have been the basis of the majority of resource-based work by most organisations in KwaZulu-Natal. Phillips described his major drawback as a lack of reliable soil and climatic information and stated that his work would require updating when this information became available. Criticism of the Bioclimatic Groups (BCGs) really reflected a superficial understanding and use of them. A good example can be seen in BCG 3, which has generally been used in its entirety and not taking sub-groups into account. BCG 3a is a cool, misty area, highly suitable for timber production, but marginal for maize because of a lack of heat units. BCG 3b is suitable for timber and reasonably good for maize. BCG 3c is marginal for timber, but has a high potential for maize, whereas BCG 3d is not at all suitable for timber and is marginal for maize because of the low rainfall.

The Bioclimatic Groups have proved invaluable in land use planning except for the limitations stated by Phillips, these being the limited information on soil and to a lesser degree, climate. The availability of land type information provided the opportunity of overcoming these limitations.

1.3.5 Vegetation Studies in the Three Rivers Region, Natal (Moll, 1971)

In this study Moll deals with the catchment areas of the rivers lying between the Thukela (Tugela) River in the north and the Mkhomazi (Umkomaas) River in the south, the catchments of these two rivers being excluded. This plant ecology study and the accompanying map provided a useful source of information when developing the BRUs, particularly in the selection of plant indicator species and in testing the boundaries of the proposed BRUs.

1.3.6 Summary of the KwaZulu-Natal studies, 1945 to 1971

The studies of Acocks (1953), Edwards (1967) and Moll (1971) were all plant ecology surveys and, as such, provide insufficient localised information on soils and climate. However, the vegetation types do occupy single bioclimatic areas, and as Moll (1971) pointed out, "It is also considered that similar vegetation types have similar agro-economic potential and that vegetation is a key factor to be considered in planning for the future". This was recognised in the classification of the BRUs and vegetation type boundaries and transitional areas defined by these authors were referred to when establishing BRU boundaries.

Both Pentz (1945) and Phillips (1973) defined agro-ecological zones for the Province. These proved to be important reference works, but both lacked the in-depth soil, climate and agriculturally based information necessary for the role envisaged for the BRUs.

1.3.7 Land Types (LTs), (Land type survey staff, 1986)

The land types (Land type survey staff, 1986) were considered for use as AEZs, but were found to be more useful as a source of information on soil. Two factors eliminated the use of LTs as AEZs. The number of LTs in the Province was prohibitive; north of 29° latitude alone there are in excess of 855 LTs, many of which have two or more spatial occurrences. In addition, the changes in the natural resources from one LT to another were, in many cases, not sufficiently different to effect a change in production, that is, crop production or grazing capacity, and would not effect a change in management. From a practical point of view the large number of units would be unwieldy, but could be grouped into units of similar ecological significance and agricultural productivity. This in effect was done to create BRUs. In the LTs the primary delineation was soils, and climate was a secondary value. In the delineation of the BRUs, it was necessary to have an assessment that was primarily climate based for the BRUs and the differences of terrain between the LTs were accepted if the influence of climate on productivity was not significant. The technique used to define the climate of the BRUs was considered to be an improvement and so climate was assessed specifically for the programme.

Vegetation was not generally used for the delineation of the LTs and, in many places, appreciable differences were noted in the vegetation within LTs. It was important to recognise where these changes had occurred as a result of management, but where a change in species composition indicated a change in climatic conditions within these LTs, they were then split into two or more units.

1.4 Aims of the Bioresource Unit (BRU) Classification Programme

The primary aim of the BRU classification programme is to provide a reconnaissance appraisal of the natural resources and the agricultural potential of the Province. This can then be used to facilitate planning and development of the natural resources at Provincial level, estimating production potential at district level and for extracting detailed information at project level.

The issue of sustainable land use is recognised in the Province of KwaZulu-Natal and the mission statement of the Department of Agriculture is "*To foster an improvement in the quality of life and promote the development of a progressive and prosperous agricultural community by promoting the implementation of appropriate, economically viable and environmentally responsible production systems*" (Anon., 1996). The objectives include the:

1 compilation, documentation and storage, in easily accessible form, of relevant agricultural, veterinary and resource information;
2 promotion of conservation and improvement of natural resources;
3 optimum utilisation of farms and land holdings;

4 identification of new production and marketing opportunities for farmers and rural based agri-business;

5 development of new, relevant, agricultural technology and farming systems applicable to the various target groups; and

6 provision of efficient professional and technical services to the farming community which will ensure that all advice given is environmentally and economically sound and technically correct.

In the classification of the BRUs several objectives were set, viz to:

1 map the natural resources of the Province of KwaZulu-Natal into agro-ecological zones of reasonable homogeneity;

2 compile, document and store in easily accessible form relevant agricultural and resource information;

3 match crop and animal requirements to the edaphic and climatic conditions within the agro-ecological zones;

4 identify areas within the Province of particular sensitivity to over-exploitation;

5 identify areas of high agricultural potential in order to justify the retention of such areas as agricultural land; and

6 assist in the sound land use planning of the natural resources.

Several points can be made with reference to the literature study that had important effects on the classification of the BRUs.

1 In the East African study, Pratt & Gwynne (1977) stated that in classifying AEZs climate should be used as a dominant parameter and that the present vegetation can be misleading. The guidance of climate was considered to be very important in the classification of BRUs, and although vegetation was used, care was taken to recognise its significance, particularly if in a secondary stage of succession.

2 In the agro-ecological zoning guidelines (FAO, 1996), it is stated that the latest methodology in defining AEZs involves the combination of layers of spatial information in a geographical information system(GIS), but it is stressed that computers are not essential to an AEZ study and that successful applications exist where conventional cartography was used. In the classification of the BRUs the latter method was used and a GIS was later used to process the products of the BRUs.

3 In the SARCCUS report (Scotney, 1987) the criteria considered as important for the classification of AEZs are listed. All of these were used in a basic form for the BRU classification.

4 Pentz (1945) went straight to the point of defining farming areas using broad climate, soil, vegetation and topographical criteria. In defining the criteria to be used for the classification of BRUs, growth requirements for commonly grown crops such as maize were used. The ecological units (BRUs) defined had all the necessary criteria such as rainfall, temperature and soil forms to be assessed for farming regions or enterprises.

5 Acocks (1953) and Phillips (1973) both proved useful for defining altitude ranges for physiographic zones and in turn for defining broad temperature zones. These two authors and Edwards (1967) and Moll (1971) were invaluable for assessing possible BRUs and plant indicator species of the units.

6 The Land Types main role was in providing the essential soil information, both as a guide to the boundaries of BRUs, and for the inventories of the BRUs.

CHAPTER 2
DESCRIPTION OF THE PROVINCE OF KWAZULU-NATAL

Introduction

KwaZulu-Natal (KZN), a province of the Republic of South Africa (RSA), is situated in the eastern zone of the Republic of South Africa (Fig. 2.1), and lies between approximately 27° and 31° south, and 29° and 31° east. The Province stretches from the Indian Ocean in the east, to the Drakensberg Mountains in the west, where Lesotho is the neighbouring country. Mpumalanga Province, Swaziland and Mozambique form the border in the north and the Eastern Province lies on the southern border. A portion of Eastern Province, 269 900 ha in extent, is enclosed within KZN in the south. The Province is approximately 300 km long and 300 km wide, has an area of 8 860 683 ha and constitutes approximately 7% of the area of the RSA (Anon., 1972). It has a population of 8.5 million people (21% of South Africa's population) (Erasmus, 1994).

2.1 Topography

KwaZulu-Natal has a rugged topography. It rises steeply from the coast to a hinterland at altitudes of 600 m to 900 m ASL with a more gradual incline to the western part of the Province with altitudes of 1 200 m to 1 500 m. The border along the Drakensberg Mountains is very steep, rising to an altitude of over 3 000 m above sea level.

The major rivers flow across a generally eastern-sloping terrain and, in so doing, cut through the several geological strata which are aligned approximately north/south. Deeply incised valleys and basinlands have been formed and with the steep watersheds between the rivers, the construction of roads and railway lines from north to south across the Province has been expensive and difficult.

The great variation in topography has had a profound effect on the agricultural potential and development of KZN. The wide variations in slope, soil, altitude and aspect have resulted in great ecological diversity. Large contiguous areas suitable for crop production are found only on the north-eastern coastal plain and to a certain extent on the interior basin in north-west KZN. Most of the cultivation in the Province is found in limited areas characterised by moderate slopes and soils of suitable depth and drainage.

Fig.2.2 represents a cross-section through the Province from Durban to the Drakensberg and displays some of the topographical features of KZN.

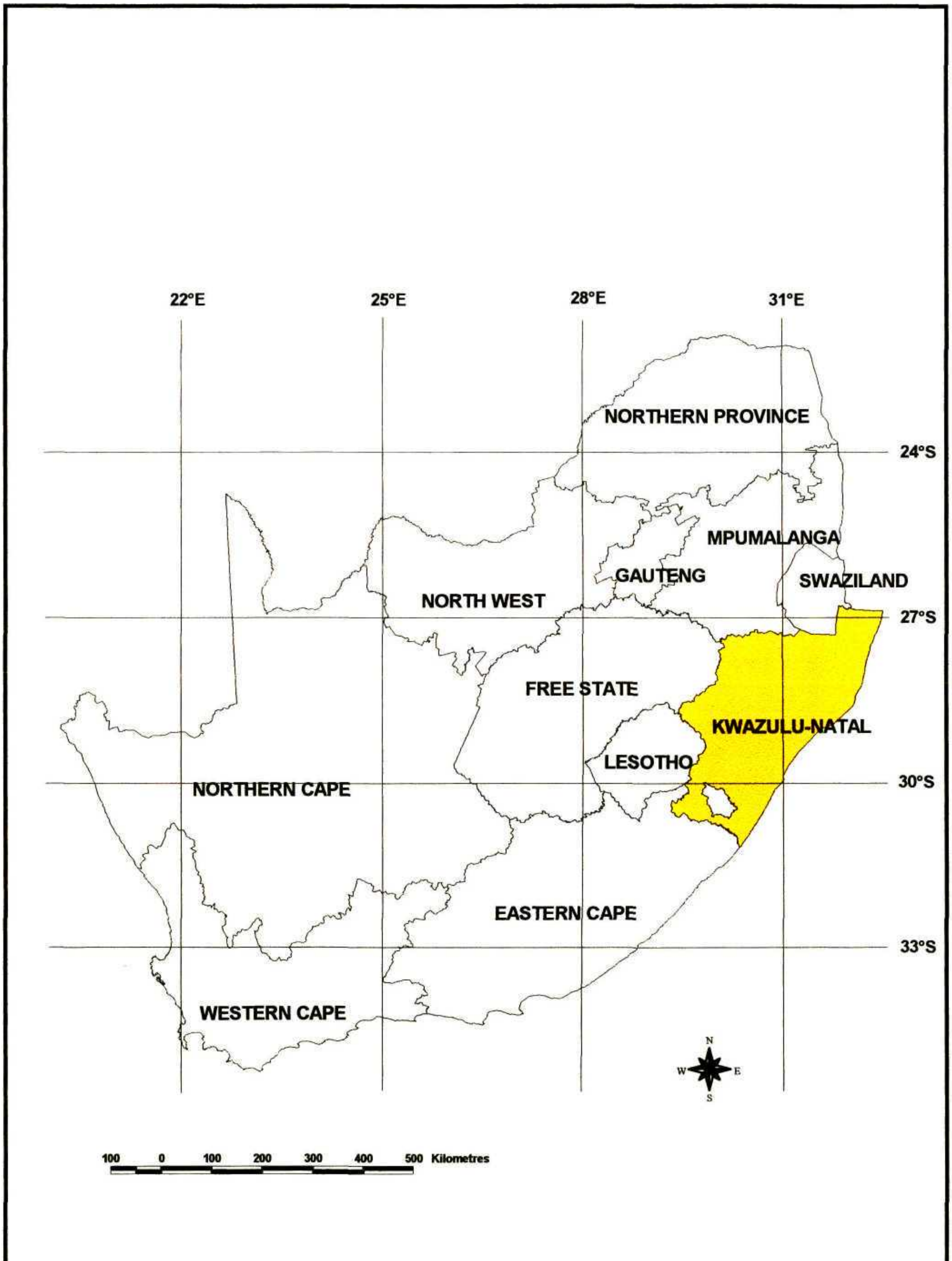

Figure 2.1 : Location of Kwazulu-Natal in the Republic of South Africa

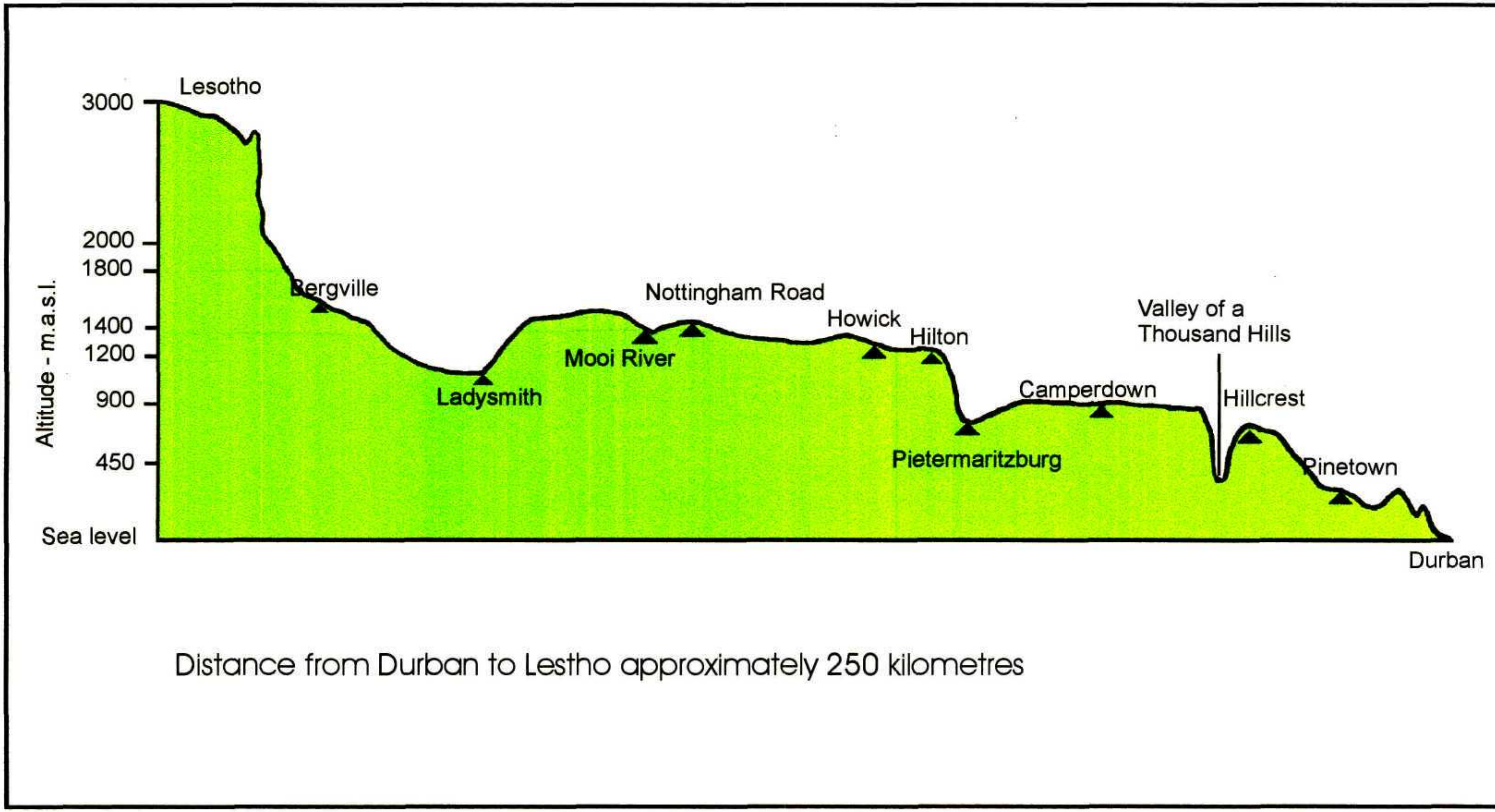

FIGURE 2.2 TOPOGRAPHY OF KWAZULU-NATAL

(A cross-section from Durban to the Drakensberg Mountains)

2.2 Geology

The variety of different geological materials underlying KZN contributes, with the variation of climate, to the marked ecological diversity encountered. The various geological formations and their distribution in the Province as described by King (1972), are illustrated in Fig. 2.3.

2.2.1 The Metamorphic Basement Complex

The Basement Complex rocks which, according to radioactive datings, were formed about 1 100 million years ago, consist of granites, gneisses, and schists and contain minerals such as feldspar, hornblende and mica. Where there has been crustal uplift, these rocks are exposed at the surface, such as the domed granite outcrops in the Valley of a Thousand Hills. These rocks, which were formed within the Earth's crust, tend to weather rapidly, with the feldspar crystals breaking down to clays, and the quartz crystals to sand.

These Basement rocks, in their many variations, are exposed mainly in the deep river valleys, although in places have they have been uplifted to prominent positions, e.g. the east-west crustal fractures which form the Ngoye Range near Empangeni.

2.2.2 The Natal Group Sandstone

A sequence of rock strata lie above the Basement Complex rocks, the oldest of which is the Natal Group Sandstone (NGS). This forms some of the spectacular scenery of vertical cliffs in the central and southern part of the Province. The sandy material which formed these strata, was laid down as sediments and varies from layer to layer, with the basal layers having been derived from the older formation on which they lie, that is, the weathered granite and quarzites. The thick upper part of the NGS consists of micaceous, sandy beds of various grain sizes. It is considered that some sediment may have originated in northern KZN and moved southwards (King, 1972). With transport, the particles became finer, resulting in maroon shales speckled with mica flakes. A second zone of orthoquartzite of the NGS, some 15 m to 18.5 m thick, had a source in the west. A washing back and forth, possibly by the sea, left a dominance of uniform, rounded quartz grains that, over a period of time, formed the orthoquartzite rock. The pebble beds found in the Dalton area may also have come from the west (King, 1972).

The NGS forms the impressive cliff faces of the Kloof Gorge and the Hillcrest plateau and extend northwards to Ndwedwe, Glendale and Mapumulu. In the Thukela River valley, the cliff faces are most impressive, especially to the east of the village of Kranskop, "The Kop" being a well-known view site. North of the Thukela River, the NGS forms the Melmoth and Eshowe plateaux and part of the steep country in the vicinity of Nkandla. Beyond Eshowe, the NGS is absent. Orthoquartzite cliffs surround many plateaus and in southern KZN, Oribi Gorge and the Mtamvuna Gorge are formed where the rivers have cut their way through the NGS.

Above the NGS is a series of sedimentary strata which cover the larger part of the Province. There are three successive sedimentary Groups, namely the Dwyka, Ecca and Beaufort and the Stormberg Series.

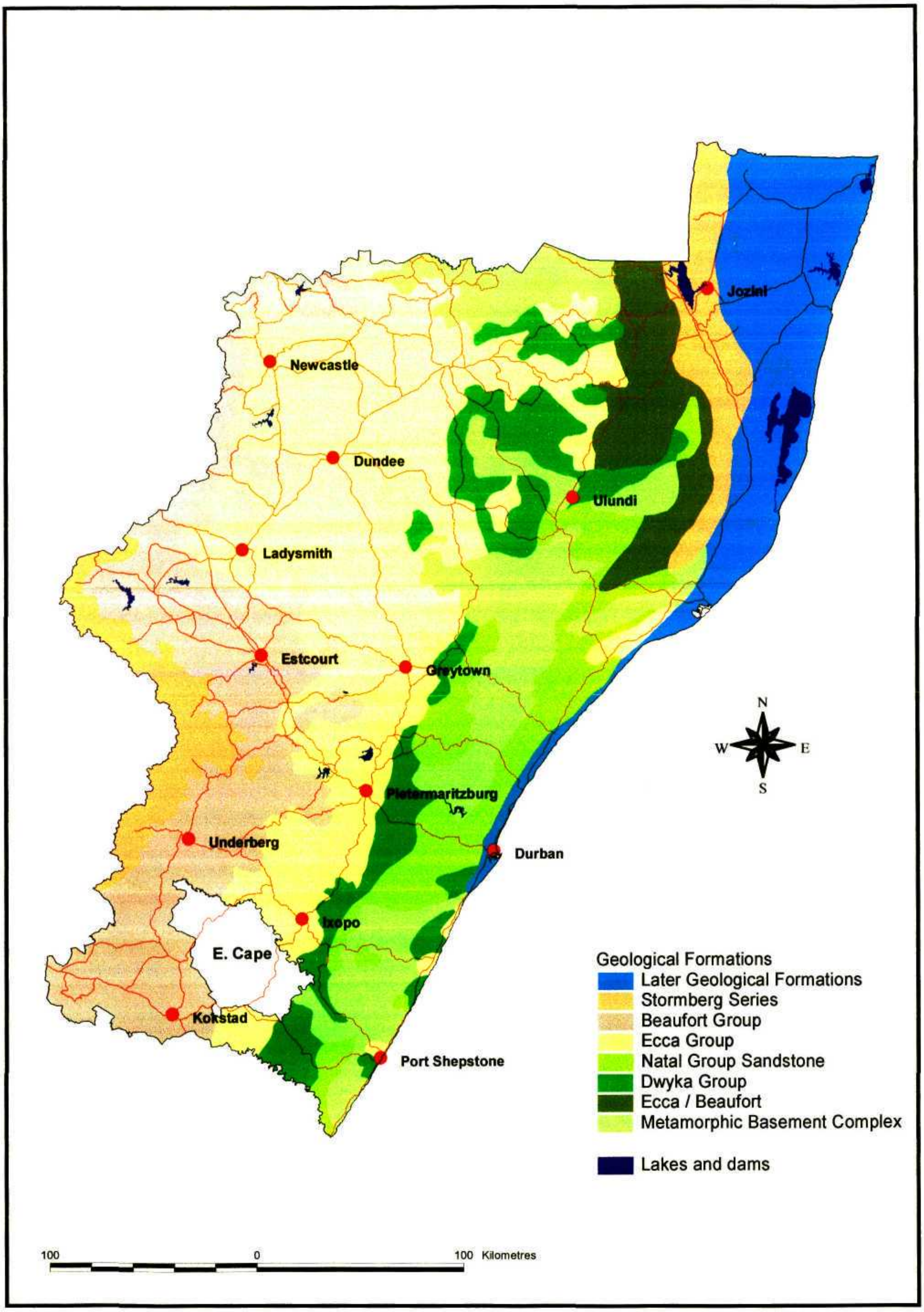

Figure 2.3 : The Geological Formations of KwaZulu-Natal

2.2.3 The Dwyka Group

The Dwyka is exposed only in the eastern part of the Province and its composition indicates its origin. Laid down during a glacial period, the original "mud" that was dragged along by the glaciers has a green-blue matrix and is studded with boulders and pebbles that vary considerably in size. These boulders and pebbles are of differing origins, representing samples of the rock rubble that was once beneath the ice. Rock types include granite, gneiss, quartzite, sandstone and orthoquartzite. Evidence of the fact that these were borne along in glaciers are the flat facets, scratches and striations worn on the stones as they were transported by the glaciers and ground against underlying material.

This accumulation of rock rubble was then hardened and cemented together by the pressure of the overlying material. Below this hardened rock, striated glacial pavements may be found, polished by the glacier as it moved over the rock surface. In northern KZN, these striations indicate that the ice moved in from the north, whereas along the coast, the indications are that the movement was from the north-east, i.e. from the direction where the Indian Ocean lies today.

2.2.4 The Ecca Group

The Ecca Group has a total thickness of about 700 metres. Laid down in extensive bodies of fresh water during a cold temperate period, the Ecca shales and sandstones lie above the Dwyka. Sandstones of the Ecca Group crown the prominent escarpment that extends from the Thukela River to the west of the towns of Greytown, Pietermaritzburg and Ixopo as far as the Mzimkhulu (Umzimkulu) River. These sandstones have a coarser grain size and crumble more easily than the NGS. In the northern part of the Province, coal seams are found within the sandstones of this Group, which also form the many minor escarpments in that area.

The shales of the Ecca Group tend to be dark and are exposed in the midlands and coastal areas. Bricks of good quality are made from Ecca shales which, because of a high iron content, burn red.

2.2.5 The Beaufort Group

The Beaufort Group were originally alluvial flats laid down during a warm temperate period and consist of grey-blue sandstones which weather rapidly when exposed, and shales which are even less resistant to weathering. Layers of these two materials can be seen as ledges on hillsides in the western part of the Province. Formations of the Beaufort Group extend from the foothills of the Drakensberg eastwards towards the towns of Donnybrook, Howick, Weenen and Ladysmith. North of Ladysmith, they narrow to a strip along the western and northern border of the Province. The shales of this Group are exposed in many dongas and are red, green or maroon in colour.

2.2.6 The Stormberg Series

The Stormberg Series, which forms the entire face of the Drakensberg, consists of the Molteno, Red Beds, Cave Sandstone and Basalt formations.

Material of the Molteno stage consists of shales and sandstones. Thickest in the south, where sandstone and shale bands are intermixed, it is widest in the Drakensberg Gardens area. It then becomes less apparent towards the north where, in the Loteni River valley, the terraces are less prominent.

The Red Beds and the Clarens Sandstone (Cave Sandstone) are found along the whole length of the Drakensberg. The Clarens Sandstone, which is approximately 100 metres thick, is well known for its sheer yellow cliff faces which, in general but particularly in the Drakensberg north of Giant's Castle, define the area known as the "Little Berg". A lack of bedding in the cliff faces and the size-grading of the particles, indicate that the sandstone was laid down as wind-blown sands under hot desert conditions. The Red Beds lie immediately below the Clarens Sandstone and are apparent as unstable slopes of red, crumbly shale and red micaceous sandstone, providing the name for this geological layer.

After the sedimentary accumulations of the Karoo system had been laid down, they were disrupted by an outpouring of lava which covered very extensive areas with solidified lava hundreds of metres thick. At Mont-aux-Sources the basalt layer is 1 350 metres thick. The Ubombo Mountains in north-eastern KZN were developed by an ejecta of basalt and silica, forming rhyolite. North of Empangeni and west of the Ubombo Mountains, a large area of basalt extends northwards to Pongola.

Lava that reached the surface solidified into basalt. However, much of the lava never reached the surface but intruded into fissures and passageways in the sediments of the Ecca and Beaufort Groups, the Natal Group Sandstone, and into the Basement rock. This lava, which cooled slowly compared with the surface lava, is known as dolerite and is harder and has finer crystals than the basalt. The material in the fissures formed dolerite dykes, and on exposure these dolerite ridges form a common feature in the landscape. The passageways, or sills, are sub-horizontal and are exposed at the surface following erosion, where they form hard caps to hills. Examples can be seen at Griffin's Hill near Estcourt and Mt. Gilboa, in the Karkloof.

2.2.7 Later geological formations

After the period of geological build-up, the African Surface was subjected to a series of uplifts and the splitting of Gondwanaland. This initiated a series of erosion cycles which have led to the physiography and surface geology of KZN as it is today. New geological formations developed when alluvia was deposited on the coastal belt. This coastal belt underwent periods of submergence, when the sea flooded the land as far west as the Ubombo Mountains. During this period, deposits of marine material accumulated. Later the land re-emerged, exposing sandy flats with marine shell deposits. Depressions remained, forming lakes and lagoons such as Lake St. Lucia and Lake Sibaya. This coastal plain is widest in the north in Maputaland, where it is approximately 75 km wide, narrowing in the vicinity of Mtunzini, whereafter it is a narrow strip down the north and south coasts of KZN. It consists of Quaternary, beach-derived aeolian sands, which cover most of Maputuland and which are underlain by calcareous Cretaceous sediments.

2.2.8 Faulting and erosion

The whole landscape described above underwent changes when faulting uplifted parts of the strata in relation to adjacent strata. Submergence also occurred. Then the river systems, flowing largely from west to east, cut through the geological layers, exposing fresh faces in the deeply incised valleys. This exposed material was then subjected to a wide range of climatic conditions, with the resultant wide diversity of soils in KZN.

2.3 Climate

Climate is a particularly important criterion when assessing the potential of land for development, be it agricultural, industrial or urban. In the agricultural context, climate has a significant effect on the suitability of enterprises chosen. Particular crops, pastures, plant communities in the veld and animals, require a range of climatic conditions in which to live successfully.

The wide diversity of climatic conditions in the Province is a result of the large variation in physiographic features. The controlling influence on the Province's climate is the position of the South Indian Ocean subtropical anti-cyclone off the south-east coastline. As a permanent feature of the general atmospheric circulation, it occupies different positions in winter and in summer. In winter the anti-cyclone strengthens as it moves north over the land causing inversion conditions which result in pronounced atmospheric stability and reduced precipitation. In summer, the anti-cyclone weakens, moving to a southerly position off the coast. Prolonged spells of rain in the summer are frequently associated with the advection of cool, maritime air from the north-east, east and south-east because of a shift in the general circulation associated with the anti-cyclone, and following convergence of air or orographic influences, or a combination of the two.

2.3.1 Precipitation

The term precipitation refers to moisture obtained from rain, snow, hail, mist, dew and frost. Of these, rainfall is the primary source of water for plant growth and the only form for which comprehensive records are obtainable.

It should be noted that the term "mist" is used to indicate orographic mist and low cloud. The meteorological definition for such an event is fog, but the use of the term mist is traditional and used generally. An example is the term "mistbelt" which is widely used.

In winter, spring and early summer, most of the rain is caused by cold fronts, moving into the Province from the south-west. These are often preceded by hot, desiccating, dry "Berg" winds from the north and north-west. Summer rain usually originates from thunderstorms. Rainfall in KZN is extremely variable, ranging from approximately 560 mm to 2 000 mm per year (Fig. 2.4). The highest rainfall areas are in the Drakensberg, the highland areas over 1 400 m, and along the coast, particularly near "the bulge", on the north coast in the vicinity of Richards Bay, and in the extreme south, in the Port Edward area. High rainfall is also experienced in the south-east facing forest areas, associated with the major erosion scarps such as the Karkloof Forest and the Ngome Forest. The driest areas include the Lowveld on both sides of the Ubombo Mountains in the north-eastern part of the Province, some of the deep river valleys, and the basin plainlands of the Thukela River.

2.3.2 Temperature

The number of climate stations that record temperature in KZN is limited and the occurrence of frost is seldom measured. According to Wolstenholme (1976), a mean temperature greater than 18°C in the coldest month of the year indicates a tropical climate, and mean temperatures in the coldest month of 13°C to 18°C indicate a subtropical climate. On this basis, most of the coastal and lowland regions of KZN have a subtropical climate. Mean temperatures below 13°C in the coldest months of the year indicate a temperate climate, and most of the upland and highland regions fall into this category. Figure 2.5 illustrates the temperature zones of KZN.

2.3.3 Evaporation

Evaporation is a useful index of plant growth potential because maximum plant growth is achieved when water supply equals water demand, i.e. evapotranspiration. Very few climate stations in KZN record evaporation and for the purpose of classifying BRUs, the average of the 1' by 1' gridded A-Pan values within a BRU, derived from the temperature grid via month-for-month multiple regression equations (Schulze & Mhaharaj, 1991), was used.

2.3.4 Insolation

The total amount of sunshine received by an area plays an important role in determining the type of vegetation that develops. This is particularly apparent in the deeply incised valleys of the Province where the north-facing slopes receive more insolation than the south-facing aspects. The north-facing slopes are both warmer and drier and often support a xerophytic vegetation of succulent plants and *Acacia* species. The south-facing slopes usually support vegetation such as forests that require moister conditions. A rain shadow can also play a role in enhancing this effect, with the north-facing slopes sheltered from the moisture of cold fronts, while the south-facing aspects receive the full benefit of these conditions. Evaporation from the latter is lower than on the north-facing slopes and this also contributes to the vegetation suffering less water stress than on the drier, warmer slopes.

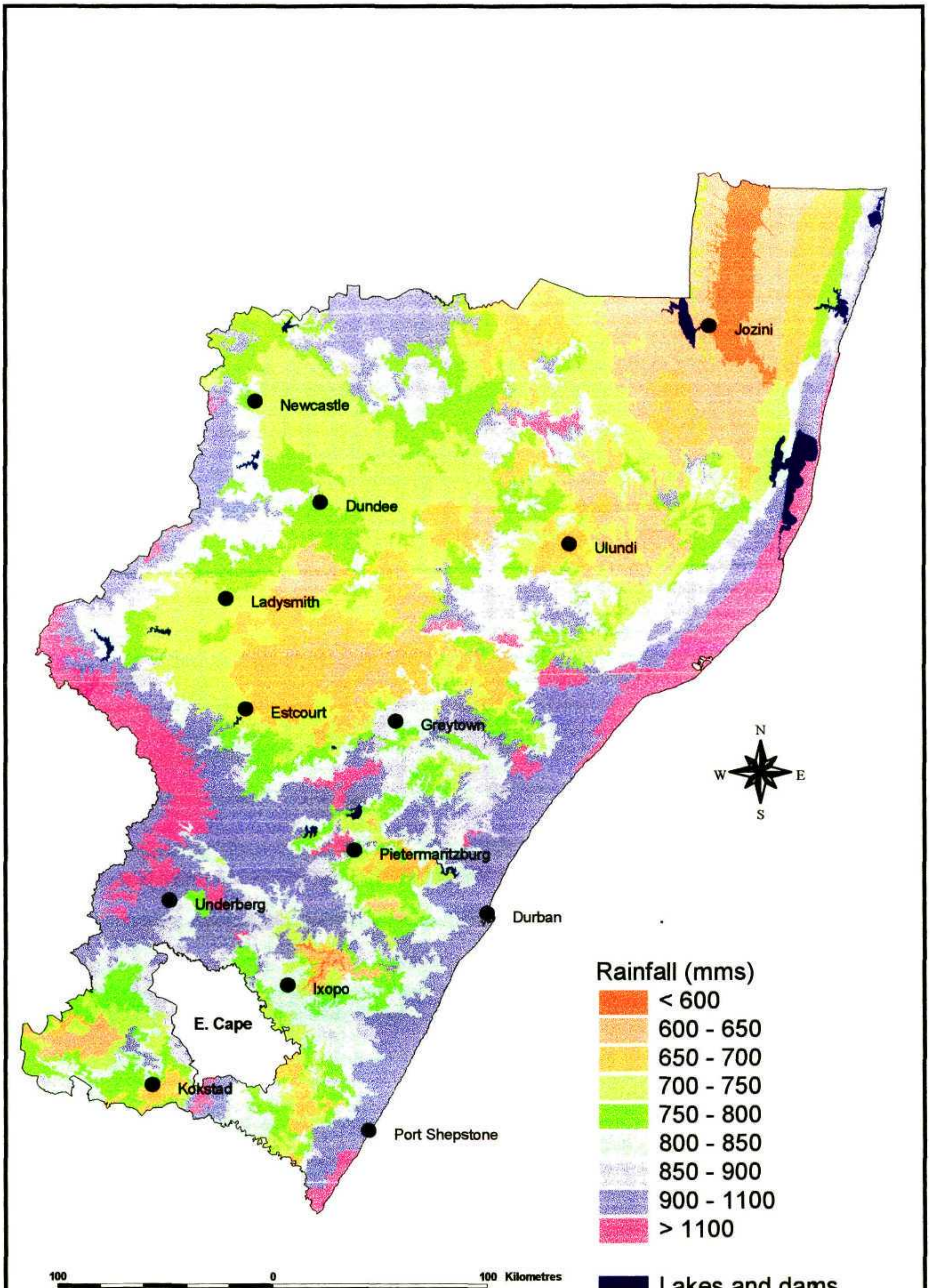

Figure 2.4 : Mean Annual Rainfall of KwaZulu-Natal

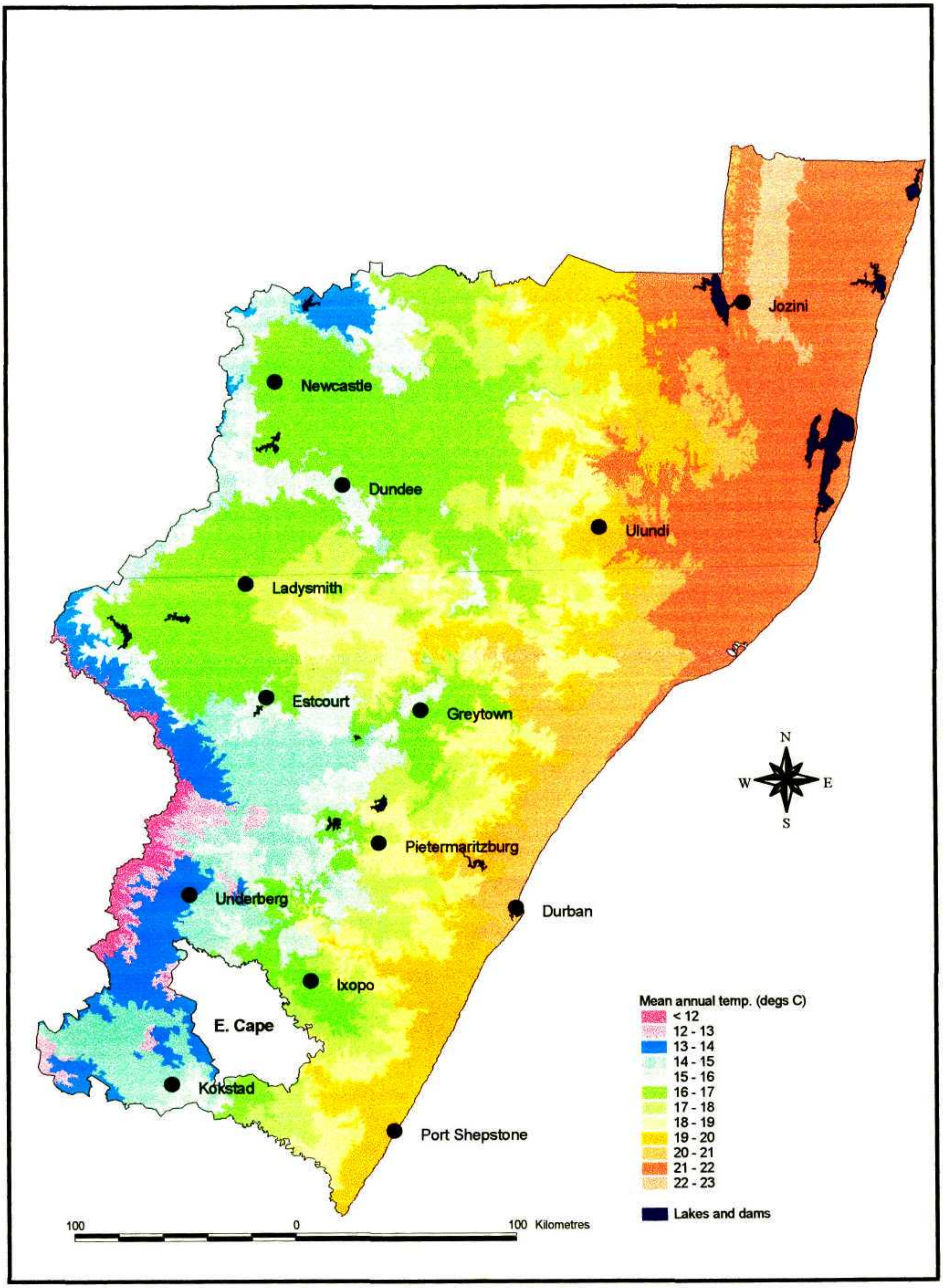

Figure 2.5 : Mean Annual Temperatures of KwaZulu-Natal

According to Moll (1971) the possible sunshine hours in the upland areas in winter are higher than on the coast. In summer this situation is reversed. Cedara, for example, receives a greater amount of sunshine in June than Durban, particularly in the afternoon. This implies that there are fewer clouds over the interior on winter afternoons than over the coast and, as a result, there will be a greater loss of heat through radiation during winter nights in the interior, resulting in the occurrence of frost in these areas.

2.3.5 Wind

The most important role of wind is the transportation of dry and moist air over the Province. The windiest period is from August to November. North-easterly winds, up to gale force, blow along the coast, and hot, dry Berg winds, which blow from the north-west, mainly in August and September, are of particular importance. They also reach gale force occasionally and become warmer as they lose altitude, having a desiccating effect on the vegetation. This is accompanied by a drop in humidity and an increase in the fire hazard during this dry period of the year. The major effect of the Berg winds is on the north and north-west facing slopes. Winds from the south-east frequently follow Berg winds and carry the misty and rainy conditions of cold fronts. Summer is characterised by winds from the south-west and north-east, particularly along the coast, while inland areas receive wind most frequently from the south-east and north-west.

The change from Berg wind to cold front conditions can be marked. For example, on a particular day at Cedara, a sudden change of wind from the north-west to the south-east occurred at approximately 14h00 with no significant change in wind speed, and induced a temperature drop from 32.4°C at 14h00, to 21.9°C measured at 15h00, and an increase in humidity from 19% at 14h00 to 80% at 15h00 (Siddons & Clemence, 1985).

The pattern of predominant daily wind directions and peaks during the burning season of July to October varies as indicated in a study of wind behaviour at Cedara by Siddons & Clemence (1985). North and north-westerly winds, defined as the warmer, drier group, are predominant in the early part of the day, decreasing as the proportion of moister winds from the south and south-east increase. The proportion of each wind group varies monthly, as reflected in Table 2.1.

Table 2.1 : Predominant daily wind directions at Cedara 1983/1984

Wind direction	July	August	September	October
North/North-west				
Peak hour *	11h30	10h45	07h45	09h30
Percentage occurrence **	40%	36%	55%	55%
Duration (time) ***	09h30 - 14h30	09h30 - 12h30	06h30 - 17h00	06h30 - 11h45
South/South-east				
Peak hour	18h00	19h30	18h45	18h15
Percentage occurrence	68%	85%	78%	88%
Duration (time)	10h30 - 19h45	09h33 - 19h30	10h45 - 19h45	06h30 - 19h15

* "Peak hour" refers to the average time of the day when the particular wind blows at its peak velocity.

** "Percentage occurrence" refers to the average percentage of occurrence of the wind direction.

*** "Duration" indicates the average duration in time that the wind blows per day.

2.4 Soils

The environmental diversity in KZN results largely from the variety of parent rock [for example granite, sandstones, shales and tillite(diamictite)] and a wide range of climatic conditions, both of which are often found within short distances. The interaction of geology and climate has resulted in a large number of different kinds of soils which are best described in association with the geology of KZN (Anon., 1986a). Refer to Fig. 2.3 for the geology of KZN.

Recent sands cover most of the Maputaland plains in north-eastern KZN and these occur, as a narrowing band, down the coast of the Province. In the north the upland sites are mainly covered by grey Fernwood soils and, to a lesser extent, sandy Clovelly soils. Red sands are found on the prominent dune ridges. Along the south coast the sandy Shepstone form is encountered in places. In depressions, soil types consist of the Champagne form and, in places, the deep well-drained sands of the Fernwood form.

On the Coastal Lowlands and in the southern hinterland of the Province, granite has weathered into shallow medium- and coarse-textured Glenrosa soils. In the drier valleys of the northern interior, exposed granite has given rise to similar Glenrosa soils, with duplex soils found frequently in bottomland sites.

The NGS is often exposed on moist upland plateaux remnants, and here humic Inanda and Nomanci forms are common. On the slopes, common soils are shallow Cartref and Glenrosa forms and occasional red sandy-clay Hutton forms.

Extensive areas of Dwyka tillite are exposed in the river valleys of the Lowland areas and in the basin of the

Thukela River. In the dry interior valleys fine- and medium-grained sandy-loam soils of the Mispah and Glenrosa forms are widespread, while shallow plinthic soils such as Westleigh and Longlands forms are also found. In bottomland areas, severely-eroded calcareous duplex soils of the Swartland and Valsrivier forms are common. In the moderately moist Lowland areas, Swartland and Valsrivier forms are dominant on Dwyka tillite, while in the Moist Mistbelt areas of inland KZN, deep, highly-weathered Griffin forms are common.

Sandstones and shales of the Ecca and Beaufort Groups comprise much of the bedrock over the interior of the Province and these produce a variety of soil patterns. In relatively dry areas, the dominant soil on shale is Mispah, but it may occur in association with plinthic and duplex soils. Margalitic soils are also found. In cool, moist upland landscapes, however, the Clovelly form is widespread on shale. A wider spectrum of soils are found on sandstone. The Ecca Group are dominantly medium-grained, while the Beaufort Group commonly has finer sand fractions. In the dry interior valleys of the Province, the dominant soil types on sandstone include the duplex Swartland, Valsrivier and Estcourt forms. These same soil types may be found together with the Longlands form in the moister upland sites of these valleys.

Where dolerite has intruded into the sandstones, heavier textured soils of the Shortlands, Bonheim, Arcadia and Rensburg forms are common and in the moist interior basins Avalon and Longlands forms predominate. In the cool, Moist Mistbelt and Highland areas above 900 m a.s.l., dystophic clays and sandy clays of the Clovelly, Griffin, Hutton and Katspruit forms are common.

In general, dystrophic soils have developed where the rainfall exceeds 900 mm per annum, and leaching has resulted in fertility problems. With a decrease in rainfall less leaching of nutrients takes place, giving rise to mesotrophic and eutrophic soil types that tend to have problems of a physical nature.

2.5 Hydrology

Relative to the rest of the RSA, KwaZulu-Natal is rich in water supplies. While KZN makes up only 7% of the area of the Republic, it is estimated that it produces 25% of the country's streamflow (Schulze, 1977). According to Schulze (1977) the average rainfall in KZN is 927 mm, while that of the entire Republic is only 485 mm. Favourable climatic conditions result in less evaporation than in the remainder of the RSA and approximately 40% of the nation's water originates in KZN. An indication of the tremendous value of KZN's water to the Nation is the Tugela-Vaal Scheme by which water is pumped from the Thukela (Tugela) River to the Vaal River to serve industrial areas in Gauteng. The average abstraction rate of this scheme is 561 million m^3 per annum (Anon, 1986a).

According to Schulze (1977) about 25% of the water supplies of the Province originates above an altitude of 1 400 m, i.e., in the Highland and Montane areas. The major rivers of the Province are indicated in Fig. 2.6. The estimated sustained draught of the rivers of KZN is 7.34 km^3 annually. The Thukela River is the major river of the Province and yields 48.2% of the mean annual runoff from a catchment which itself constitutes 46% of the total catchments in KZN. Another important river is the Mgeni (Umgeni). This river's catchment comprises only 5% of the area of KZN but supplies water to two-thirds of its people.

Although both the rainfall and the rivers of the Province are rated as reliable sources of water relative to those of the rest of the Republic, periods of drought do occur. Critical dry periods, defined as less than 25 mm in a three week period in the first four months of the year, which represent the grain filling stage of maize and other cereals, are longest in the central Thukela Valley and north-eastern KZN, and the annual frequency of these occurrences is two to three such episodes. On the other hand, the drought risk in the midlands of KZN is negligible (Schulze, 1977).

Flooding, which occurs mainly in September and October, is also a problem in KZN. This usually occurs when heavy, sustained downpours follow a period of thunderstorm activity which saturated the soil.

In the worst of the floods severe damage is caused, resulting in soil loss, extensive damage to crops, homes, and villages, e.g. the low-lying suburbs of Ladysmith have suffered frequent damage when the Klip River has burst its banks. A flood-retention dam has now been built on this river above the town. Schulze (1977) reported on the magnitude of some of the flood-inducing downpours. On March 18th, 1976, Durban Airport recorded 81.2 mm of rain. This was followed by 68.5 mm on the following day and 160.3 mm on the 20th, a total of 310 mm in three days. The floods resulting from this deluge left many homeless and a death toll of 25 people. Water mains were severed, leading to water shortages and reports gave production losses of over R50 million, while damage to roads amounted to R6 million. The highest daily rainfall recorded in South Africa is 590.3 mm, which fell in Eshowe on 4 May, 1940, causing extensive damage.

A third negative aspect of KZN's river systems is the heavy sediment loads carried to the sea, leading to the expression that the rivers are often "too thick to drink and too thin to plough". Estimates of seven million tons of soil per annum being carried to the sea by the Thukela River have been made (Anon., 1972). This is the result of the poor conservation status of the catchment areas which are, over large areas, severely overgrazed, causing a high percentage runoff and soil removal. Many of the watercourses are eroded, aggravating the situation. Schulze (1977) stated that the Mkhomazi River has a peak sediment load in February which averages 0.85% by mass which amounts to over 2.5 million tons of soil. He points out that this amounts to an incredible 5 tons of sediment flowing into the sea every 4.8 seconds and that for the period November to March the loss of soil averages 5 tons every 9.5 seconds of every day. Another example provided by Schulze (1977) is that during the February-March 1956 floods in the Tugela Location, an average of 7.5 tons of soil was lost every day for every square kilometre. High erosion rates constitute major problems for agriculture and for hydrological engineering.

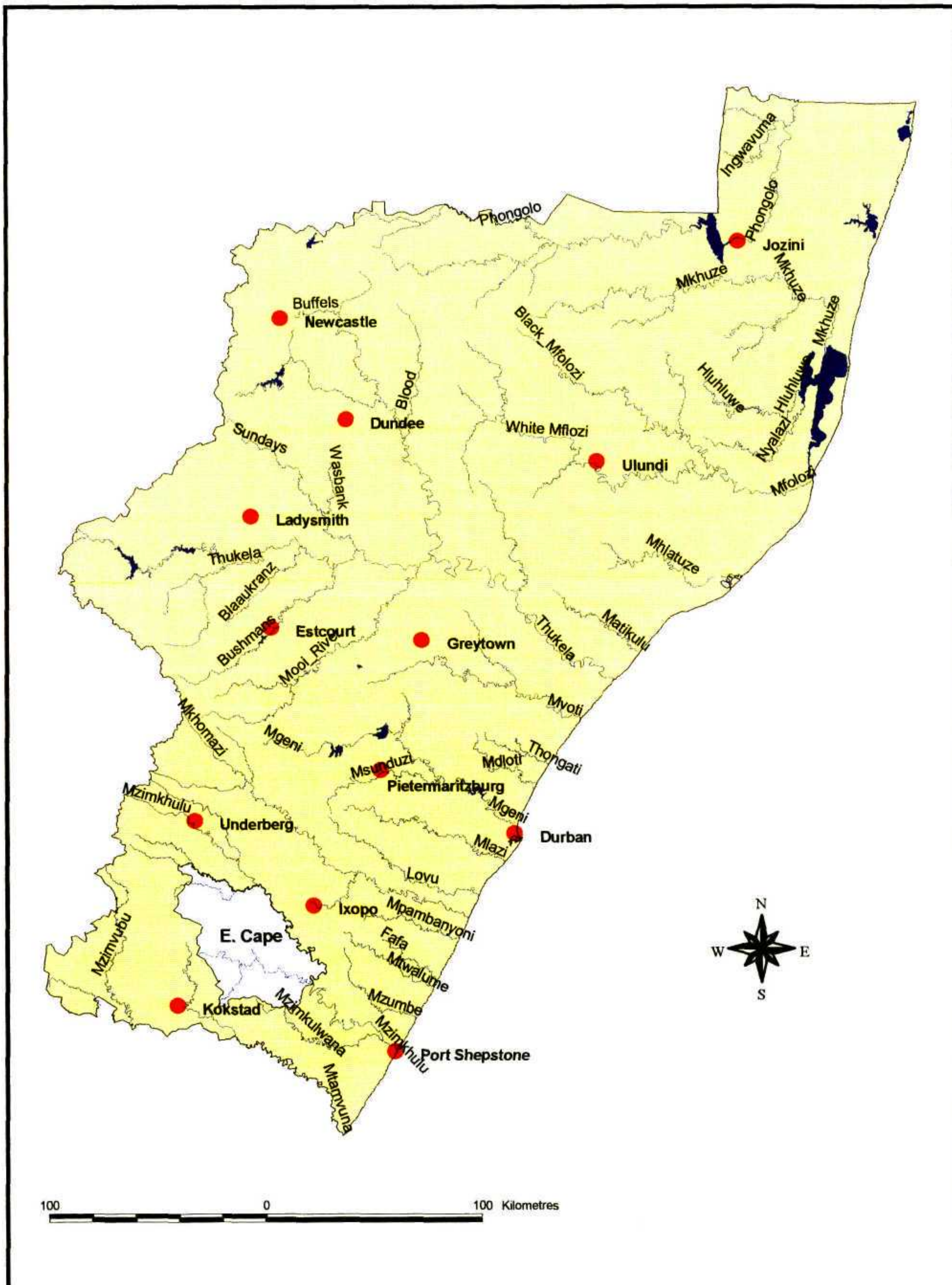

Figure 2.6 : The Major Rivers of KwaZulu-Natal

2.6 Vegetation

Several invaluable studies of the vegetation in KZN have been undertaken, providing a sound understanding of the nature and distribution of the Province's vegetation. Some of the best ecological studies were done by Pentz (1945), Acocks (1953), Edwards (1967) and Moll (1971).

Approximately 80% of the area of KZN is still under natural vegetation and this plays a vital role in both the agricultural economy and in the conservation of soil and water resources. Nevertheless, a considerable proportion of the natural vegetation will give way to cropping, afforestation and urbanisation in the future.

Phillips (1973) maintained that before man had a major influence on the vegetation, climate, soil and natural fire would have had an influence on the development of vegetation in its progress towards one of several climaxes in the Province. During the past century, however, man and his livestock have had a considerable influence on the various stages of succession. The broad vegetation types of the Province are shown in Fig. 2.7 are derived from the agro-ecological zones of Pentz (1945).

2.6.1 Coast and Coast Hinterland

Most of the natural vegetation in the Coast and Coast Hinterland zone has been destroyed and replaced by crops, mainly sugar cane. The remaining vegetation consists of relict forest communities which indicate the past and potential distribution of this vegetation type, and patches of *Acacia* scrub and palm clumps. The remaining grassland is generally in a degraded condition (Anon, 1972).

2.6.2 Mistbelt

The vegetation of the Mistbelt zone has similarly been replaced largely by crops and commercial timber plantations. Isolated patches of relict forest are found mainly on south-facing aspects in areas where they are protected from fire. The grassland, as a result of excessive burning and selective overgrazing, has deteriorated to a sward dominated by unpalatable Ngongoni grass (*Aristida junciformis)*.

2.6.3 Highland and Montane

In the Highland and Montane zone, the vegetation remains relatively undisturbed and the veld is in relatively good condition. Isolated relict forests occur mainly on steep, rocky, south-facing aspects, where fires are usually of low intensity because of the rocky nature and moist conditions which prevail on these slopes. The Montane area of the Drakensberg is mainly under the protection of conservation bodies and forests are thus fairly extensive.

2.6.4 Tall Grassveld

The Tall Grassveld zone covers most of the interior basin of the Thukela River. Erosion is a serious problem in this area and the veld varies in condition from good to poor quality, the latter being found mainly on erodible, duplex soil forms. The invasion of thorn scrub *(Acacia* spp.) poses a threat to the stock farmer.

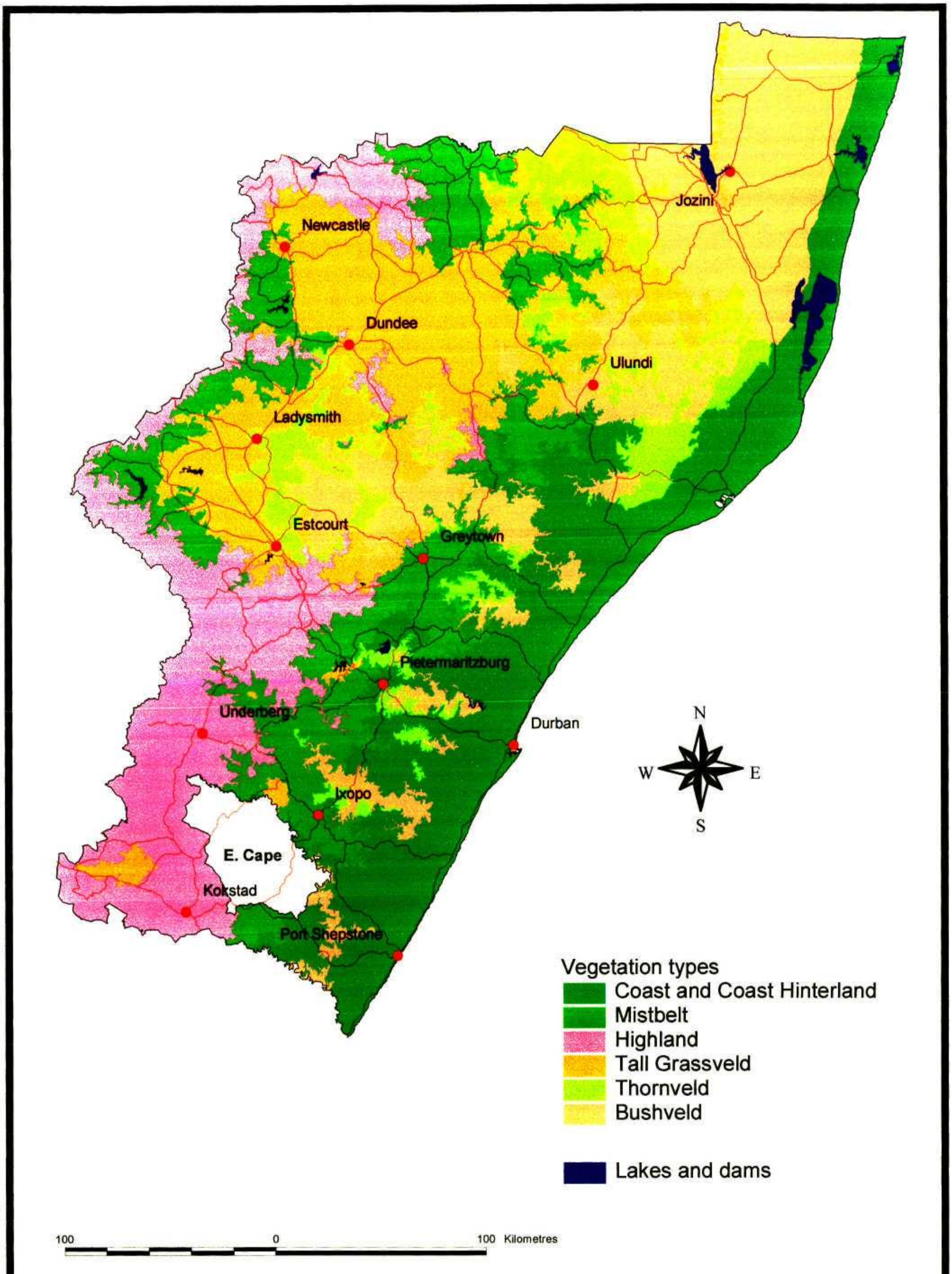

Figure 2.7 : The Broad Vegetation Types of KwaZulu-Natal

2.6.5 Thornveld

The Thornveld zone is found around the upper perimeter of most of the river valleys. This is a secondary veld dominated by *Acacia* spp. that have invaded the grasslands from the river valley vegetation. The condition of the veld ranges widely from a highly productive condition to very poor quality veld of low productivity and basal cover, dominated by pioneer species.

2.6.6 Bushveld

The Bushveld is found in north-eastern KZN and in the valleys of most of the rivers. The vegetation is dominated by a wide variety of trees and the grassland is highly palatable, carrying stock effectively throughout the winter without the benefit of supplementary feed.

2.6.7 The weed problem

There are several weeds which pose a problem to the land user. These include several exotic weeds such as black wattle (*Acacia mearnsii)* and silver wattle *(Acacia dealbata)* which invade veld, particularly along watercourses in high rainfall areas (>800 mm per annum). Other exotic species include American bramble (*Rubus cuneifolius), Lantana camara* and triffid weed (*Chromolaena odorata).* Among the indigenous plants Currys Post weed *(Athanasia acerosa)* is invasive on overgrazed veld in the Highland and Montane areas and *Senecio* spp. and tulip *(Moraea spathulata)* are toxic to stock (Anon., 1986a).

2.7 Agricultural land use

The same zones shown in Fig. 2.7 can be used to broadly classify the land use zones of the Province. Details such as area, altitude range, soil, MAP and MAT of each land use zone are given in Table 2.2. Soil data was adapted from Phillips (1973) and climate data from the climate stations in appendix 1.

Table 2.2 : Details of area, altitude, soil, MAP and MAT of the land use zones (LUZ)

LUZ	Area (ha)	Altitude m.a.s.l	Arable* %	High potential soil %	MAP mm	MAT °C
Coast and Coast Hinterland	1 924 026	< 900	35	12	740 - 1 423	17.6 - 22.0
Mistbelt	1 418 612	901 - 1 400	45	37	738 - 1 280	16.7 - 17.0
Highlands and Montane	1 539 405	1 401 - 1 800	22	7	620 - 1 400	11.5 - 14.3
Tall Grassveld	1 664 562	451 - 1 400	33	14	645 - 1 000	16.0 - 19.5
Thornveld	785 901	320 - 1 200	16	7	644 - 846	17.1 - 21.1
Bushveld	1 528 744	< 450	51	17	587 - 800	19.0 - 22.0

* "Arable" refers to land which is suitable for cultivation (i.e. not too steep or rocky to plough and/or cultivate)

2.7.1 Coast and Coast Hinterland

Sugar cane is the most important crop of this zone and covers approximately 35% of the cultivated land in KZN. Its contribution to the Province's agricultural production is about 40% and the zone produces almost 90% of the national cane crop. Timber, mainly from Eucalypts, has become increasingly important, particularly in the northern areas. Subtropical fruits produced include bananas, litchis and pawpaws, and vegetable production is also important.

2.7.2 Mistbelt

The Mistbelt, with favourable climate and good soils, is an area of high agricultural potential. Most of it is afforested and commercial timber, including Eucalypts, Pine, Wattle and Poplar, is the most important form of land use. Sugar cane is grown at lower altitudes in the central and southern areas on frost-free slopes. The potential for maize production is high, particularly in the Greytown area. It is an important milk producing area.

2.7.3 Highlands and Montane

Found mainly in the western areas of the Province, this zone has cold winters with frequent severe frost. Snowfalls are experienced in the high-lying areas. It carries close to one third of the Province's cattle and sheep and it has considerable potential for increased livestock farming. Maize and potatoes are the most important crops grown, and a considerable area of land is devoted to fodder production to carry livestock through the cold winters. The Drakensberg has spectacular scenery and has been set aside for water yield, nature conservation and tourism.

2.7.4 Tall Grassveld

The largest portion of this zone lies in the interior of the Thukela River basin. Livestock farming, mainly cattle, is the most important source of income. Soil has to be carefully selected for cultivation, particularly because deep soils are required in an area where rainfall during the growing season is unreliable. Crops are irrigated on suitable soils adjacent to the main rivers.

2.7.5 Thornveld

This zone lies on the upper perimeter of the major river valleys and on the western boundary of the bushveld. It is an extensive farming zone suited mainly to cattle, goat and game farming, with the density of the bush dictating the balance of animal types, or species, in the case of game animals.

2.7.6 Bushveld

The bushveld is situated mainly on Lowland areas in north-eastern KZN and in the valleys of the major river systems. Summers are hot and winters warm, although in the upper river valleys in the south, severe frosts do occur. The relatively high percentage of arable land in this zone (Table 2.2), has limited cropping potential unless it is situated adjacent to a reliable source of water for irrigation, because the rainfall is too low for crop production. On selected sites along rivers such as the Thukela and Phongola, there is good potential for cropping under irrigation. In the north, crops such as sugar cane, cotton and vegetables can be grown, but in the south, frost-sensitive crops such as sugar cane cannot be grown due to low winter temperatures. Because of climatic factors the major portion of this area is suitable only for stock and game farming. Production is relatively cheap because of the high quality of the winter grazing, so that winter supplementation is not required. Tourism is a very important industry and game reserves such as Mkuze, Hluhluwe-Umfolosi Park, Phinda and Ndumu, are situated in this zone (Anon., 1972).

Chapter 3
PROCEDURE FOR THE IDENTIFICATION AND MAPPING OF BIORESOURCE UNITS.

3.1 Introduction

Both the Food and Agricultural Organisation (FAO) of the United Nations and the Southern African Regional Commission for the Conservation and Utilisation of the Soil (SARCCUS), realised that to meet the need for food in the year 2 000 in Africa an appreciable increase in food production would be required. This increase would have to be done in a sustainable manner and not at the expense of the natural resources. The limits of the natural resources would have to be recognised and crop and animal requirements would have to be matched to edaphic and climatic conditions. To achieve the sound matching of agricultural production with the natural resources, an inventory of the resources must be compiled, preferably within land systems referred to as agricultural ecological zones (AEZs) (FAO, 1996).

A land system was referred to by Pratt & Gwynne (1977) as a composite area for study purposes and was described by them as an area throughout which there is a recurring pattern of topography, soils, and vegetation. Generally, land systems should be described in terms of geomorphology, geology, climate, soils, and vegetation, but, according to Pratt & Gwynne (1977), most have been based mainly on geomorphological criteria, and these have generally been found to be too complex climatically to be of practical value for development planning. This problem was taken into consideration in the current study when planning the AEZs, to be known as Bioresource Units (BRUs) in KZN.

Phillips (1973) investigated the many different interpretations of the concept of ecology and summarised an ecosystem as including "climax and successional stages of communities of plants and their associated animals, the manifold variations in local and micro-climates, soil series and phases and niches for the varied forms of life, and the like." Further, he stated that "the ecosystem embraces an intricate diversity of systems from relatively simple to infinitely elaborate composition, structure and biological complexity." Phillips stated that countries like the United States of America, in particular, had realised the importance of basing development and planning on the ecosystem approach. He stressed that relevant to the adoption of an ecological approach to development planning, is the concept that there is a fundamental association between all forms of life and their interrelationships, the environment that affects them and that they, in turn, affect. It is imperative to recognise that this sensitive equilibrium can be upset by any development process. When mapping units of land systems therefore, Phillips stated that it is important to recognise that the ecosystem is a very good indicator of the presence, the nature, boundaries, transitional zones, and potentialities of the natural elements for the development of units and sub-units.

To meet Phillips' definition of an ecosystem as closely as possible, it was decided that rainfall and temperature in particular, plant communities, terrain type, slope and the soil association code (Land type survey staff, 1986), would be the criteria used to define the BRUs of the Province.

3.2 Definition of the Bioresource Unit (BRU)

A Bioresource Unit is a class of land within which the environmental factors such as soil type, climate, terrain form and vegetation, display a sufficient degree of homogeneity such that uniform land use practices and production techniques can be defined.

Note: This definition will apply to most land systems, the major difference being one of scale. The primary criterion for the demarcation of the BRUs was climate, and most BRUs have a range in rainfall of 50 mm/annum or less, although some exceed this figure to a maximum of 100 mm/annum. This limits the size of the units and accounts for the large number (590) in the Province. Phillips' Bioclimatic Groups have a wider rainfall range, the smallest of which is 100 mm/annum, and the largest is 550 mm/annum, while mean temperature ranges are from 1°C to 5°C, and evaporation from 25 mm to 152 mm per year.

3.3 Preparing a Base Map for Field Survey Purposes : Maps 1

3.3.1 Land Types (Maps 1)

As mentioned earlier (Section 1.3.4), the lack of reliable information on the soils and climate were major drawbacks in fully defining the Bioclimatic Groups (Phillips, 1973). The development of Land Types (LTs), defined by the Soil and Irrigation Research Institute [now the Institute for Soil, Climate and Water (ISCW)], and the soil association maps produced, have removed this problem and thereby provided a good basis for mapping and for acquiring the necessary soil information to define the ecotopes of the BRUs (see Section 4.1). Therefore the decision was made to use the LTs as a base map to utilise the valuable soil information they contained. The LTs could then be grouped according to climate, the most important criterion for classifying BRUs.

A set of 1:50 000 topo-cadastral maps of the Province were obtained. The outlines of the LTs, and the codes of their broad soil patterns, were traced onto these maps from the field sheets of the ISCW, which were also at a scale of 1:50 000. The symbols for the broad soil associations are given in Table 3.1. The lower case letters in the code refer to further sub-divisions in the soil properties such as base status and the percentage of the area of the LT covered by each soil type. The full coding system can be found in any of the LT memoirs, for example in Land type survey staff (1986). The 1 : 50 000 topo-cadastral maps on which the information to be used in the classification of BRUs was plotted or written, was referred to as Maps 1.

A summary of the preliminary procedures for classifying BRUs is given in Section 3.3.2.

3.3.2 Summary of preliminary procedures

The procedure followed inthe classification process is summarised in the flow chart.

Step 1 :	Prepare a **Base Maps** for field surveys These are **Maps 1** Use 1 : 50 000 topo-cadastral maps

Step 2 :	Trace the **Land Types** onto **Maps 1** Add the **Broad Soil Pattern codes** to the Land Types

Step 3 :	All available **Rainfall Records** are written on **Maps 1** Rainfall in millimetres, total years recorded, name of station or farm Pencil in **rainfall symbols**, R = < 600 mm, S = 601 mm - 650 mm, T = 651 mm - 700 mm, U = 701 mm - 750 mm, V = 751 mm - 800 mm, W = 801 mm - 850 mm, X = 851 mm - 900 mm, Y = 901 mm - 1 100 mm, Z = >1 100 mm (see page 37)

Step 4 :	Add **Physiographic Region** symbols By drawing region boundaries, i.e. on the contour lines of 450m, 900 m, 1 400 m, 1 800 m and 2 000 m. Fill in **symbols,** 0 m - 450 m = a, 451 m - 900 m = b, 901 m - 1 400 m = c, 1 401 m - 1 800 m = d, 1 801 m - 2 000 m = e and > 2 000m = f (see page 39)

Step 5 :	Apply preliminary **BRU codes,** rainfall plus physiographic regions For example : Wc for an area with a rainfall of 801 mm to 850 mm and lying within an altitude range of 901 m to 1 400 m

Table 3.1 : Broad soil associations of the Land Type Survey

Broad soil association	Symbols
Red and yellow apedal, freely drained soils	Aa - Ai
Plinthic catena: upland duplex & margalitic soils uncommon	Ba - Bd
Plinthic catena - upland duplex and/or margalitic soils common	Ca
Prismacutanic and/or pedocutanic diagnostic horizons common	Da - Dc
One or more of: vertic, melanic, red structured diagnostic soils	Ea
Glenrosa and/or Mispah forms	Fa - Fc
Soils with a diagnostic ferrihumic horizon	Ga, Gb
Grey regic soils	Ha, Hb
Miscellaneous land classes	Ia - Ic

3.3.3 Rainfall records

All rainfall records of the Province that could be obtained were plotted, in millimetres per annum, followed by the number of years recorded and the station or farmer's name, onto the 1 : 50 000 topo-cadastral maps (Maps 1). The main sources of the rainfall figures were the ISCW and the Weather Bureau. In addition, 600 sets of rainfall records were collected from farmers throughout the Province (Land type survey staff, 1987). These farmer records, which are not listed in appendix 1, were plotted on the maps. Those with records of ten years or more, were considered to be satisfactory, but records of shorter duration were compared with nearby stations with long-term records and adapted if corresponding years showed a similar pattern of rainfall. In many cases these were the only figures available for a particular area and gave an indication of rainfall which was then compared with other indicator factors such as vegetation species and communities. The names, locality and details of official weather stations used are given in Appendix 1.

3.3.4 Rainfall symbols - Maps 1

The decision on the rainfall symbols to be assigned to the BRUs was based on ecological indicators developed in the midlands of KZN. The following guidelines were applied:

A mean annual precipitation (MAP) of 800 mm or more was considered to indicate that an area was suitable for rainfed crop production, and maize, a widely grown crop, was used as the standard measure (Smith, 1993). Soils in areas with a MAP in excess of 800 mm were mainly dystrophic (and to a lesser extent mesotrophic), and apedal. Areas with a precipitation range of 750 mm to 800 mm, were generally regarded as requiring at least supplementary irrigation for crop production. In addition, within this rainfall range, soils were mainly mesotrophic and there was a high percentage of plinthic soils. Of note was that, in general, the invasion of *Acacia* species was found to have currently reached areas with this rainfall range, and that this was largely limited to *Acacia karroo* and *A. sieberiana*.

In the rainfall range of 700 mm to 750 mm, structured soils, such as Shortlands, Swartland, Valsrivier and

Estcourt, as well as margalitic soils formed mainly on dolerite, became common. Bush encroachment was widespread.

In areas with a MAP of less than 700 mm, broad-leaved tree species associated with bushveld vegetation were apparent and *Acacia tortilis* was the main invader species in valley bottom sites.

The indications were that a range of 50 mm defined rainfall sufficiently and thus 600, 650, 700, 750, 800, 850 and 900 mm were accepted as limits, after which the range was increased to 200 mm as it was assumed that additional rainfall over 900 mm would not make a significant difference to the production of crops (Smith, 1993), or to changes in vegetation communities.

Upper case letters were given as symbols for the rainfall ranges as indicated in Table 3.2.

Table 3.2 : Rainfall symbols of the BRUs

MAP (mm)	Symbol
< 600	R
601 - 650	S
651 - 700	T
701 - 750	U
751 - 800	V
801 - 850	W
851 - 900	X
901 - 1 100	Y
> 1 100	Z

Some Land Types had one or more rainfall stations plotted within their boundaries. After assessing these rainfall figures, the appropriate symbol was assigned to the LT. For example, where a LT had three stations with rainfall figures of 810 mm, 823 mm and 840 mm, it would be assigned the symbol "W". To decide on the symbol to be assigned to a particular LT, the effect that aspect, altitude and topography were likely to have on rainfall was considered in relation to an adjacent LT with records, and a symbol was placed in the LT. To support this decision, the soil types of the LT, plant growth and species regarded as indicators of rainfall were noted. In some cases the rainfall pattern could not readily be assigned to a range of 50 mm and then the symbol would indicate a wider range of 100 mm, the maximum range that it was necessary to use. For example, an area with rainfall records of 820 mm and 880 mm per year would be given the symbol "WX".

3.3.5 Temperature symbols within physiographic regions - Maps 1

In addition to the paucity of rainfall stations in the Province, very few of these stations had records of temperature. It was obvious that a modelling technique would have to be applied for the final temperatures to be assigned to the BRUs. However, in order to provide an initial gross parameter of temperature to the Land Types, and recognising the relationship between altitude and temperature, physiographic regions, based on certain altitude breaks, were defined. The altitude ranges were initially based on those used by Acocks (1953) and Phillips (1973) as important physiographic regions that are readily recognised in the field.

Before finalising the altitude breaks that came to be used, the physiographic features were checked in the field. The old N3 main road from Durban to Ladysmith and then the road from Ladysmith to Bergville and on to the Drakensberg was, with a few exceptions, found to be a suitable transect line across the Province along which the physiographic features could be observed. This cross-section is represented in Fig. 2.2.

The first significant change from the coastline occurs at the upper limit of the Natal Group Sandstone (NGS) which lies below Kloof-Hillcrest. This feature occurs between the 400 m and 500 m contour and the 450 m contour was taken to be the dividing boundary between the Coastal area and the Lowland area where a distinct change in climate occurs. Above the NGS a marked decrease in temperature occurs, which is accompanied by a change in species composition, the coastal species such as *Phoenix reclinata*, *Acacia robusta* and *Strelitzia nicolae* being absent.

The prominent escarpment that extends from the Greytown-Kranskop district through Pietermaritzburg to Ixopo, is crossed by the N3 between Pietermaritzburg and Hilton. This escarpment is capped by the sandstones of the Ecca Group and the sudden change in altitude gives rise to a change in climate, the higher area being appreciably cooler, and forms the Midlands Mistbelt. The 900 m contour lies very close to the upper edge of this escarpment and this altitude was taken as the demarcation line between the Lowland and Upland physiographic groups. The 900 m contour demarcates the line above which frost is an important feature and where sugar cane can grow only on frost-free crests, and where bramble, which requires frost to fruit effectively, is found.

The escarpment lying above the Karkloof Forest extends westwards, where the N3 highway crosses it in the vicinity of Curry's Post and Nottingham Road. A distinct change in plant community can be seen above this line, with Highland Sourveld species such as *Buddleja salviifolia* and *Leucosidea sericea* occurring predominantly above an altitude of about 1 400 m. In the northern part of the Province the plateau lying above Utrecht is situated above 1 400 m and this is an important contour for the delineation of the occurrence of severe frosts. Snow occurs at this altitude every two to three years (Moll, 1971). The 1 400 m contour was therefore taken as the break between the Upland area and the Highland area.

The next break is a most prominent feature, the "Little Berg." The altitude varies considerably, however, and the 1 800 m contour line was taken to be the demarcation line between the Highland area and the Montane area. The mapping of this line was not restricted to this altitude, however, but was placed as close to the footslopes of the "Little Berg" as possible. The 2 000 m contour was then selected to define the lower margin of the Escarpment Montane area.

The physiographic regions were given a symbol and named according to their position in the landscape. They are given in Table 3.3 and compared with the dominant physiographic regions described by Acocks (1953) and Phillips (1973).

Table 3.3 : A comparison of the Physiographic Regions of the BRUs, Acocks (1953) and Phillips (1973)

BRUs			Acocks (1953)		Phillips (1973)	
Altitude (m)	**Symbol**	**Name**	**Altitude (m)**	**Name**	**Altitude (m)**	**Name**
0 - 450	a	Coast	0 - 450	Coastal Forest & thornveld	0 - 457	Coast Lowland
451 - 900	b	Lowland	451 - 900	Ngongoni Veld	458 - 915	Coast Hinterland
901 - 1 400	c	Upland	901 - 1 350	Natal Mistbelt Ngongoni Veld	916 - 1 372	Upland
1 401 - 1 800	d	Highland	1 351 - 1 850	Highland Sourveld	1 373 - 1981	Highland
1 801 - 2 000	e	Montane	1 851 - 2 150	*Themeda-Festuca* Alpine Veld	1 982 - 3 353	Montane
> 2 000	f	Escarpment Montane				

The physiographic regions (Table 3.3) were used to group BRUs into temperature zones, but it should be noted that the altitude breaks were used only as a guide and were not strictly adhered to as boundaries for the BRUs. The MAT within these regions has been defined in Table 3.4. The average rate of decrease in temperature with an increase in altitude is approximately 5.3°C per 1 000 m (Pratt & Gwynne, 1977). Some disparity occurs due to diurnal temperature ranges and patterns of cloudiness, but starting with a MAT for the coastal plain of 22.0°C (taken from coastal weather stations), that for the lowland region would be 19.5°C, the upland region 17.1°C, the highland region 14.7°C and the montane region would be 13.1°C. It can be seen from Table 3.4 that these estimations are reasonably consistent with temperature records up to an altitude of 1 400 m, but that there is a discrepancy of 1.6°C for the Montane region. It was decided nevertheless that these regions would give an adequate indication of temperature for the BRU classification.

Table 3.4 : Physiographic regions and their mean annual temperature

Physiographic region	Calculated MAT (after Pratt & Gwynne, 1977) (°C)	MAT records (°C)
Coast	22.0	22.0 in north 18.5 in south
Lowland	19.5	19.5 in north 17.6 in south
Upland	17.1	16.7 - 17.1
Highland	14.7	14.1 - 14.3
Montane	13.1	11.5
Escarpment Montane	-	9.7

Schulze (1982) found that temperature correlated well with latitude and altitude, both of which can be determined accurately. The poor network of temperature recording points in KZN meant that interpolation between sites was necessary. Thus the average of the 1' by 1' gridded values of minimum, maximum and mean monthly temperature were used as the best approximation available (Schulze, 1982), and the temperature figures assigned to each BRU were decided using this procedure.

3.3.6 BRU coding

The rainfall and altitude symbols were then combined to form a preliminary code which was written in each Land Type on Map 1. For example a code of "Wc" would indicate that the particular Land Type had a range in rainfall from 800 mm to 850 mm, and that it lay between 900 m and 1 400 m above sea level. A code of "TUb" would indicate a rainfall range of 650 mm to 750 mm and and an altitude between 450 m and 900 m above sea level.

3.3.7 Defining vegetation types

As an aid in defining the BRUs, the role of vegetation was considered to be invaluable as an indication of changes in soil and climate, and in assessing the potential of an area. For this purpose, certain vegetation types which could be readily recognised as indicators of changes in ecosystems, were selected.

It was not the intention to create names for the vegetation types, but rather to retain, wherever possible, the old terminology and names familiar to academics, agriculturalists, naturalists and particularly farmers. The names used by Pentz (1945), Acocks (1953), Edwards (1967), Moll (1971) and particularly Phillips (1973), whose Bioclimatic Groups are well known and used in KwaZulu-Natal, were considered. The most appropriate names were selected where the parameters of the vegetation types and the Bioclimatic Groups, and other ecological groups, indicated that land use and management would be similar. The names were modified where necessary, to make them more descriptive. The scale at which the BRUs were mapped permitted much greater detail to be shown compared with the small scale of previous studies. As a result, there will be a discrepancy between the lines of the current vegetation types and earlier work, such as the Bioclimatic Groups, for zones of similar description and name. What is described in this study as the Moist Midlands Mistbelt, and Phillips Bioclimatic Group 3, are good examples to illustrate the point. A study of Phillips' and the BRU maps will indicate that they represent similar ecological areas, but that the boundaries differ.

A study of Phillips (1973) and Acocks (1953), revealed that there was a marked similarity in the altitudinal limitations of the respective plant communities defined by these authors, and that these altitude breaks fitted physiographic features in the landscape. These broad physiographic regions are given in Table 3.3. The vegetation types were then defined within these regions. It was recognised that certain vegetation types would overlap these altitudinal limitations, as did the vegetation communities of the above-mentioned authors. The selection of these vegetation types will be explained in Chapter 5.

Twenty three vegetation types (Table 3.5), later to be described as Bioresource Groups (BRGs), were identified and these can be seen in relation to the works of Acocks (1953), Edwards (1967), Phillips (1973), and Moll (1971) in Appendix 2. A summary of the justification for defining each of the vegetation types, and a list of the indicator species for each vegetation type can be found in Chapter 5.

In defining the vegetation types, it was recognised that ecosystems may be natural, induced and synthetic, or artificial (Phillips, 1973). Prior to the influence of man, biotic diversity was little altered, but changes are now common and most of the ecosystems within KZN, and in South Africa for that matter, have been altered to varying degrees. This applies mainly where there has been widespread destruction of the natural vegetation, which in turn has affected all other elements of the environment. Man has replaced natural ecosystems with those of his own making, as can be seen in extensive sugar cane fields and timber plantations in particular. This poses the problem of recognising transitional areas. The variation in the vegetation composition of the veld is so great that to classify an area solely on the presence of one or two species would give an incomplete and often misleading indication of its character. Ideally it would be more appropriate to use the total vegetation, including grasses, woody plants and herbs as a basis for classification. Moll (1971) used the term "plant indicators" to describe the plant species used to identify vegetation types, and generally included a range of species which would be appropriate for a plant ecology study. The purpose of this study, and the time restrictions, prohibited such an investigation being made and so the number of plant indicator species, and in many cases plant indicator communities, were limited to those species and communities that could be readily recognised without conducting time-consuming field sampling. These were used to support other parameters, including the maps of Acocks (1953), Edwards

(1967) and Moll (1971,1980) in the identification of vegetation types, transitional zones and subsequently BRUs.

Table 3.5 : Vegetation types (also referred to as Bioresource Groups) selected for the classification of BRUs

Number	Vegetation type (Bioresource Groups)
1	Moist Coast Forest, Thorn & Palm Veld
2	Dry Coast Forest, Thorn & Palm Veld
3	Moist Coast Hinterland Ngongoni Veld
4	Dry Coast Hinterland Ngongoni Veld
5	Moist Midlands Mistbelt
6	Dry Midlands Mistbelt
7	Northern Mistbelt
8	Moist Highland Sourveld
9	Dry Highland Sourveld
10	Montane Veld
11	Moist Transitional Tall Grassveld
12	Moist Tall Grassveld
13	Dry Tall Grassveld
14	Sour Sandveld
15	Moist Lowland Tall Grassveld
16	Dry Lowland Tall Grassveld
17	Coast Hinterland Thornveld
18	Mixed Thornveld
19	Moist Zululand Thornveld
20	Dry Zululand Thornveld
21	Valley Bushveld
22	Lowveld
23	Sandy Bush and Palm Veld

In selecting plant indicator species, in addition to those species which had become familiar indicators during initial field trips, reference was made to the dominant species described for each of the ecological areas of Acocks (1953), Moll (1971, 1980) and, more particularly, Edwards (1967). The latter two authors listed plant indicator species for each of the plant communities they described. The studies of Pooley (1993) also provided a great deal of information on plant indicator species. For this study, certain alien species were added to the list of indigenous indicator species, mainly to assist the survey in severely disturbed and extensively cultivated areas.

In using the plant indicator species in the field survey, the presence of any particular plant indicator was insufficient to classify an area into a vegetation type. A species in association with several other plant indicator species could, however, give a strong indication of a vegetation type, and the abundance of the species was important. The presence of *Acacia karroo* could indicate the possibility that the area in question fell into any of 12 of the vegetation types selected. Should *Strelitzia nicolae* , *Phoenix reclinata* and *Acacia robusta* also be present, however, the indication would be that the area would fall into either the Moist or Dry Coast Forest, Thorn and Palm Veld. The demarcation between "moist" and "dry" vegetation types was to be 800 mm MAP. Examination of the rainfall map would then indicate whether the area was moist (over 800 mm MAP) or dry (less than 800 mm MAP) Coast Forest, Thorn and Palm Veld. The relative abundance of a species was also important and growth form could indicate that the plant was in a marginal area for its growth requirements.

Plant indicator species and communities were selected to assist in the identification of vegetation types and to detect transitional zones between them. These species are listed in Table 3.6 which was used as a recording sheet for the classification of BRUs in the field. In areas where major development had occurred, remnant plants and communities played a role. Frequently, however, even these were absent and then the success of exotic crops, their growth forms and their production levels, were used as indicators. It is important to recognise, however, that indigenous vegetation is the only reliable indicator of bioclimatic, or bioresource potential, despite the fact that the vegetation community or indicator species may be of a secondary nature. From a conservation point of view, it is important to attempt to map the vegetation communities as they were before major degradation or alteration occurred, as it may be considered desirable to attempt to preserve or reconstruct some of the earlier ecosystems to enhance biodiversity, particularly for those animals and plants requiring specialised habitats.

It was not considered important to recognise only undisturbed, or primary vegetation communities. Secondary communities are widespread, and a good example of this is the invasion of *Acacia* species into the Dry Tall Grassveld. This has, or should have had, a major influence on farming enterprises and management systems. It was felt that this should be recognised and so major secondary invasions, although they are ongoing, were used to defined BRG boundaries.

Wet and dry phases of one plant community were, in the case of the Bioclimatic Groups, often overlooked by users and this posed a problem in regional planning when a broad Bioclimatic Group was not truly representative of a specific farming enterprise or land use. The example of Bioclimatic Group 3 has been quoted in this respect (Section 1). This problem was overcome by separating what could be regarded as rainfed areas from areas that would require irrigation for crop production. This splitting of a plant community is artificial, but has practical implications for the use of the BRGs and the maps.

3.3.8 Additional criteria used for the classification of BRUs

Rainfall, temperature, soil and vegetation were the main criteria used in the classification of BRUs. Other factors which were recorded during the preliminary field survey included terrain type, slope, vegetation pattern, and extent of cultivation. All these additional criteria were recorded for each Land Type and were later referred to when final decisions had to be made.

3.3.8.1 Terrain type

Terrain types were recorded as:

mountainous;
valley;
broken (when slopes had abrupt changes of slope);
rolling (when slopes had smooth changes of slope) or
flat.

3.3.8.2 Slope

Slope, recorded as a visual assessment and not accurately measured, was indicated as:

gentle (0 to 5%);
moderate (5 - 12%) or
steep (greater than 12%).

3.3.8.3 Extent of cultivation

This was a generalised visual impression which could be improved upon by an inspection of the symbols for cultivation on the field map (Map 1). The extent of cultivation was recorded in broad categories as:

limited (less than 10% cultivated);
moderate (11% - 50% cultivated) or
widespread (> 50% cultivated).

All forms of cultivation, including areas under timber, were regarded as cultivated.

3.3.8.4 Vegetation types (Edwards, 1983)

These were described as:

forest;
scrub forest;
bushland;
bushland thicket;
woodland;
woodland thicket;
wooded grassland;
bushed grassland;
bush clump grassland;
grassland and
swamp.

These vegetation types are described and illustrated in Appendix 3.

Table 3.6 : Field recording sheet

BRU Code:	**LT/BRU code:**		**Topo-cadastral map no:**		
Rainfall symbol:			**Extent of cultivation:**		
Physiographic region symbol:			**TREES & SHRUBS**	**DOMINANT**	**PRESENT**
Terrain type:			*Athanasia acerosa*		
Slope:			*Berchemia zeyheri*		
Land type soil code:			*Boscia albitrunca*		
Vegetation type (1 - 23)			*Buddleja salviifolia*		
Vegetation pattern:			*Carrisa macrocarpa*		
GRASS SPECIES	**DOMINANT**	**PRESENT**	*Combretum mol. & apic.*		
Aloteropsis semialata			*Cyathea dregei*		
Andropogon eucomus			*Dichrostachys cinerea*		
Aristida congesta			*Diospyros (lyc)* scrub		
Aristida junciformis			*Euclea* spp.		
Bothriochloa insculpta			*Euphorbia ingens*		
Digitaria eriantha			*Euphorbia triangularis*		
Digitaria tricholaenoides			*Felicia filifolia*		
Diheteropogon filifolius			*Greyia sutherlandia*		
Eragrostis gummiflua			*Halleria lucida*		
Eragrostis superba			*Hyphaene coriacea*		
Festuca costata			*Lantana camara*		
Harpochloa falx			*Leucosidea sericea*		
Hyperthelia dissoluta			*Newtonia hildebrandtii*		
Hyparrhenia hirta			*Olea euro. sub. africana*		
Monocymbium ceres.			*Phoenix reclinata*		
Panicum maximum			*Podocarpus* spp.		
Pogonarthria squarrosa			*Protea* (large)		
Setaria incrassata			*Pteridium aqualinum*		
Sporobolus pyramidalis			*Rauvolfia caffra*		
Stiburus alopecuroides			*Rubus cuneifolia* (alien)		
Trachypogon spicatus			*Schotia brachypetala*		
TREES & SHRUBS			*Sclerocarya birrea*		
Acacia burkei			*Strelitzia nicolae*		
Acacia dealbata (alien)			*Syzygium cordatum*		
Acacia karroo			*Solanum mauritianum* (a		
Acacia mearnsii (alien)			*Spirostachys africana*		
Acacia nigrescens			*Terminalia sericea*		
Acacia nilotica			*Trichilia emetica*		
Acacia robusta			*Ziziphus mucronata*		
Acacia sieberiana			**Other Dominant spp.**		
Acacia tortilis					
Acacia xanthophloea					
Albizia adianthifolia					

3.4 Preliminary field survey

With the preliminary rainfall and physiographic region symbols on the base map (Map 1), the Midlands of KZN (Magisterial Districts of Pietermaritzburg, Umvoti, Weenen, Estcourt, Mooi River and Lions River), an area familiar to the author, was used to test these hypotheses. The Province was then travelled extensively in order to verify the codes on the field maps. The LTs had been mapped on the Vryheid, Mkuze and Richards Bay 1 : 250 000 maps and this assisted in the process of checking, in that the broad soil pattern codes were available. For the remainder of the Province, the classification of BRUs progressed ahead of the final production of the LT mapping and inventory production, and only preliminary field maps, without any accompanying resource information, were obtained to use as base maps for planning.

During the field survey, changes in soils, plant indicator species and the vegetation types, vegetation patterns or communities, as well as the other information required, were recorded on the field recording sheet. Agricultural land use and the growth forms of both indigenous and exotic plants were important, as well as crops grown, and the success of these crops, as these factors were useful indicators of climatic conditions. Changes in plant indicator species and growth form would often indicate a need to change the rainfall symbol of a proposed BRU, or to change the boundary. Care had to be exercised in recognising the relationship between rainfall and temperature and their combined influence on the growth form of plants, as well as the effects of soil form and depth in influencing growth form. Comparisons of the growth form of various plant indicator species in LTs where the rainfall was established with a reasonable degree of accuracy, helped to indicate an appropriate rainfall range.

While confirming, or adapting, the rainfall codes, the compatibility of adjacent LTs was considered and if rainfall symbols were the same and other factors like vegetation community, topography, and suitability for similar farming enterprises were compatible, the line between them was deleted and the final units became the proposed Bioresource Units. In this way one or more LTs became a BRU. In many cases, LTs types were split where a lack of homogeneity was apparent within a LT and the different divisions were assigned to the appropriate, adjacent BRUs. In some cases, LTs were split into three or four different BRUs. An example of the lack of uniformity encountered in some LTs is apparent on the mountain Tafelkop in the Greytown-Kranskop area. Tafelkop lies on the edge of a dry valley and the northern xerocline is covered in a thicket of *Acacia* species, while broad-leaved tree species are found on the southern mesic slope. All the slopes of Tafelkop have, however, been included in one LT. This LT was split, and the northern slope was included with other LTs to form a relatively dry BRU, while the portion on the southern slope was included in a BRU that was relatively moister than the BRU north of Tafelkop.

The broad soil patterns within the LTs were referred to as a parameter for changes in ecosystems and therefore BRUs. With few exceptions, once the climate and vegetation boundaries were defined, the soil patterns within the proposed BRUs were found to be acceptable. Where this was not so, the boundaries were re-examined to ascertain where discrepancies existed. These were usually found to be errors in either the judgement of rainfall or of the vegetation. In some cases, neither was considered to be at fault, and the inconsistency was accepted within the BRU.

Changes in topography were considered as proposed boundaries for BRUs where they created a marked change in the application of management. For example, where a proposed BRU changed from moderately sloping, rolling terrain, which was or could be extensively cultivated, to steep, rugged terrain, the latter prohibiting cultivation, a boundary would be introduced to separate the areas of differing topography, thus creating two BRUs from the originally proposed one.

Many areas in the Province were inaccessible, even by four-wheel drive vehicles. An example is the extremely rugged topography of the Valley of a Thousand Hills and in particular the many steep mountains with sandstone cliff barriers. For these areas, transparencies of the 1 : 10 000 orthophoto maps were studied in detail. Again, by comparing the patterns and textures on the photo with well known areas, a very good indication of the vegetation pattern could be gained. The texture of the grassland was a good indicator of veld type and rainfall, for example. In high rainfall areas, the texture on the photo is well-knit and smooth. This changes, as the rainfall decreases, to become increasingly broken and patchy. A similar pattern existed in timber plantations.

By placing the 1 : 50 000 field map, with a grid representing the orthophotos over it, adjacent to the orthophoto on a light table, information could be transferred from the orthophoto to the 1 : 50 000 field map. This technique was discovered rather late in the survey and was then used to verify decisions in other problem areas, even in areas of easy accessibility.

3.4.1 Summary of the preliminary field surveys

Step 1 :	Test hypotheses in the field in a familiar area (Pietermaritzburg, Umvoti, Weenen, Estcourt, Mooi River, Lions River)

Step 2 :	Field trips throughout KwaZulu-Natal Complete recording sheet for each Land Type * Terrain type * Slope * Vegetation type * Vegetation pattern * Plant indicator species Observe and indicate joining of compatible Land Types

3.5 Preparation of the proposed BRU map (Maps 2)

A second set of 1 : 50 000 topo-cadastral maps of the Province was obtained on which were marked the proposed BRUs, so eliminating all the non-essential LT boudaries. Many adjacent LTs were found to be compatible concerning the parameters selected to demarcate BRUs and these were then amalgamated into BRUs, and the outline inked in on Maps 2. Where the status of LTs remained uncertain, the outlines were retained as pencil lines. The information on the field recording sheets was found to be invaluable in the exercise of making decisions on the BRU boundaries.

3.6 Final field surveys for the BRUs

Maps 2, which had the proposed BRU boundaries marked on, were then taken into the field for final checking. With the confusion of lines on the maps reduced once the LTs boundaries were removed, there was much greater clarity. The second phase field surveys were carried out in different areas with one or more people who were considered to have a thorough knowledge of the area. The proposed BRUs were checked against the parameters defined on the field survey sheet. Once the BRU boundaries were found to be satisfactory, the BRU codes were marked on the maps.

3.7 Finalising the BRU Map

A final check on the rainfall symbols for those BRUs lacking rainfall stations and where estimated symbols had been allocated, was undertaken by comparison of these values with those of a 1' by 1' mean annual precipitation grid produced by the Computing Centre for Water Research (CCWR) (Dent, Lynch and Schultz, 1987). In some cases, field inspections were again done before the final rainfall symbol was allocated.

3.8 Numbering the BRUs

Each BRU had, by this stage, been given a climate code which would place it in a rainfall and altitude range. To identify each individual BRU, a number was then added to complete the code. This was done from north-west to south-east across the Province. Starting in the north-west corner of the Frankfort 1 : 250 000 sheet and moving across the map, numbers were added to the existing codes, each code having its own numerical order, for example, the first "Wc" encountered was given the number "1", that is, it would be coded "Wc1". The next "Wc" became "Wc2". Numbering was done progressively in this way across the Frankfort sheet, then across the Vryheid sheet and on to the Mkuze sheet, all of which have a common southern limit of 28° south. Numbering was then continued on the Harrismith sheet and on to the Richards Bay sheet and so on progressively across the Province.

There are many cases where BRUs are split into one or more units, for example where a flat area is split by a narrow, steep-sided valley which can be regarded as a completely different ecological area. Each of these spatial occurrences has the same natural resource description, and each occurrence is then identified by a lower case letter such as "a", "b" or "c" attached to the code, that is, Wc8a and Wc8b are separate occurrences of Wc8. The inventory describing the natural resources of this BRU will cover the spatial occurrences collectively, that is, there will be one inventory for the complete Wc8.

For the purpose of computer identification, each individual BRU was given a unique number so that the BRU in the extreme north-west of the Province is number 1 while the BRU in the extreme south-east has the number 590.

At this stage, the final Bioresource Unit map could be produced on 1 : 50 000 topo-cadastral maps. The final step was the digitizing of the BRU lines by the GIS staff of the Natural Resource Section of the Department of Agriculture at Cedara. To assist a user to identify a particular BRU, the BRU maps were produced on transparent material at a scale of 1 : 250 000 which could then be superimposed on the 1 : 250 000 topo-cadastral maps of South Africa.

An example of the BRUs of the Albert Falls area is provided in Fig. 3.1. A wide diversity in ecological conditions can be seen in this area. Tb10 is situated in the south-east corner of the map. It lies within an altitude range of 600 m to 700 m, has a MAP of 680 mm, and a MAT of 18.7°C. This is a dry Valley Bushveld unit with a vegetation pattern of bushland thickets. Slopes are moderate to steep and 40% of the area has high potential soils. Lying adjacent to the Mgeni River, there is good potential for irrigation.

Ub14 lies at an altitude range of 609 m to 950 m, with a MAP of 747 mm, and a MAT of 18.3°C. The vegetation type is Coast Hinterland Thornveld and it has a vegetation pattern of bushland thickets of *Acacia karroo, A. nilotica, A. sieberiana* and *Lantana camara.* There are both sandy soils and a high percentage of duplex soils. As a result of the relatively low rainfall and poor soils, the agricultural potential of the area is low.

Yb8 lies immediately north of the Mgeni River. This unit lies in an altitude range of 668 m to 1 130 m, the MAP is 993 mm and the MAT is 17.8°C. Frost occurs rarely in the unit. The dominant soil pattern consists of deep, well-drained soils and 73% of the area has high potential soils. The vegetation type is Moist Ngongoni Veld and most of the area is under cultivation, including sugar cane, maize, avocado, citrus and various timber species. With the good rainfall and soils, this unit has a particularly good agricultural potential.

Zc6 lies in an altitude range of 913 m to 1 680 m. It has a MAP of 1 152 mm and a MAT of 16.0°C. Lying in the Moist Midlands Mistbelt vegetation type, a high percentage of this BRU is covered by the Karkloof Forest. The main land use is commercial timber.

Wd14 lies in the Moist Highland Sourveld at the top of the escarpment above the Karkloof Forest and within an altitude range of 1 291 m to 1 763 m. The MAP is 826 mm and the MAT is 14.7°C. In this high-lying area severe frost is a frequent occurrence and snowfalls occur every two to three years (Moll, 1971).

These descriptions of the BRUs on the Albert Falls map provide a very good picture of the wide diversity that is found within relatively small geographic areas. The wide range of rainfall, temperature, vegetation types, and soil patterns results in a widely diversified land use potential. Numerous other smaller BRUs are also found within the area covered by this map, but only the larger units have been partially described to give an indication of the ecological diversity found within a relatively small area.

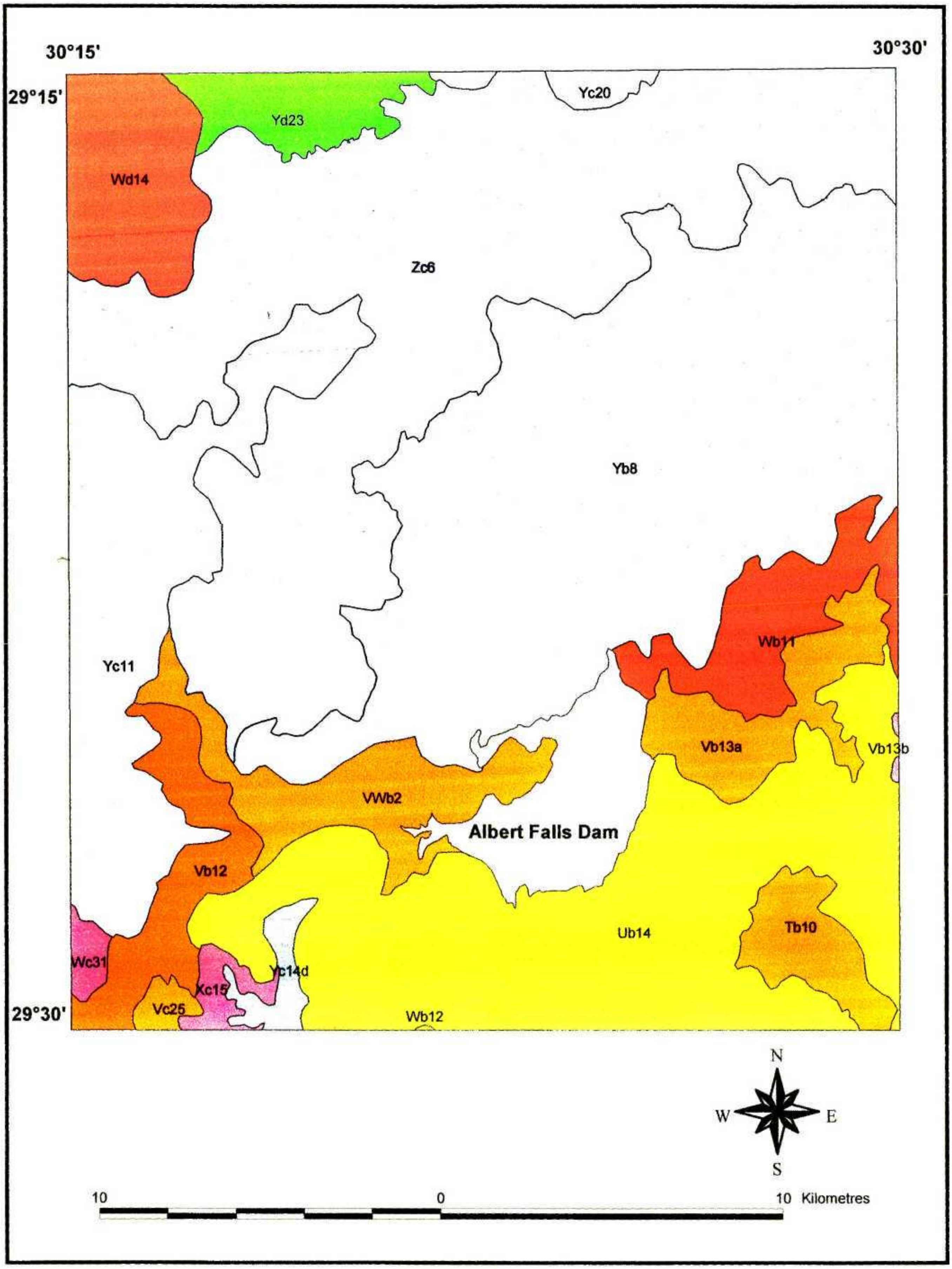

Figure 3.1 : The Bioresource Units of the Albert Falls Area (2930AD)

Chapter 4
ECOTOPES - CRITERIA FOR IDENTIFICATION

Despite the fact that the BRUs were demarcated to achieve a reasonable degree of homogeneity regarding the natural resources contained within them, factors such as rockiness, slope, soil form, depth and texture, can still vary widely within a BRU. This situation also occurs within most of the LTs. This indicates that there will be a considerable range in site specific potential within most BRUs. To determine this potential and the management necessary to achieve that potential, it is necessary to define the quality of the land in question in relation to the climate. The climate of the BRUs has been defined and restricted to fairly narrow ranges of rainfall, temperature and evaporation which, it is believed, will restrict the range of potential production. The remaining factor to be considered is the potential of the soil for production. This combination of factors forms a class of land which is referred to as an ecotope.

4.1 Definition of an Ecotope

The definition of an ecotope has been adapted from MacVicar *et al.* (1974), and MacVicar *et al.* (1986), to meet the role it plays in the context of the Bioresource Programme.

An ecotope is a class of land which is defined in terms of soil (form, texture and depth) and soil surface characteristics (rockiness and slope). The range of variation in these characteristics in an ecotope must be such that, in terms of the farming enterprises that it can support, the potential yield class for each enterprise and the production techniques required for these enterprises, the defined area will be uniform and there will be a significant difference between one ecotope and another. Further sub-divisions would not make significant differences in production or management practices.

Note : * An ecotope is a conceptual unit based on soil information extracted from the LT survey. The different ecotopes are not spatially defined in the programme, but are expressed as percentages of the total area of the BRU, which are transferred into physical reality when mapped after a survey. This applies to both crop and veld ecotopes.

* If potential production from different soil forms are insignificant, they are combined in ecotopes.

* An agricultural enterprise refers to a single form of land use such as maize, wheat, beef cattle or sheep.

* Each BRU has a climate table which defines a climate unique to that BRU. All the ecotopes within a particular BRU, while having varying descriptions of soil detail, will be subject to the climate of the BRU.

The LT survey was used in this study specifically to extract the valuable soil information it contains. This survey records the occurrence of different soil forms in the LT as an area and as a percentage of the total area of the LT, but it does not map the sites where the soils were found. In using the LT inventories to define the ecotopes, only information supplied by the inventories could be used and some important criteria had to be omitted. At the time when the LT were being mapped, the definition of the soil component centred on the soil series of the binomial system for South Africa developed by MacVicar *et al.* (1977). All the ecotopes were described using the soil forms defined in this system. Soil series were defined to separate forms into different ecotopes which have a marked difference in drainage. Since then a new taxonomic soil classification system for South Africa has been produced (Soil Classification Working Group, 1991). To assist those who are only familiar with the new classification system, a corresponding descriptions of the two systems (Manson, 1995), is given in Appendix A4.

When examining the procedure for defining ecotopes, it was decided to apply different criteria to crop and veld ecotopes as it was felt that the effects of the natural elements on crop and veld production are different, and that more precise information could be applied to the crop ecotopes, whereas broader parameters would be sufficient to define those for veld.

4.1.1 Description of a crop ecotope

Crop ecotopes are based on certain soil characteristics and each of these has a symbol, and a combination of the symbols provides a code for the crop ecotopes. These symbols are defined in Table 4.1.

Table 4.1 : Symbols relating to soil factors used for the identification of crop ecotopes

Symbol	Soil form (series), texture and depth
	Soil forms and series
A	Humic soil forms - No, Kp, Ia, Ma
B	Well-drained soil forms - Hu, Cv, Gf, Fw(10 - 22), Sd, Ct, Sp, Bv, Oa
C	Alluvial soil forms - Vf, Du
D	Plinthic and moderately drained soils (yellow-brown B horizons) and gleycutanic soil forms, - Av, Pn, Gc
E	Plinthic, gleycutanic and E horizon soil forms, poorly drained - We, Lo, Wa, Kd (10 - 15), Cf
F	Margalitic soil forms - Bo, Ik, My, Mw, Tk, Ar
G	Poorly drained margalitic soil forms - Wo, Rg
H	Shallow soil forms - Ms, Gs (< 300 mm)
I	Poorly drained soil forms - Ka, Kd (16 - 19), Fw (>30) and Wa and Lo in bottomlands .
J	Duplex soil forms - Sw, Va, Ss, Es
	Texture symbols
1	> 35% clay in A horizon
2	15 - 35% clay in A horizon
3	< 15% clay in A horizon
	Depth symbols
1	> 800 mm effective depth
2	500 - 800 mm effective depth
3	300 - 500 mm effective depth
4	200 - 300 mm effective depth
	Areas not considered for crop ecotopes
	Slope over 12%
	Rock complexes, solid rock
	Streambeds, rivers, pans and erosion areas
	Swamps, shifting dunes and coarse deposits
	Depth < 200 mm
	MB2, MB3, MB4 (degrees of arability recorded in the Land Type inventory)

Notes on Table 4.1

* All the above information is extracted from the Land Type inventory.
* The term A horizon refers to the top soil.
* The ecotopes are based on the binomial system for South Africa (MacVicar *et al.*, 1977)
* Red, and yellow-brown overlying red profiles, indicate a well-drained soil.
* Yellow-brown profiles indicate a moderately drained soil.
* The symbols A to I indicate an approximate order of soil potential for crop production, from high to low potential.
* Some soils do not belong precisely under the description for the symbol in which they have been placed, but have been placed in

the category considered appropriate to their crop production potential.

* The variation in cropping potential can be as great within a soil form as it is between soil forms.
* The effective depth of a soil refers to the depth within which no impediment to root development is found. Restriction to root growth can be caused by features such as rock, strong structure, or a poorly drained horizon.

A crop ecotope defined as B.1.1 would be a well-drained soil with a topsoil clay percentage exceeding 35% and a depth exceeding 800 mm. An ecotope described as B.1.1. could be found in BRU Wc8 and one of the same description could be found in BRU Xc5. Both these ecotopes have the same soil factors, but whereas the first ecotope is in a rainfall zone of 801 mm to 850 mm, the second is in a rainfall range of 851 mm to 900 mm. Other factors such as heat units and evaporation are likely to be different and so the potential crop production will be different for these two ecotopes.

4.1.2 Definition of a veld ecotope

The veld ecotope description fits within the general description of the ecotope, with uniformity referring particularly to productivity of the herbage and thus to grazing and browsing capacity.

Note:

* Vegetation patterns can indicate present and past management and as such are changeable. They are therefore not used to define the veld ecotopes and such information is not available in the LT inventory. The vegetation would, however, be recorded when describing a veld ecotope.

* Only information available in the LT inventory was used to define veld ecotopes.

* The aspect on which an ecotope is sited is an essential factor governing the growth of the veld but cannot be defined as it was not recorded in the LT inventory. This information must be recorded when field studies are carried out.

* The ecotope information, together with the climate records of the BRU, can be used to calculate grazing capacity.

* The veld ecotopes encompass the entire area of the BRU, notwithstanding the fact that much, or all of the area, may have been cultivated. The total area of the veld ecotopes will reflect the total area of the BRU.

It was again decided that broad parameters would be used to define the soil component of the veld ecotope. Certain grass species can act as indicators of soil condition, depth, texture and moisture status (Tainton *et al.*, 1976) (Van Oudtshoorn, 1992). Considering these indicator species, broad soil groups were selected, these being well-drained deep soils, well-drained shallow soils, margalitic, duplex, sandy, poorly drained, plinthic and wet soil forms. Examples of these soil groups and some of the grass indicator species occurring on them are listed below. Some of the soil types, such as plinthic and duplex soils, do not have grass species which can be readily related to them.

4.1.2.1 Soil types and indicator grass species

Well-drained, deep soil

A wide variety of grasses will grow in these soils. The main point is that productivity on deep, well-drained soils is likely to be higher than on shallow, well-drained soils.

Well-drained, shallow soil

Aristida adscencionis, Chloris virgata, Cynodon dactylon, Aristida barbicollis, Melinis repens, M. nerviglumis, Eragrostis racemosa, Microchloa caffra, Sporobolus stapfianus, Loudetia simplex, Eragrostis capensis

Sandy soil

Trichoneura grandiglumis, Pogonarthria squarrosa, Loudetia simplex, Hyperthelia dissoluta, Diplachne eleusine, Perotis patens

Margalitic soils

Bothriochloa insculpta, Setaria incrassata, Brachiaria eruciformis, Chloris mossambicensis

Wet soil

Paspalum urvillei, P. dilatatum, Andropogon eucomus

Poorly drained soil

Imperata cylindrica, Leersia hexandra, Phragmites australe, Hemarthria altissima, Acrosceras macrum, Ischaemum fasciculatum, Typha capensis (this species is not a grass)

Table 4.2 provides the symbols which are used to define the code for veld ecotopes.

Table 4.2 : Symbols used for the identification of veld ecotopes

Symbol	Soil form and series
A	**Well-drained soil forms,** (depth > 200 mm) - Kp, Ma, Ia, No, Ct, Sp, Vf, Av, Pn, Gf, Cv, Bv, Hu, Sd, Oa, Gs, Ms, Gc, Fw (series 10, 11, 12, 20, 21, & 22) and Du (if an alluvial layer with > 15% clay content is found, the Du will be included together with poorly drained soils under symbol P).
S	**Well-drained soil forms,** (depth < 200 mm), forms as above, but mainly Ms and shallow Gs
B	**Margalitic soil forms** - Ar, Bo, Tk, Ik, My, Mw, Wo and Rg (If the latter two are in bottomlands, they are placed under poorly drained soils, symbol P)
D	**Duplex and Plinthic soil forms** - Sw, Va, Ss, Cf*, Es*, Wa*, Lo*, We* and Kd*. If those marked with an * are in bottomlands, they are placed under poorly drained soils, symbol P
P	**Poorly drained soil forms** - Ka, Lt, Rg*, Wo*, Kd and Du. If those marked with an * are *in TU 1 to 4 they are placed under margalitic soils, symbol B. If Du soils have* < 15% clay, they are placed under group A.
V	**Vlei and wet soil forms** - Vlei, Ch and Fw (30, 31, 32, 40, 41, 42)
	Soil texture symbols
1	Greater than 15% clay in the A horizon.
2	Less than 15% clay in the A horizon.
	Slope symbols
f	Slopes up to 12%
s	Slopes greater than 12%
	Rockiness symbols
n	no mechanical limitations to cultivation, rocks can be present, but area arable
r	non-arable; large rocks, very shallow soil, lack of soil

Rocky areas and streambeds are recorded as such.

Notes on Table 4.2 :

* Symbol A refers to both well- and moderately-drained soils.
* The Dundee form can be relatively poorly drained if an alluvial layer with high clay content (>15%) is present.
* The shallow soils are, with few exceptions, Mispah and Glenrosa forms.
* *Margalitic soil forms situated on slopes other than bottomlands can be relatively dry and usually support grass species associated* with well-drained situations, whereas those situated in bottomlands are usually poorly drained and support hygrophilous grass species.
* Certain soil forms, which are difficult to place into the categories in Table 4.2, have been grouped with soils that are considered to have similar characteristics regarding grass growth. An example is the Kroonstad form which has a poorly drained B horizon and has been grouped with the duplex soils. When situated on slopes other than bottomlands, the Kroonstad form can be seasonally dry and has been placed with the duplex soils for convenience.
* the term "arable" is used to describe an area, or soil, that can be cultivated or ploughed, whereas "non-arable" refers to an area that has some restriction to ploughing such as excessive slope, rockiness or lack of depth.

4.2 Crop Production Models

Schoeman & Scotney (undated) stressed the need for an overall record of the natural resources and the ability to determine the agricultural potential of the country. A combination of the data base of the BRUs and the crop models assists in meeting this need. Crop production models developed by Smith (1993), were used to give an indication of the suitability of the ecotopes within the BRUs for specific crops and the levels of production that could be achieved. All the information used for the models is available in the BRU inventories and factors such as rainfall, altitude, temperature and evaporation are used. These factors are briefly described below.

4.2.1 Rainfall

A measure of the seasonal distribution of rainfall is required to cater for the different seasons in which crops grow.

4.2.2 Temperature

The energy status of the environment is indicated by temperature and this indicates the rate of growth of the plant. The measure of temperature is expressed as Heat Units which are calculated as the average daily temperature minus the base temperature below which the growth of a crop will cease. Crops have different base temperatures. Maize, soya beans and dry beans have a base temperature of 10°C; the base temperatures of lucerne and Italian ryegrass are 5°C and 4.4°C respectively. The daily Heat Units are calculated for the full growing season of a particular crop.

4.2.3 Evapotranspiration

The total amount of water that evaporates from the soil surface, plus the amount that is lost through transpiration from the plant, is known as evapotranspiration. The average evapotranspiration for a cropping season is taken as 0.75 of the evaporation measured by a Class A pan.

4.3 Application of the Crop Models

The crop production models utilise the soil information contained in the ecotopes and the climate data of the BRU to provide production figures for a range of crops in tons/ha/annum. These crops are maize, wheat, sugar cane, soyabean, dry beans, cowpeas, groundnut, cotton, banana, sorghum, sunflower, cabbage, potato, tomato, carrot and lucerne. Pasture yields can be calculated for kikuyu, coastcross II, star grass, *Eragrostis curvula*, Smuts finger grass, annual ryegrass, perennial ryegrass, tall fescue, oats (grown as a winter pasture) and veld. Timber production yields can be estimated for black wattle (bark and timber), *Eucalyptus grandis*, and *Pinus patula*, *P. elliotti* and *P. taeda.*

Schoeman & MacVicar (1978) emphasised the need for evaluating land by placing an agricultural potential on it. MacVicar (1974), described the meaning of the term "potential" in agriculture at several levels, including experimental, best farmer and specific farmer potential. He defines specific farmer potential as the adviser's estimate of what the farmer he is advising can achieve. For the purposes of the Bioresource

Programme it was decided to use an estimate of 70% of experimental potential, i.e., the agricultural reseachers' estimate of the acceptable practices in field trials in order to find that combination of practices which will give the best result. The figure of 70% is the level of management applied to the general farming community which can be adjusted by the adviser to meet any situation.

Chapter 5
BIORESOURCE GROUPS

5.1 Introduction

On completion of the mapping of the BRUs, it became apparent that many adjoining units, while having differing levels of agricultural potential, fell within the same vegetation type, one of the parameters used to classify BRUs. It also became apparent that the vegetation types could clearly define the broad agricultural enterprises that could be practised within them and that these differed in type or enterprise, or in the level of production or management from one vegetation type to another. It was decided to retain the defined vegetation types which then were called Bioresource Groups (BRGs). The difference between BRUs and BRGs is, then, a matter of scale. The BRUs are suitable for planning at farm or project level, while the BRGs are more useful for provincial or district planning purposes. There are 23 BRGs in KZN, and these are listed in Table 5.1 and illustrated in Fig. 5.1. Fig. 6.2 gives an example of a BRG with BRUs which are found within it, and example crop and veld ecotopes which could only be mapped after being identified in the field.

The BRG, which is essentially a grouping of BRUs with the same vegetation type, incorporates the same broad characteristics used to define the BRUs. The main emphasis of classification is, however, based on vegetation type and climate, and the BRG can thus be regarded as a bioclimatic group. Phillips (1973) defined a Bioclimatic Group as "a specific plant community and a corresponding specific complex of climatic and related soil factors which are reciprocally regulating and regulated" and "a complex of climatic conditions controlling the vegetation within a natural region. It is constituted by a certain interplay of climatic factors and biotic phenomena, so integrated as to permit the development of natural vegetation to a stage where this is in dynamic equilibrium within the climate".

Table 5.1 : Bioresource Groups of KwaZulu-Natal

BRG No	BRG Name	BRG No	BRG Name
1	Moist Coast Forest, Thorn & Palm Veld	13	Dry Tall Grassveld
2	Dry Coast Forest, Thorn & Palm Veld	14	Sour Sandveld
3	Moist Coast Hinterland Ngongoni Veld	15	Moist Lowland Tall Grassveld
4	Dry Coast Hinterland Ngongoni Veld	16	Dry Lowland Tall Grassveld
5	Moist Midland Mistbelt	17	Coast Hinterland Thornveld
6	Dry Midlands Mistbelt	18	Mixed Thornveld
7	Northern Mistbelt	19	Moist Zululand Thornveld
8	Moist Highland Sourveld	20	Dry Zululand Thornveld
9	Dry Highland Sourveld	21	Valley Bushveld
10	Montane Veld	22	Lowveld
11	Moist Transitional Tall Grassveld	23	Sandy Bush and Palm Veld
12	Moist Tall Grassveld		

5.2 Definition of the Bioresource Group

A Bioresource Group is a specific vegetation type controlled by an interplay of climatic and biotic factors such as soil and altitude. Note that :

* a BRG consists of a group of BRUs, each with the same vegetation type and related to one another in terms of climate and broad soil association patterns.

* a BRG may consist of one continuous unit of land, for example, BRGs 10 and 23.

* most of the BRGs consist of spatially separated units of land, for example, BRG 5, the Moist Midlands Mistbelt, occurs across the midlands of the Province and includes the districts of Melmoth, Kranskop-Greytown-Lions River-Richmond, Ixopo and Harding. All of these areas qualify as BRG 5, but are separated by the dry valleys of the Thukela, Mkhomazi and Mzimkhulu rivers. In this case, each separate unit is given an appropriate name and is numbered consecutively from north to south, that is, the Melmoth area is referred to as BRG 5.1 - Melmoth.

* in some cases, two areas close to one another may be separated by a narrow valley that belongs to another BRG. These areas are similar enough to have the same pattern of natural resources and are described under one inventory, for example BRG 5.1a and BRG 5.1b.

* some BRGs have internal divisions which would indicate that one or more factors within the area differ to the extent that a change in management requirements could, for example, be indicated. A good example is BRG 1, the Moist Coast Forest, Thorn and Palm Veld. It extends along the entire coastline of the Province and there is a very close correlation between it and Bioclimatic Group 1 of Phillips (1973) and the Coastal Forest and Thornveld of Acocks (1953), both of whom saw it as one unit. There is, however, a marked difference in temperature from north to south. In the north, the mean annual temperature is 22.0°C, while in the south it is 18.5°C. This can indicate an important difference in the type of crops, such as subtropical fruits, that can be grown, and the level of production that can be achieved. Soil types change considerably from north to south and it is along these lines that breaks in the unit have been mapped, with sands in the north, duplex soils in the area between Stanger and Empangeni, and Mispah and Glenrosa soil forms being dominant in the south. Insufficient knowledge of the effects of temperature on plant growth precludes divisions being made precisely on a temperature basis and so the changes in soils conveniently serve to break the BRG at regular intervals and give divisions for temperature as well. The result is that BRG 1 consists of five adjacent units numbered and named BRG 1.1 - Maputaland Coast, BRG 1.2 - Zululand Coast, BRG 1.3 North Coast, BRG 1.4 - Durban, and BRG 1.5 - South Coast.

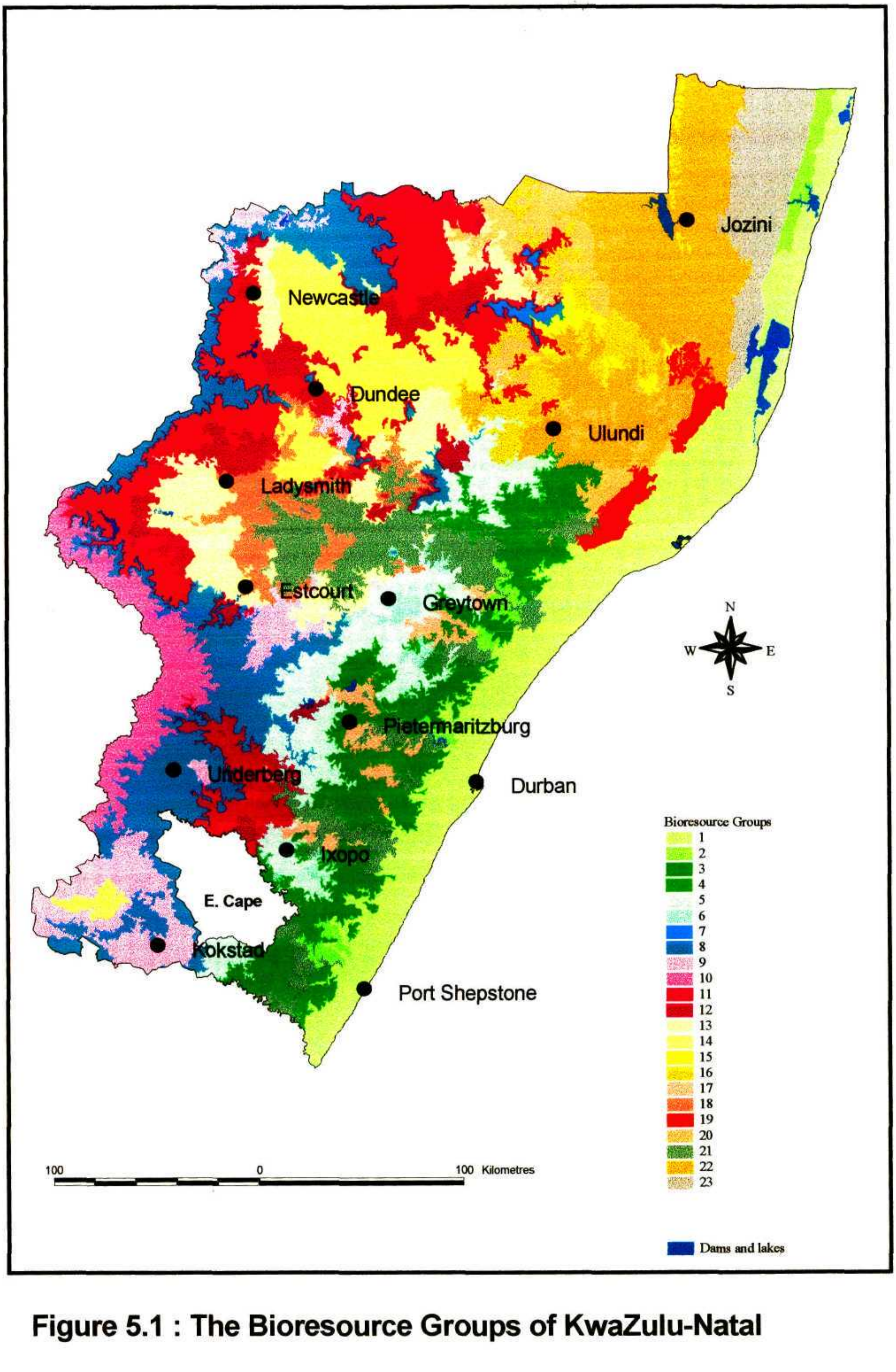

Figure 5.1 : The Bioresource Groups of KwaZulu-Natal

5.3 Planning and Mapping Procedures

The procedure used for defining the vegetation types was described in Chapter 3 and the physiographic regions which influence them were listed in Table 3.3. The physiographic regions give the approximate boundaries of the BRGs, although some of them overlap to a considerable degree.

5.4 The Classification of the Bioresource Groups and their Plant Indicator Species

While mapping the BRUs all identifying criteria were listed, including the vegetation type in which they were situated. Thereafter all BRUs occurring in the same vegetation type were grouped to form Bioresource Groups. Following the production of the final BRU map, an additional set of maps was produced at a scale of 1 : 50 000 which displayed the outlines of the BRGs only. These maps were then taken into the field with a group of specialists from the Department of Range and Forage Resources (formerly Grassland Science) of the University of Natal, and the Pasture and Natural Resource Sections from Cedara for final checking.

A summary of the justification for defining each of the BRGs (vegetation types) and a list of their plant indicator species follows. A list is given in tabular form in Appendix 5. Reference is made to the derivation of names and particularly to Pentz (1945), Acocks (1953), the Bioclimatic Groups (BCG) of Phillips (1973), and Moll (1971). Comparisons of the broad parameters used in the identification of the BRGs and the BCGs of Phillips (1973) are given in Appendix 6, while corresponding altitude ranges of the BRGs and those of Acocks (1953) and Edwards (1967) are given in Appendix 7.

In the brief descriptions of the BRGs, an abbreviated name is given in brackets for some of the BRGs. Various sources supplied information on trees (Pooley, 1993), and grasses including Tainton *et al.* (1976), Gibbs Russell *et al.* (1990) and Van Oudtshoorn (1992).

BRG 1 : Moist Coast Forest, Thorn and Palm Veld (Moist Coast)

[Acocks (1953) - Coastal Forest and Thornveld, Pentz (1945) - Coastal Evergreen Bush]. The name for BRG 1 was derived from Acocks and Pentz. "Palm" was added to cater for the occurrence of these plants in the BRG.

BRG 1 lies below 450 m above sea level and the range in mean annual precipitation (MAP) is from 800 to 1 272 mm. This ecological zone has been widely recognised by previous authors and is similar to BCG 1 of Phillips (1973). The primary veld has been mostly replaced by sugar cane and the remaining natural vegetation is severely disturbed. Indicator species were generally, however, found in small areas.

Plant indicator species: *Aristida junciformis, Sporobolus pyramidalis, Acacia karroo, A.nilotica, A. robusta, Carissa macrocarpa, Hyphaene coriacea, Lantana camara, Phoenix reclinata, Rauvolfia caffra, Syzygium cordatum, Trichilia emetica, Strelitzia nicolae, Albizia adianthifolia.*

BRG 2 : Dry Coast Forest, Thorn and Palm Veld (Dry Coast)

BRG 2 lies below 450 m altitude and the MAP ranges from 741 to 815 mm. The major difference between BRG 1 and BRG 2 is a change in the balance of the plant indicator species with an increase in the abundance of *Acacia* species, a result of the drier conditions. Coastal forest is absent and there is a reduction in the abundance of palms.

Plant indicator species: *Aristida junciformis, Digitaria eriantha, Sporobolus pyramidalis, Acacia karroo, A. nilotica, A. robusta, Hyphaene coriacea, Lantana camara, Phoenix reclinata, Rauvolfia caffra, Syzygium cordatum, Trichilia emetica, Strelitzia nicolae, Albizia adianthifolia.*

BRG 3 : Moist Coast Hinterland Ngongoni Veld (Moist Ngongoni Veld)

[Acocks (1953) - Ngongoni Veld, Pentz (1945) - Open Bush : Sandy. The name for BRG 3 was derived from the name given by Acocks].

This BRG lies between 450 and 900 m altitude and correlates very closely with the moist phases of BCG 2. The MAP range is from 804 to 1 159 mm. Humic topsoils and sandy profiles are common features.

Plant indicator species: *Aristida junciformis, Digitaria eriantha* (tall form), *Lantana camara, Rauvolfia caffra, Syzygium cordatum, Solanum mauritianum, Albizia adianthifolia.*

BRG 4 : Dry Coast Hinterland Ngongoni Veld (Dry Ngongoni Veld)

BRG 4 lies within an altitude range of 450 and 900 m and has a MAP ranging from 756 to 780 mm. The plant indicator species are similar to those of BRG 3, but there is a reduction in the abundance of *Aristida junciformis* and *Acacia karroo* is scattered sparsely across the landscape, being found particularly on termitaria.

Plant indicator species: *Aristida junciformis, Digitaria eriantha* (tall form), *Acacia karroo, Lantana camara, Rauvolfia caffra, Syzygium cordatum, Solanum mauritianum.*

BRG 5 : Moist Midlands Mistbelt

[Acocks (1953) - Natal Mist Belt Ngongoni Veld, Pentz (1945) - Temperate Forest. The name for the BRG was derived from Acocks, but abbreviated to meet the current common name applied].

BRG 5 lies between 900 and 1 400 m altitude and correlates with the broad definition of the moist phases of BCG 3, that is, BCG 3a, 3b and 3c, but by being classed as an area where the MAP exceeds 800 mm (a range of 801 to 1 276 mm), the agricultural potential is reasonably uniform throughout the BRG. Soil forms are generally apedal.

Plant indicator species: *Alloteropsis semialata, Aristida junciformis, Digitaria eriantha* (tall form), *Digitaria* *tricholaenoides, Harpochloa falx, Acacia dealbata, A. mearnsii, Cyathea dregei, Halleria lucida, Podocarpus* spp., *Pteridium acquilinum, Rubus cuneifolia, Solanum mauritianum.*

BRG 6 : Dry Midlands Mistbelt

This BRG lies generally at a lower altitude than BRG 5, but within the 900 to 1 400 m altitude range. The MAP ranges from 738 to 825 mm and is similar to the drier phases of BCG 3. Plinthic soil forms are common.

Plant indicator species: *Alloteropsis semialata, Aristida junciformis, Digitaria tricholaenoides, Harpochloa falx, Hyparrhenia hirta, Acacia dealbata, A. mearnsii, Rubus cuneifolia, Solanum mauritianum.*

BRG 7 : Northern Mistbelt

BRG 7 lies within an altitude range of 900 to 1 400 m and has a MAP range of 981 to 1 123 mm. It is similar to BRG 5, but differs in that *Aristida junciformis* is only rarely present, whereas in BRG 5 further south, this unpalatable grass has become the dominant species, thus reducing the value of the veld. Acocks (1953), described this area as North-Eastern Mountain Sourveld, whereas he saw the area in the south as Natal Mistbelt Ngongoni Veld, and so, he too, recorded them as areas of substantial difference. Soil forms are apedal.

Plant indicator species: *Alloteropsis semialata, Aristida junciformis, Harpochloa falx, Acacia dealbata, A. mearnsii, Cyathea dregei, Halleria lucida, Podocarpus* spp., *Pteridium acquilinum, Rubus cuneifolia, Solanum mauritianum.*

BRG 8 : Moist Highland Sourveld

[Acocks (1953) - Highland Sour Veld, Pentz (1945) - Highland Sour Veld. The titles provided by these authors have been retained, with "sourveld" as one word].

BRG 8 lies within an altitude range of 900 to 1 400 m and the MAP ranges from 800 to 1 265 mm. Phillips (1973), recognised the importance of defining different sub-regions within the Highland Sourveld. BCG 4a to 4e, are similar to BRG 8, and are characterised by highly leached soils, whereas BCG 4f and 4g have partially leached soils. The areas comprising BRG 9 have been separated from the areas in BRG 8 for the same reason. Soil forms are apedal and humic topsoils are common.

Plant indicator species: *Alloteropsis semialata, Digitaria tricholaenoides, Diheteropogon filifolius, Harpochloa falx, Monocymbium ceresiiforme, Trachypogon spicatus, Acacia dealbata, A. mearnsii, Athanasia acerosa, Buddleja salviifolia, Halleria lucida, Leucosidea sericea, Podocarpus* spp., *Protea* spp. (trees), *Pteridium acquilinum, Rubus cuneifolia.*

BRG 9 : Dry Highland Sourveld

BRG 9 lies within an altitude range of 900 to 1 400 m, usually at the lower limits of the range. In the Kokstad district a substantial area lies below 900 m which could place the area in BRG 6, but the low mean annual temperatures (Kokstad has a mean annual temperature of 14.7°C compared with 16.7°C at Mispah in BRG 6) indicates that it is better placed in a Highland Sourveld BRG. Plinthic soil forms are common and the MAP for most of the BRG is less than 800 mm. A major difference compared with Phillips' (1973) BCG 4f which occurs in the Kokstad district, is that areas which were described as BCG 8b now fall into BRG 9. BCG 8 is a mixed grassland (Dry Tall Grassveld), whereas in this area, although the MAP is low, the grass loses its palatability in the late summer and cannot support animals through the winter as mixed and sweetveld can. The relatively low temperatures, which reduce evaporation and increase the effective rainfall, are considered to play an important role in this regard. It was therefore decided to map it as a sourveld area, albeit very dry and locally regarded as "sweetveld". The MAP ranges from 620 to 816 mm in high-lying areas.

Plant indicator species: *Alloteropsis semialata, Digitaria tricholaenoides, Diheteropogon filifolius, Harpochloa falx, Hyparrhenia hirta, Trachypogon spicatus, Acacia dealbata, A. mearnsii, Felicia filifolia, Halleria lucida, Leucosidea sericea, Diospyros lycioides.*

BRG 10 : Montane Veld

[Pentz (1945) includes this area under Highland Sour Veld and Acocks (1953) deals with it under several titles. The title for the BRG is considered to be a general term for mountainous terrain].

The main body of BRG 10 lies above an altitude of 1 800 m, but the toe-slope of the "Little Berg" was used as a demarcation line for the lower limit of the BRG. Below this line, the rolling hills were regarded as Highland Sourveld (BRG 8). The MAP of this BRG is 900 to 1 389 mm. BRG 10 bears a close affinity to BCG 5 except that in the latter the "Little Berg" was described as BCG 4, or Highland Sourveld. Plant communities and climate differ considerably from the true Highland Sourveld, however, and the "Little Berg" was regarded as having a closer affinity to Montane Veld than to Highland Sourveld. It is recognised that great diversity in both plant communities and climate exist in BRG 10 as defined, but these differences can be readily obtained from the inventories of the BRUs and ecotopes defined for this area.

Plant indicator species: *Alloteropsis semialata, Festuca costata, Monocymbium ceresiiforme, Stiburus alopecuroides, Athanasia acerosa, Buddleja salviifolia, Cyathea dregei, Greyia sutherlandia, Halleria lucida, Leucosidea sericea, Podocarpus* spp., *Protea* spp. (trees), *Pteridium acquilinum.*

BRG 11 : Moist Transitional Tall Grassveld

[This BRG has been separated from the Tall Grass Veld of Pentz (1945) and the Southern and Northern Tall Grassveld of Acocks (1953), because both climate and soil patterns indicate that the potential is higher than the general areas defined by these authors].

BRG 11 lies at an altitude of 900 to 1 400 m and has a range in MAP of 800 to 1 116 mm. It is very similar to BCG 6 in description, but major differences in area demarcation now occur. The area stretching from Donnybrook to Lufafa Road, which was formerly described as Highland Sourveld, is now described as BRG 11. The Creighton district was described as BCG 6, but climate data indicate that the MAP is less than 800 mm, which places this area in BRG 12. Soil forms are generally apedal.

Plant indicator species: *Hyparrhenia hirta, Acacia dealbata, A. mearnsii, Diospyros lycioides.*

BRG 12 : Moist Tall Grassveld

[This BRG has been separated from the Tall Grass Veld of Pentz (1945) and the Southern and Northern Tall Grassveld of Acocks (1953), because both climate and soil patterns indicate that the potential is lower than BRG 11, but higher than the general areas defined by these authors].

BRG 12 lies in an altitude range of 900 to 1 400 m and has a MAP of 712 to 805 mm. It is similar to what Phillips (1973) defined as BCG 8, or Dry Tall Grassveld, and this BRG encompasses both the Northern and Southern Tall Grassveld of Acocks (1953). The term "moist" may be regarded as a misnomer, because in other BRGs this indicates an area with > 800 mm MAP. It is, however, regarded as a moister phase of the Dry Tall Grassveld (BRG 13). Plinthic soil forms are dominant and duplex soil forms may be encountered occasionally.

Plant indicator species: *Aristida congesta, Bothriochloa insculpta, Hyparrhenia hirta, Sporobolus pyramidalis, Acacia dealbata, A. karroo, A. nilotica, A. sieberiana, Lantana camara, Diospyros lycioides.*

BRG 13 : Dry Tall Grassveld

[This BRG has been separated from the Tall Grass Veld of Pentz (1945) and the Southern and Northern Tall Grassveld of Acocks (1953), because both climate and soil patterns indicate that the potential is lower than BRGs 11 and 12].

BRG 13 lies in an altitude range of 900 to 1 400 m and is regarded as typical Dry Tall Grassveld, with a MAP of 666 to 745 mm. This BRG is being invaded by *Acacia* species and will ultimately meet the criteria for BRG 18 unless drastic changes are made in veld management. Duplex and plinthic soil forms are common and erosion a feature in the veld and in cultivated lands. Most of the water courses have been eroded into dongas at some stage, but are showing signs of healing.

Plant indicator species: *Aristida congesta, Bothriochloa insculpta, Eragrostis superba, Hyparrhenia hirta, Sporobolus pyramidalis, Acacia karroo, A. nilotica, A. sieberiana, Ziziphus mucronata, Diospyros lycioides.*

BRG 14: Sour Sandveld

[Acocks (1953) - Natal Sour Sandveld, Pentz (1945) - Sandy Sour Veld. The title for the BRG has been derived from both these sources, but abbreviated to the title in common use in the Province].

BRG 14 lies in an altitude range of 900 to 1 400 m and has a range in MAP from 626 to 779 mm. This area was ignored by Phillips (1973) and included in BCG 8, the Dry Tall Grassveld. Acocks (1953), named it "Natal Sour Sandveld" and Edwards (1967) called it "*Tristachya-Digitaria* Grassland", both seeing it as an entity on its own. Climatically there is an insignificant difference between BRG 13 and BRG 14, but the difference in soil forms is highly important and it is therefore separated as a BRG in its own right. The Cedarville Flats area was mapped as BCG 8 in the past, but in fact differs considerably from the BCG 8 areas further north, just as it does from BRG 13. The most significant similarity this area has to any other is the nature of the sandy soils and so it has been demarcated as BRG 14 for this reason. The difference in climate (this area being much colder than the areas of BRG 14 in the north), is dealt with by providing a separate inventory for the Cedarville Flats.

It is important to note that there are ecotopes within BRG 14 which are atypical in that the soils have a relatively high clay content and are well-drained. These ecotopes should be readily recognised as having all the characteristics and potential of ecotopes of the same definition in BRG 13. Because the climate is very similar, they should have the same agricultural significance and potential as those in BRG 13. A similar situation occurs in BRG 13, where norms for BRG 14 could be applied to sandy ecotopes, that is, ecotopes which have soils with a clay content less than 15%. Duplex soils characterised by poor drainage, are a common feature of BRG 14.

Plant indicator species: *Alloteropsis semialata, Andropogon eucomus, Digitaria tricholaenoides, Eragrostis gummiflua, Monocymbium ceresiiforme, Pogonarthria squarrosa.*

BRG 15: Moist Lowland Tall Grassveld

[This BRG has been separated from the Tall Grass Veld of Pentz (1945) and the Northern Tall Grassveld of Acocks (1953). Climate and soil patterns indicate that it has a potential similar to that of BRG 11, but there is an infrequent occurrence of frost because of a lower altitude which is indicated by the term "lowland"].

This BRG, which lies between 450 and 900 m, has a MAP range from 800 to 999 mm. It lies in areas formerly described as BCG 2 and BCG 6, and which Acocks (1953) called the Northern Tall Grassveld. BRG 15 was defined separately from other tall grassveld areas because it lies in the lowland region, below an altitude of 900 m, where frosts occur infrequently and are then only of light intensity. Indicator species in these areas differ considerably from those tall grassveld areas lying above 900 m, an example being the presence of *Psidium guajava* (guava trees), which survive because of the lack of, or the low intensity of frosts. The climatic difference results in a marked difference in farming enterprises and the management techniques necessary.

Plant indicator species: *Alloteropsis semialata, Hyparrhenia hirta, Acacia mearnsii, Solanum mauritianum, Lantana camara, Rauvolfia caffra, Syzygium cordatum, Phoenix reclinata, Psidium guajava.*

BRG 16: Dry Lowland Tall Grassveld

[This BRG has been separated from the Tall Grass Veld of Pentz (1945) and the Northern Tall Grassveld of Acocks (1953). Climate and soil patterns indicate that it has a potential similar to those of BRGs 12 and 13, except that there is an infrequent occurrence of frost because of a lower altitude which is indicated by the term "lowland"].

BRG 16 has the same broad plant community as BRG 15, but is a drier phase, as reflected in the species composition. The MAP of this BRG ranges from 706 to 795 mm and it lies in an altitude range of 450 to 900 m.

Plant indicator species: *Hyparrhenia hirta, Sporobolus pyramidalis, Acacia karroo, A. nilotica, A. sieberiana, A. tortilis, Dichrostachys cinerea, Ziziphus mucronata.*

BRG 17: Coast Hinterland Thornveld

[Moll (1971) - *Acacia sieberiana* Wooded Grassland].

BRG 17 lies in an altitude range of 450 to 900 m and the range in MAP is from 644 to 825 mm. *Acacia karroo-A. nilotica-A. sieberiana* scrub has invaded the grasslands of the Dry Coast Hinterland Ngongoni Veld of BRG 4 from the Valley Bushveld of the lower valleys and BRG 17 is now a secondary veld. The effects of this invasion are such that the potential of the area and ecosystems have undergone considerable change. Consequently these areas require different management from the area in its original condition and this warrants the individual treatment of a separate BRG. In order for a BRU to be classified as BRG 17, the dominant vegetation type must be a bushland with indigenous *Acacia* spp. as the common plant indicator species (Appendix 5).

Plant indicator species: *Aristida junciformis, Panicum maximum, Sporobolus pyramidalis, Acacia karroo, A. nilotica, A. sieberiana, Dichrostachys cinerea, Lantana camara, Ziziphus mucronata.*

BRG 18: Mixed Thornveld

[Edwards (1967) - Interior *Acacia karroo-A. nilotica* Thorn Veld. Generally referred to by the farming community as "thornveld", this BRG has a mixture of broad-leaved species, particularly in the area transitional to the Valley Bushveld. This gave rise to the BRG title].

This BRG lies between 900 and 1 400 m and has a range in MAP of 651 to 786 mm. In BRG 18 *Acacia karroo-A. nilotica* scrub has invaded the Dry Tall Grassveld and this invaded area is treated as a separate BRG. Edwards (1967), stated that at least 60% of this invasion has occurred this century and that it is ongoing. An example of this invasion can be seen in the area between Estcourt and Frere. *Acacia* species have invaded up to and over the N3 highway and there is every likelihood that this invasion will progress across the Dry Tall Grassveld as far as the foothills of the Drakensberg in the future. This would mean a replacement of BRG 13 by BRG 18. Nevertheless, the demarcation of this invasive community is regarded as important, if only to draw attention to a need for drastic measures to maintain the grassland areas of BRG 13. Soil forms in this BRG tend to be shallow and rocky with a high presence of duplex and plinthic soil forms. Much of the bush encroachment has occurred in eroded areas.

In order for a BRU to be classified as a Mixed Thornveld area, bushland with indigenous *Acacia* spp. must be the dominant vegetation type.
Plant indicator species: *Eragrostis superba, Hyparrhenia hirta, Sporobolus pyramidalis, Acacia karroo, A. nilotica, A. sieberiana, Dichrostachys cinerea, Ziziphus mucronata.*

BRG 19 : Moist Zululand Thornveld
[Acocks (1953) - Zululand Thornveld. Acocks described a moist phase of the Zululand Thornveld which correlates well with BRG 19. Acocks' title is in general use and is therefore retained].

BRG 19 lies in the coastal and lowland regions and the MAP ranges from 760 to 846 mm.

Plant indicator species: *Hyparrhenia hirta, Sporobolus pyramidalis, Acacia karroo, A. nilotica, A. sieberiana, A. tortilis, Combretum apiculatum, C. molle, Dichrostachys cinerea, Euphorbia ingens, Euphorbia* spp. (trees), *Lantana camara, Rauvolfia caffra, Ziziphus mucronata.*

BRG 20 : Dry Zululand Thornveld
[Acocks (1953) - Zululand Thornveld. Acocks described a dry phase of the Zululand Thornveld which correlates well with BRG 20. Acocks' title is in general use and is therefore retained].

BRG 20 lies in the 450 to 900 m altitude range and has a MAP range of 678 to 788 mm. There is a considerable difference in the vegetation between the moist and dry phases of the Zululand Thornveld, particularly in the abundance of palm species in BRG 20, and this warrants separation.

Plant indicator species: *Hyperthelia dissoluta, Hyparrhenia hirta, Sporobolus pyramidalis, Acacia karroo, A. nilotica, A. sieberiana, A. tortilis, Dichrostachys cinerea, Euphorbia ingens, Euphorbia* spp. (trees), *Hyphaene coriacea, Lantana camara, Phoenix reclinata, Rauvolfia caffra, Ziziphus mucronata.*

BRG 21 : Valley Bushveld
[Acocks (1953) - Valley Bushveld. This title has been retained as it is in common use].

The MAP ranges from 595 to 830 mm. While Acocks (1953) defined the Valley Bushveld as a separate veld type, Phillips (1973) treated both the Valley Bushveld and the Lowveld as one Bioclimatic Group, that is, BCG 10. Considerable climatic difference occurs between the two areas and they are therefore treated as two different BRGs. The soil forms of this BRG vary widely from deep alluvial soils in the valley bottoms to shallow, rocky soils on the hills. Duplex soil forms are common and erosion is widespread. This BRG extends from the coastal region, through the lowland to the upland region.

Plant indicator species: *Aristida congesta, Bothriochloa insculpta, Eragrostis superba, Hyparrhenia hirta, Panicum maximum, Sporobolus pyramidalis, Acacia karroo, A. nilotica, A. robusta, A. tortilis, Berchemia zeyheri, Boscia albitrunca, Combretum apiculatum, C. molle, Dichrostachys cinerea, Euclea* spp., *Euphorbia ingens, Euphorbia* spp. (trees), *Felicia filifolia, Olea europaea* subsp. *africana, Schotia brachypetala, Sclerocarya birrea, Spirostachys africana, Ziziphus mucronata.*

BRG 22 : Lowveld

[Acocks (1953) - Lowveld. This title is in general use and is therefore retained. The Valley Bushveld and the Lowveld were treated by Phillips (1973) as a single entity. The Arid Lowveld (Acocks, 1953) and Bioclimatic Group 11 (Phillips, 1973), are incorporated in BRG 22 because insufficient indications of change could be found to justify a separation from the Lowveld].

The Lowveld lies below 450 m in the coastal zone and has a MAP range of 587 to 750 mm. Phillips' treatment of the Valley Bushveld and the Lowveld as one entity was not satisfactory as there is a significant difference in climate between the two areas with frost being a feature of the Valley Bushveld, but it is extremely rare in the Lowveld. This difference in winter temperatures has an effect on the species found in the areas and the type of crops that can be grown.

Plant indicator species: *Aristida congesta, Bothriochloa insculpta, Eragrostis superba, Hyperthelia dissoluta, Panicum maximum, Setaria incrassata, Sporobolus pyramidalis, Acacia burkei, A. karroo, A. nigrescens, A. nilotica, A. robusta, A. tortilis, A. xanthophloea, Berchemia zeyheri, Combretum apiculatum, C. molle, Dichrostachys cinerea, Euclea* spp., *Euphorbia ingens, Euphorbia* spp. (Trees), *Hyphaene coriacea, Olea europaea* subsp. *africana, Phoenix reclinata, Schotia brachypetala, Sclerocarya birrea, Spirostachys africana, Terminalia sericea, Trichilia emetica, Ziziphus mucronata.*

BRG 23 : Sandy Bush and Palm Veld

The MAP range of this BRG is from 635 to 730 mm and it lies below an altitude of 450 m. This area was incorporated in the Lowveld and the Coast Forest and Thornveld by Acocks (1953) and in BCG 10 and BCG 1 by Phillips (1973). The fact that this area is based on sandy soils and has distinctive plant species such as *Newtonia hildebrandtii, Hyphaene coriacea* and *Terminalia sericea,* justifies its demarcation as a BRG. As the name implies, sandy soils are common. In the Sand Forest areas the soils are deep and well-drained whereas in the Palm Veld areas the sandy topsoils overlie poorly drained subsoils (Bruton & Cooper, 1980).

Plant indicator species: *Pogonarthria squarrosa, Acacia burkei, Hyphaene coriacea, Newtonia hildebrandtii, Phoenix reclinata, Terminalia sericea, Trichilia emetica.*

Chapter 6
APPLICATIONS OF THE BIORESOURCE PROGRAMME

6.1 Introduction

In the Bioresource Programme, three levels of land systems came to be developed. Initially the intention was to map BRUs, with a second level of ecotopes, which were to be sub-units of the BRUs with finer, more restricted parameters. On the completion of the mapping process it had became apparent that the size and number of the BRUs would mean that the very large developing data base could be effectively processed only by a Geographic Information System (GIS), although at the farm planning level the data base of BRUs covering the farm, or area concerned, would be of great value.

The role that vegetation types could play in identifying the boundaries of BRUs had become evident at an early stage of mapping, and plant indicator species and communities were identified for this purpose. The decision was then made to produce a map of the vegetation types which could effectively be used as a map for wider reference purposes and for regional and provincial planning purposes. These new units became known as Bioresource Groups (BRGs). In Fig. 6.1 an example of the three levels of land systems, the veld and crop ecotopes, BRU and the BRG are illustrated. It is important to note that the ecoptopes can be mapped only once they have been identified in the field. Those mapped in fig. Fig 6.1 were not surveyed, but give an example of the possible ecotopes of this area. Each of the three levels of land systems in the Bioresource Programme plays a distinct role.

6.2 The Role of the BRU

There is sufficient uniformity in the climate and soil pattern within each BRU to give a good indication of the types of farming enterprises suitable to the area, the productivity that can be achieved and the management techniques required. The potential benefits for agriculture can, therefore, be many for regional planning, advisory and extension services, and for research purposes. Examples are listed below.

6.2.1 Provincial and regional planning purposes

* The Province, regions, defined areas, districts, catchments etc., can be evaluated for the quality of their natural resources.

* Areas can be evaluated and mapped to indicate where particular crops can be grown, and the potential yields of these crops. The potential of the Province, region, or a defined district to produce food requirements, can thus be assessed.

* Areas with highly sensitive natural resources can be identified before high impact development is planned.

* Natural boundaries can be defined for regional planning and for land use purposes.

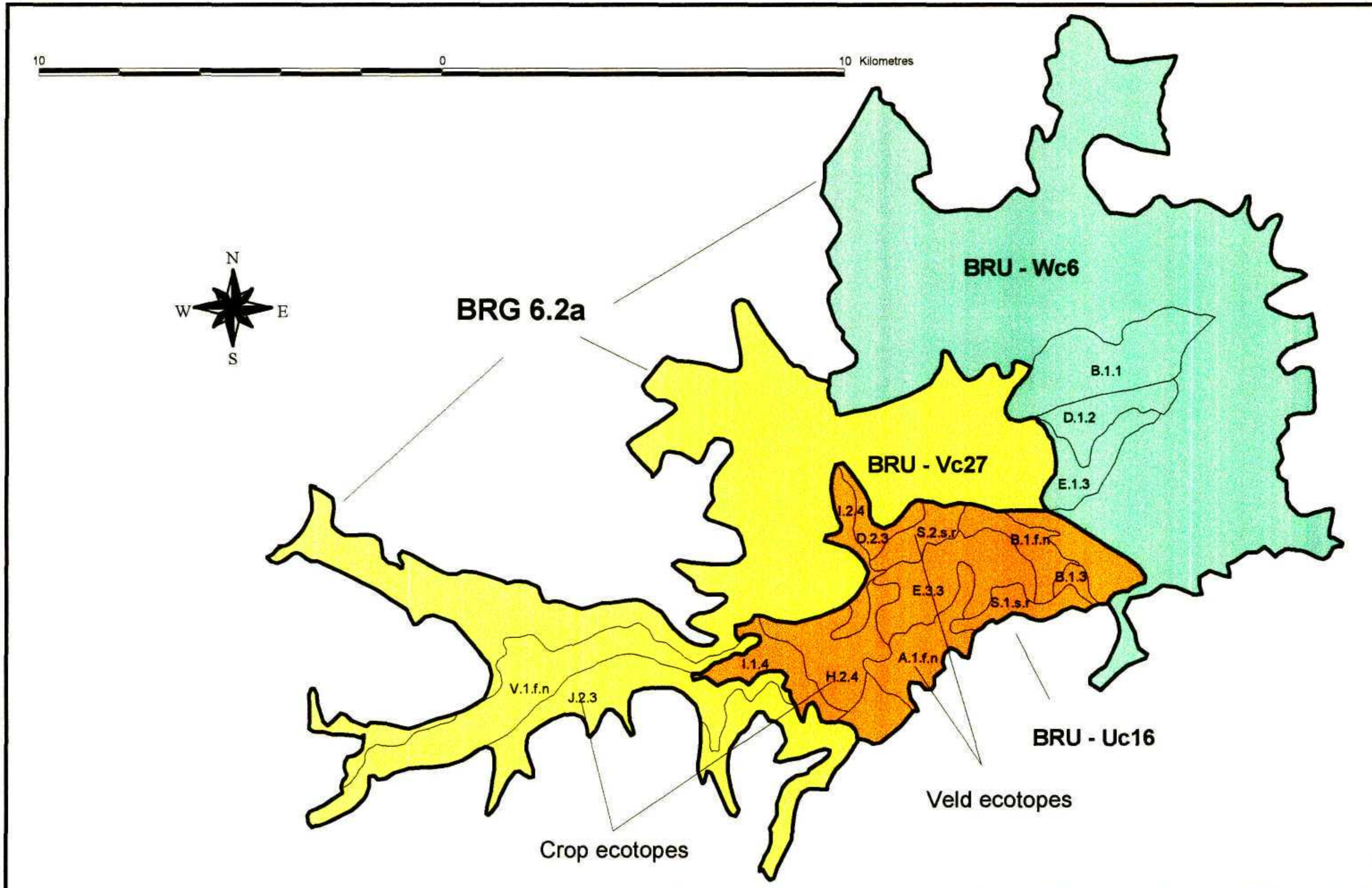

Figure 6.1 An Example of a Bioresource Group with Bioresource Units and Ecotopes

6.2.2 Advisory and extension purposes

* The data base of the BRU will supply the basic information to enable advisers to provide assistance to farmers on a wide range of resource-based subjects.

* Advice can be provided relative to specific resource situations.

* Programmes can be based on reliable resource situations and needs.

6.2.3 Research purposes

* Research programmes can, to a large extent, be prioritised according to the extent and the potential of the natural resources of any particular area.

* A lack of information concerning a BRU and an inability to provide satisfactory predictions of yields and associated cropping techniques for a BRU, could indicate a research need, particularly for those BRUs which represent large areas of high potential land.

Similar benefits can be derived in other fields of study. The environmental factors defined in a BRU should give an indication of habitat suitability for both plant and animal species. On the other hand, knowing the habitat requirements of any particular species, it should be possible to map locations suitable for such species.

6.2.4 Availability of information on the BRUs

Transparent maps of the BRUs covering each 1 : 250 000 topo-cadastral map of KZN are available from the Natural Resource Section (NRS), Cedara. By placing these overlays on the topo-cadastral maps, the relevant BRU(s) for a farm, or area, can be identified. The inventories for the BRUs are also available from the N R S. In addition, a "user friendly" computer programme has been developed which can access any BRU inventory and the inventory, or any specific information from the inventory, can be printed. An example of a BRU inventory is given in Appendix 8.

6.3 The Role of the Ecotope

Both crop and veld ecotopes have been defined in Sections 4.1.1 and 4.1.2.

6.3.1 The crop ecotope

Crop ecotopes may, or may not, be under cultivation, but will reflect the soil situation in the BRU. They are not mapped and can be mapped only once soils have been surveyed and identified in the field. The total area of all the crop ecotopes in a BRU should indicate the area of arable land, but is unlikely to reflect the total area of the BRU because certain areas would be considered non-arable.

The crop ecotope can be used to:

* define agricultural and other norms to a precision beyond which further definition of the resources would not be significant;
* define land potential, agricultural and industrial waste potential;
* locate crop production area suitability and the potential production of areas with the climate data of the BRU in which it is located, and with the crop production models;
* evaluate land for most other forms of development and use;
* indicate zones of erodible soils;
* identify areas suitable for land use such as building development, forestry and hydrological planning;
* plan situation surveys;
* function as a data base for storing research data;
* select and describe research sites and interpret research results;
* indicate where norms need to be collected or where research is lacking;
* function as a data base for soil surveys and be used as a standard for soil mapping;
* decide priorities for research;
* plan runoff potential and sediment loads;
* detect potential distribution of troublesome plants; and
* site engineering works.

6.3.2 The veld ecotope

The total area of the veld ecotopes listed in the BRU inventory will represent the total area of the BRU. They are not mapped and can be mapped only once they have been identified in the field. They have been classified using Land Type information and lack certain important criteria for a veld ecotope, such as aspect. This information can be gathered only when identifying the ecotope in the field. Many of the ecotopes in the inventory may have been cultivated and in the case of a BRU that is totally under cultivation, no veld will be present, but veld ecotopes have been defined for each BRU to provide veld norms when they are found to exist.

The veld ecotope can be used to:

* provide potential and current grazing capacities (ha/AU), expressed as the area (hectares) required to support one animal unit (AU) for the growing season; and
* provide potential and current grazing days per hectare, a measure of grazing pressure which is measured as the number of AUs in a defined area for a set number of days, i.e. (AUs x days in camp) ÷ area of camp.

6.4 The Role Of The Bioresource Group

The Bioresource Group can be used to define broad ecological areas for extensive planning purposes (mainly Provincial) in a similar way to which the Bioclimatic Groups of Phillips (1973) were used. It is used for a general description of the Province for reports and several broad norms and maps can be produced using BRG information. These mainly involve veld management norms including grazing capacity, veld burning regulations and benchmarks for veld condition. Maps relating to these subjects can be produced.

Each BRG will define a broad degree of homogeneity such that the suitability of farming enterprises can be defined. For example, each BRG can be classified according to its suitability for different lines of farming such as crops, beef farming, deciduous or subtropical fruit production.

6.4.1 Availability of information on the BRGs

Maps of the BRGs and their separate spatial occurrences are available from the NRS, Cedara. Descriptions of the BRGs are supplied in accompanying volumes. These descriptions include locality, vegetation description and veld ecotopes, soil ecotopes, water resources, land use and potential. An example report is given in Appendix 9.

The descriptions of the BRGs are contained in six volumes, i.e.,

* Coast and Coast Hinterland, containing BRGs 1, 2, 3, 4.
* Mistbelt, containing BRGs 5, 6, 7, 11.
* Highland and Montane, containing BRGs 8, 9, 10.
* Tall Grassveld, containing BRGs 12, 13, 14, 15, 16.
* Thornveld, containing BRGs 17, 18, 19, 20.
* Bushveld, containing BRGs 21, 22, 23.

A scale of 1 : 750 000, where the identification of the different spatial occurrences of the BRGs can be easily read, is convenient for reference purposes. For report purposes, the map can be produced on A3 or A4 size on which the BRGs are printed in different colours but only the BRG numbers 1 to 23 are printed. Separate maps of each BRG can be produced on A4 pages.

6.5 The Role of the Geographic Information System (GIS)

The data base of the Bioresource Programme is stored in a GIS and can be used to produce a wide variety of interpretive maps for planning or display purposes. These maps include:

* rainfall distribution;
* temperature ranges;
* soil potential for crop production;
* vegetation types;
* the extent of cultivation;

* general land potential for agriculture;
* land degradation;
* potential crop production areas and the yield potential of the areas indicated;
* potential areas for orchard crops; and
* planting dates of different localities for potatoes, tomatoes and other vegetables.

* Examples of the maps that can be produced are shown in Figs. 6.2 - 6.8.

6.6 Agricultural Information Centres

The BRU/GIS system will be used to develop agricultural information centres at agricultural offices (not necessarily of the Department of Agriculture). The intention is to have a single room dedicated for the purpose and maps displaying agricultural information superimposed over the land ownership and tribal authority patterns of the district concerned will be displayed on the walls of the room. For every map there will be an accompanying set of pamphlets covering the subject of the map. Computer programmes will be supplied which will supply information from the data base and enable the user to manipulate the information. The system will be designed for use by any visitor, irrespective of his/her knowledge or experience in agriculture, and will be of particular value to the less experienced Extension Officer in complex areas with a wide range of farming enterprises.

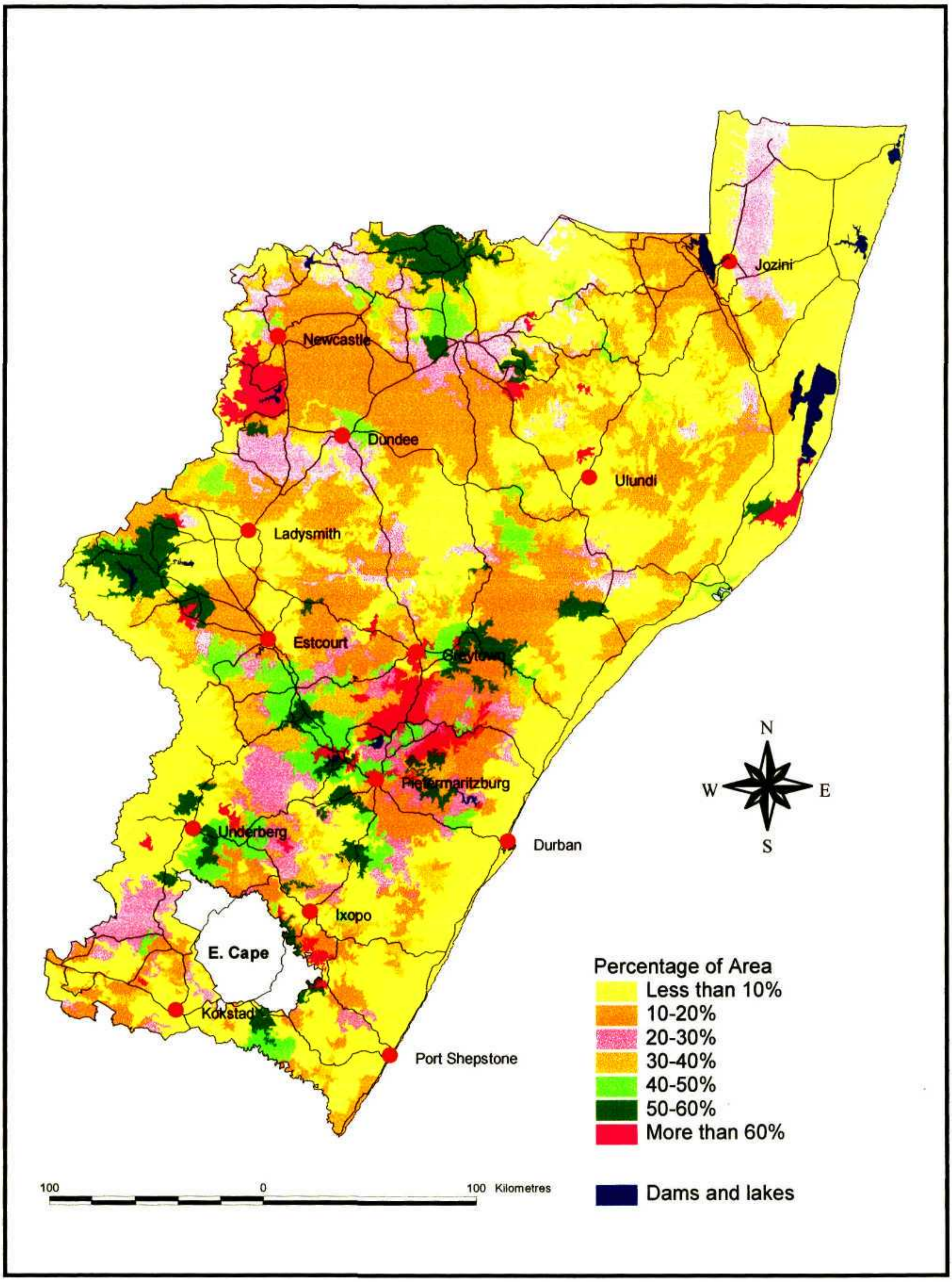

Figure 6.2 : The Distribution of High Potential Cropping Soils in KwaZulu-Natal

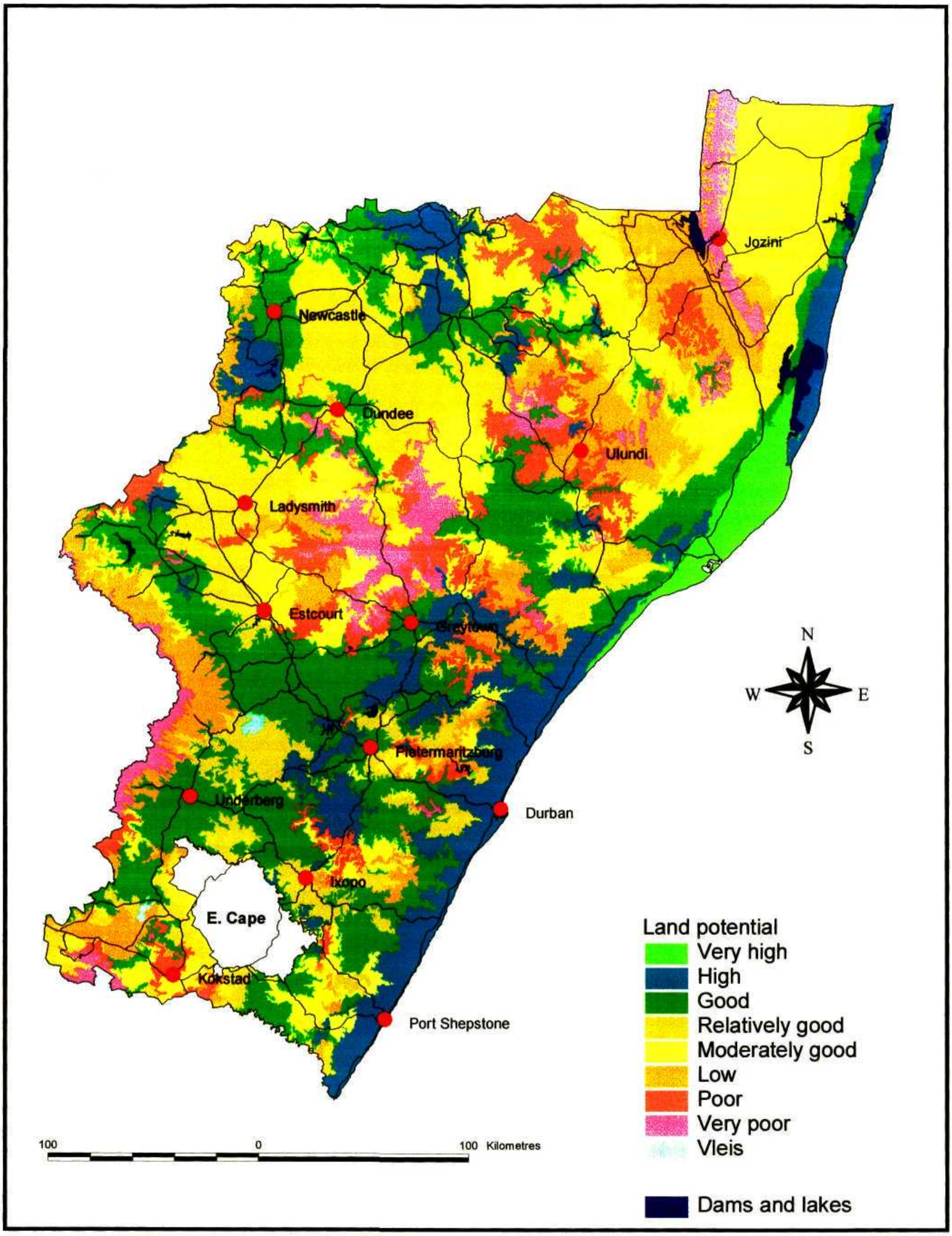

Figure 6.3 : Agricultural Land Potential in KwaZulu-Natal

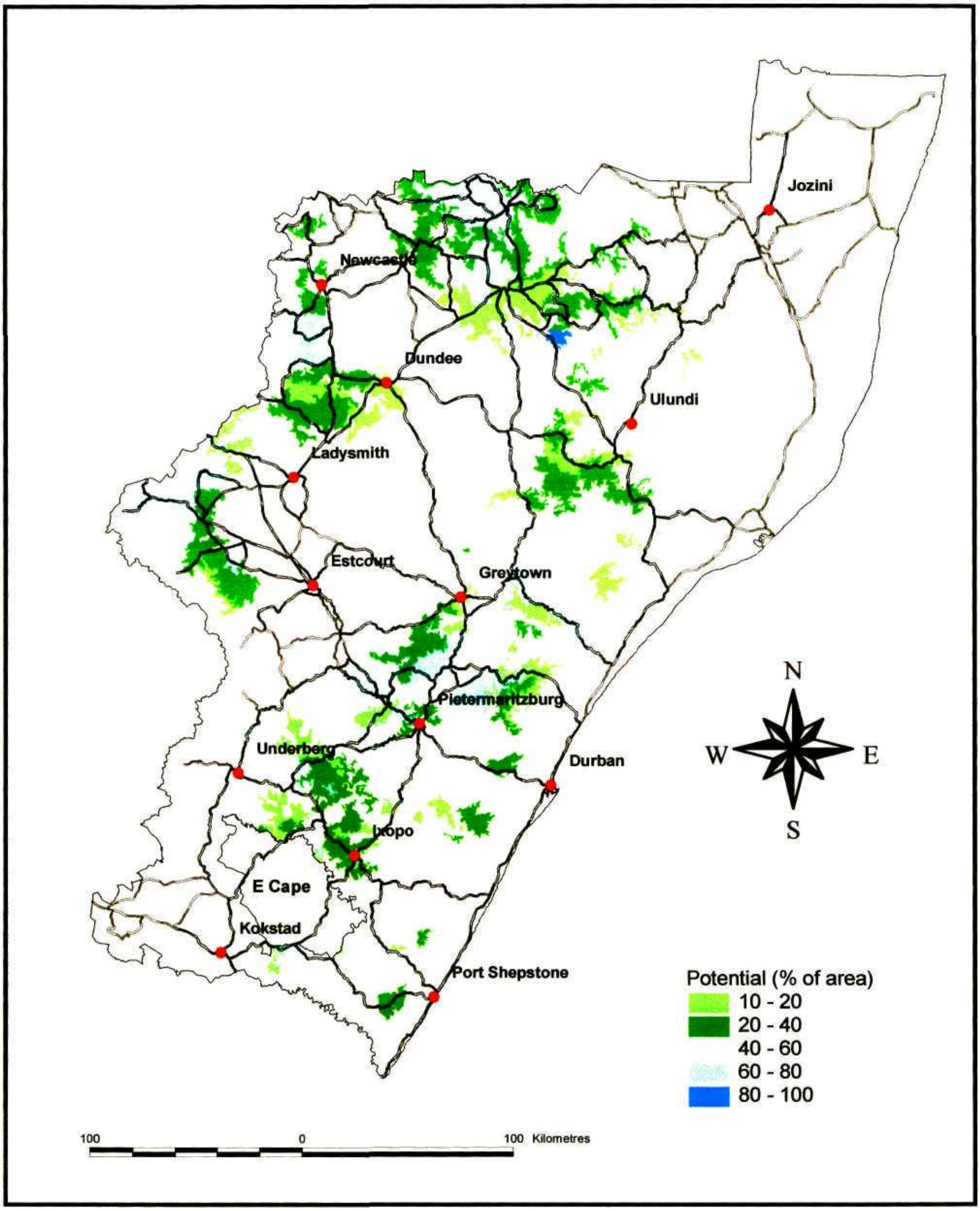

Figure 6.4 : Dryland Maize Production in KwaZulu-Natal : 5 tonnes/ha threshold

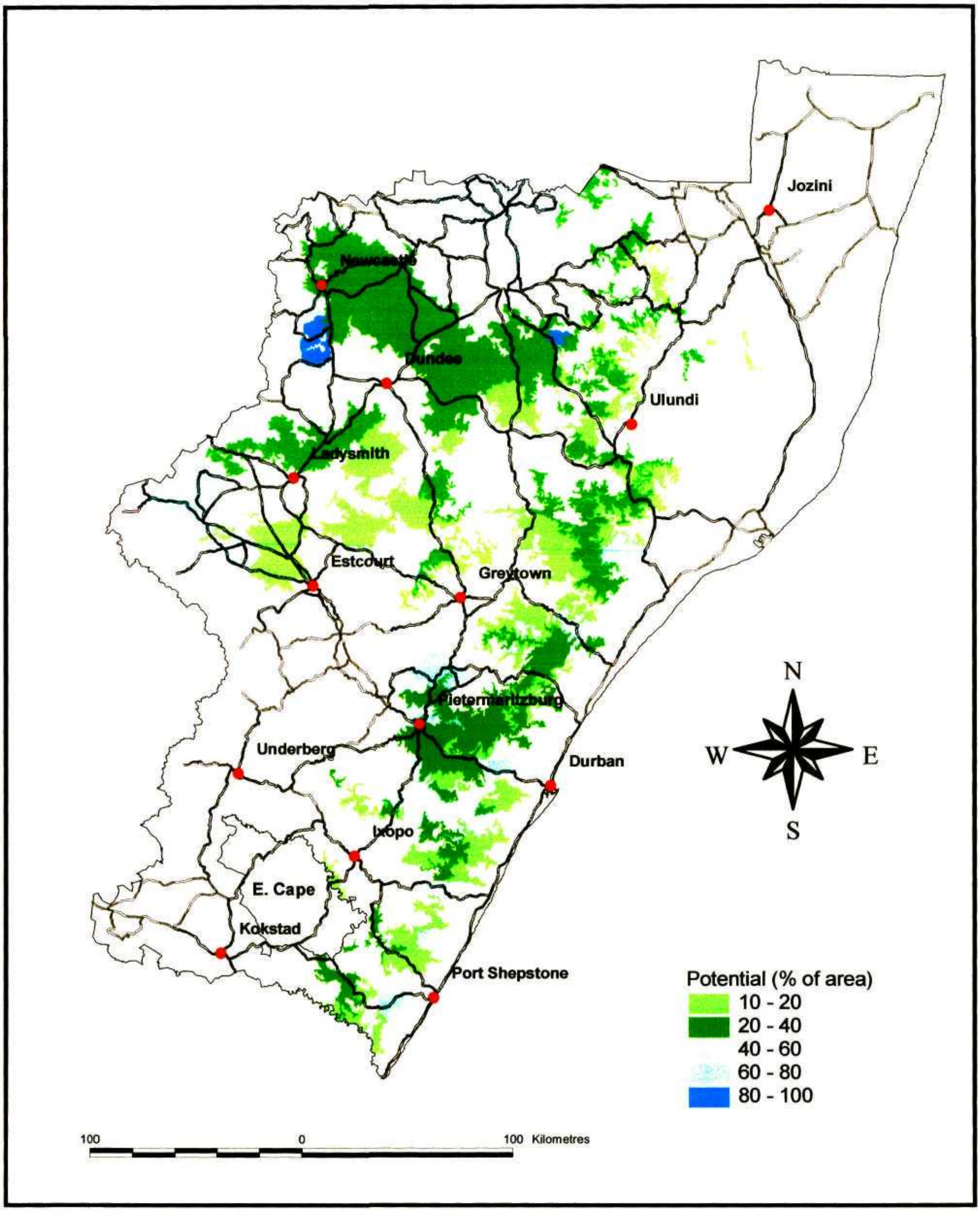

Figure 6.5 : Dryland Sorghum Production in KwaZulu-Natal : 3 tonnes/ha threshold

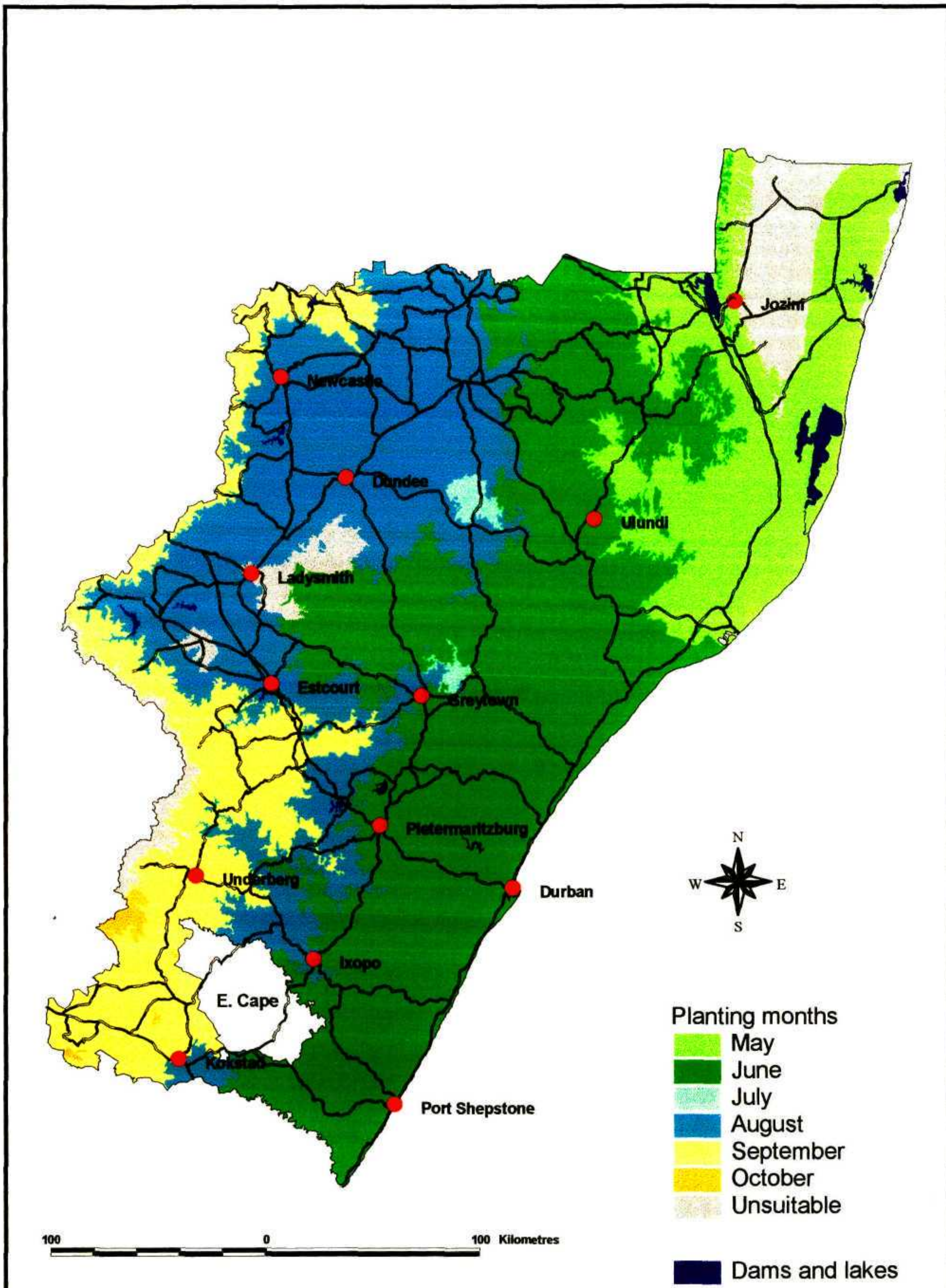

Figure 6.6 : Recommended Potato Planting Months in KwaZulu-Natal

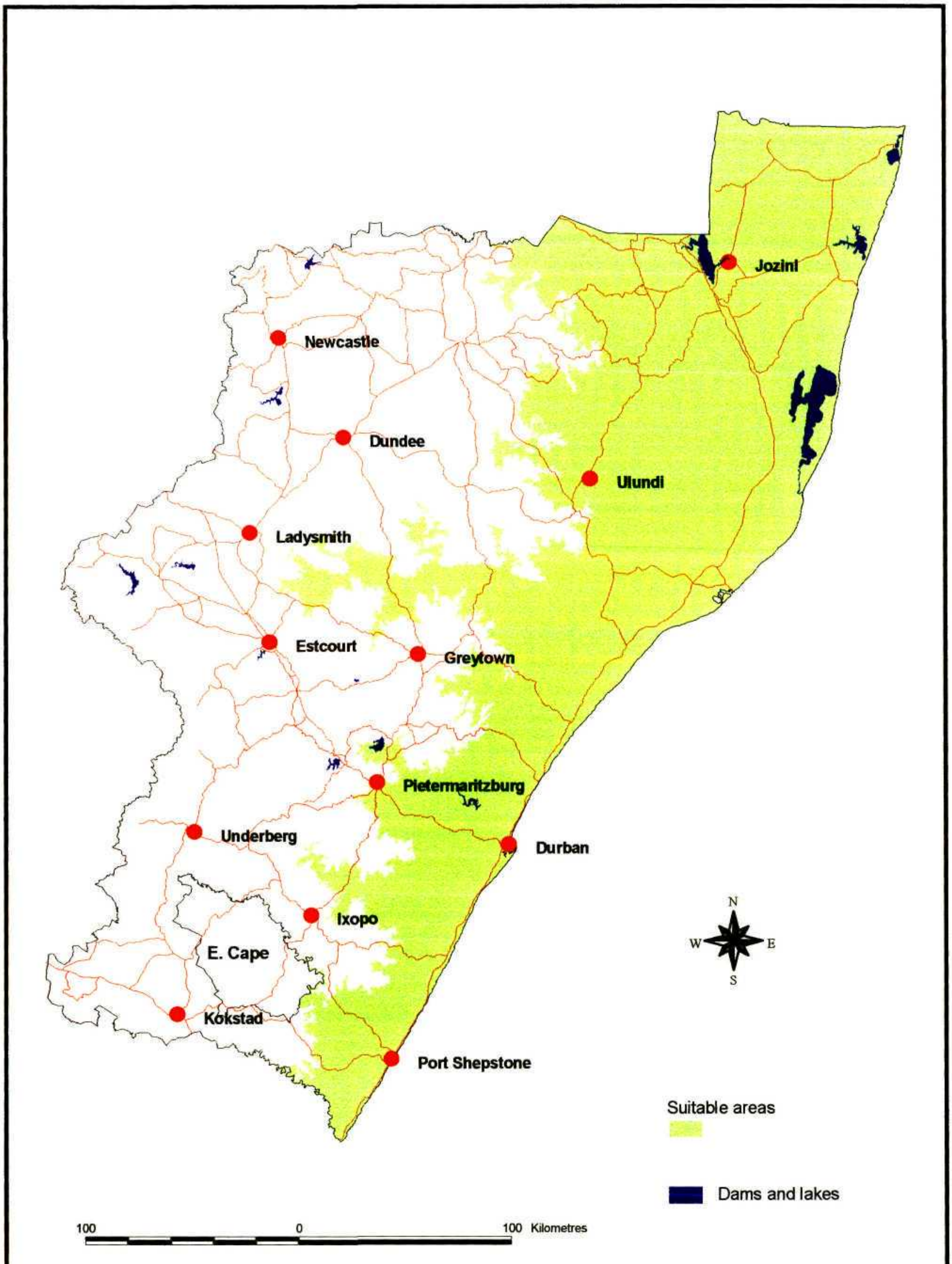

Figure 6.7 : Areas Suitable for Valencia Orange Production in KwaZulu-Natal

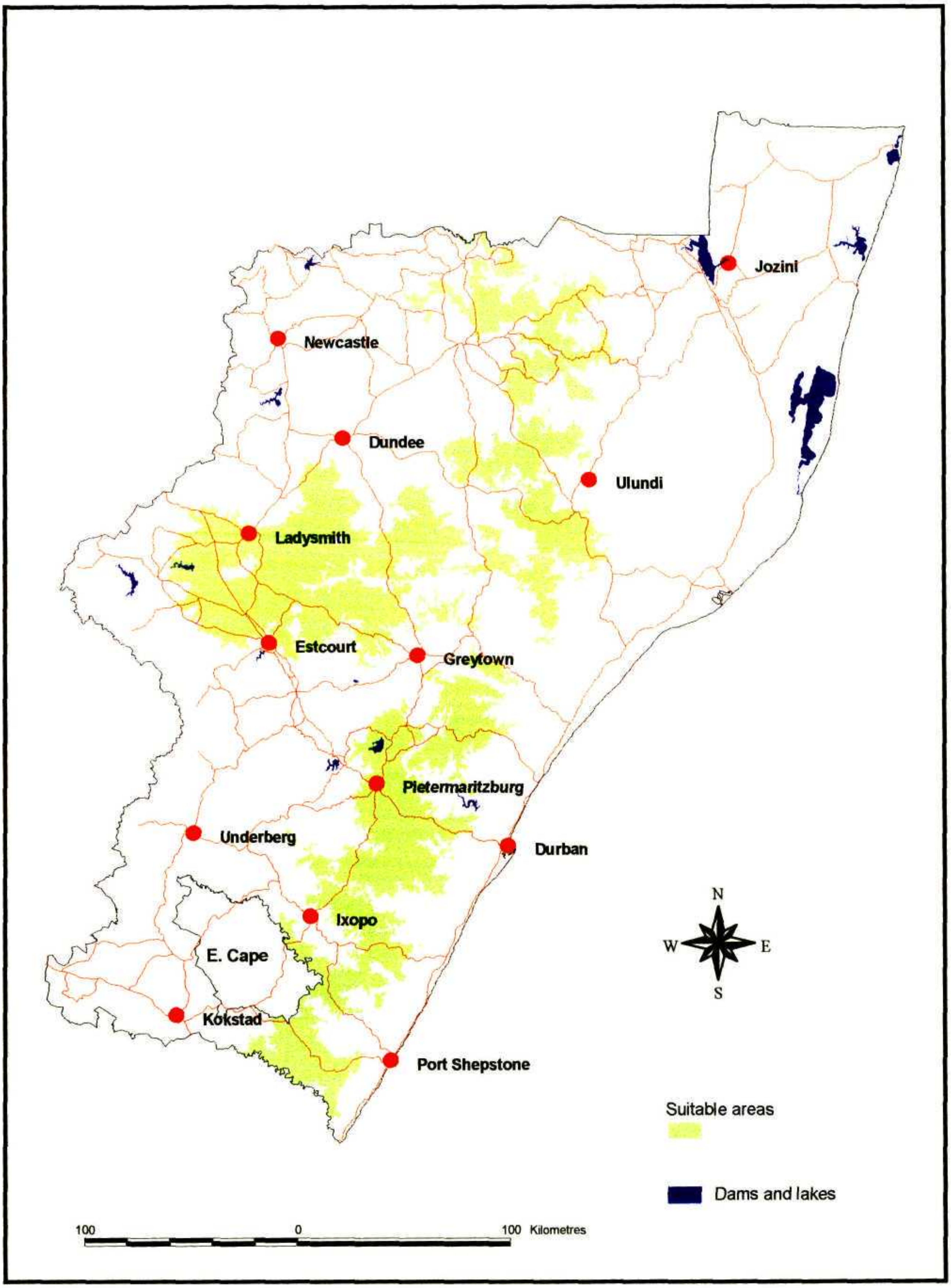

Figure 6.8 : Areas Suitable for Navel Orange Production in KwaZulu-Natal

CHAPTER 7
REVIEW OF THE BIORESOURCE PROGRAMME

Introduction

Now that the classification stage of the Bioresource Programme has been completed and field-tested it is useful to summarise its strengths and limitations, and the possible future developments of the progamme.

7.1 Techniques used in the classification of the BRUs

Phillips (1973) stated in his report on the Tugela Basin that the time was not far off when remote sensing techniques would be sufficiently advanced to be applied to a very rapid and accurate mapping of topography, vegetation, soils and other phenomena, and that it might well be applied in KZN within a decade. In a report (FAO, 1996) it was stated that most AEZs are now classified using GIS procedures, although field studies still have their place.

At the time that the Bioresource programme was commenced, remote sensing techniques were not widely used. To have used remotely sensed (satellite) information, it would have been necessary to access all the necessary layers of information, i.e. rainfall, temperature, soil types, topography and vegetation, required for the classification of BRUs. More importantly, it would have been essential to have someone fully conversant with remote sensing techniques, training the author lacked. The complexity of the terrain and natural resources of KZN, would, in addition, have made the technique extremely difficult to use and the extensive ground-truthing required would have amounted to nearly as much work as the procedures eventually adopted. Similarly, with a GIS, it would have been necessary to have layers (maps) covering these same sources of information, some of which, rainfall and temperature for example, would have to have been modelled as the coverage is insufficient to meet the needs of dealing with the wide range of diversity in KZN. Also, GIS was then in its infancy in the Province and only became available to the author after the completion of the field study, at which stage the BRU boundaries were digitised and the data base developed.

7.2 Summary of the strengths of the Bioresource Programme

In developing the data base of the programme, a wide range of natural resource information and expertise was used in the classification of the BRUs.

* As a result of the extensive data base developed, a wide range of natural resource based information and maps can be produced. It does, therefore, serve a useful role in Provincial, regional, specific area and farm planning.

* The 29 crop production models have made it possible to investigate area suitability for crops and levels of production. These models, designed to assess long-term production, have proved to have a satisfactory degree of accuracy.

* The possibility of growing any crop can be investigated if its growth and site requirements, such as soil and climate requirements, are known, and maps showing possible localities for production can be produced. In addition, a programme has been developed which can produce the inventory of a BRU, or any part of the inventory.

* A wide range of natural resource investigations can be carried out and maps produced. These include an investigation into the resource degradation of the Province and the mapping of agricultural land potential.

* The BRU inventory is valuable to the planner in that it can be used as a reference for climate and soil information, and, with the identification of the ecotopes, a great deal of agricultural information can be obtained.

* Descriptions and inventories for the BRGs have been prepared which can be used for planning purposes and which can form the basis of reports. In conjunction with the BRU inventory, a detailed description of an area can be prepared.

* A relatively simple procedure has been prepared for the identification of ecotopes. This procedure does not require the ability to classify soils into forms, but uses the recognition of features such as colour, clay percentage and effective depth. It has been tested by relatively inexperienced people in one day courses and found to be very successful.

7.3 Summary of the limitations of the Bioresource Programme

It is essential to be fully aware of the limitations of the Bioresource Programme before using the information it contains. Some of these are listed below.

* The major limitation is the lack of spatially defined soil information. While the BRU inventory gives a very good indication of the overall land potential of the area and the soils that are likely to be found, there is no indication of the location of particular soils in a specific area of interest.

* It is necessary for a certain amount of technical knowledge to be applied when using the programme and concern has been expressed about its use in official reports that may have considerable financial implications. The correct interpretation of the information is essential. While climatic information and yield data are presented in the BRU inventory, it requires a knowledge of soil types to understand and to apply the information. Similarly in the field, all the information can be applied only if one can identify the ecotopes, i.e. a knowledge of soil is necessary.

* The initial problem of identifying the BRU(s) of interest requires access to a set of 1 : 250 000 topo-cadastral maps with a transparent overlays of the BRU outlines, but these can be made available to clients.

* It is not practical to store the BRU inventories as hard copies because of the considerable amount of paper and space required. This makes access to them by the client difficult.

7.4 Future developments of the Bioresource Programme

The potential for further development is extensive, including the steps listed below.

* The inability to map ecotopes has been pointed out as a major weakness of the Bioresource Programme. Procedures will be investigated starting with the first step of mapping slopes. In KZN the vertical interval of contours needs to be relatively small to be of value and this information is not currently available. Maps such as 1 : 50 000 topo-cadastral maps, and in steep areas 1 : 10 000 orthophoto maps, offer the possibility of mapping slope. It would be relatively easy, but time-consuming, to map arable areas (<12% slope), but computer storage space would be a problem. Identifying the potential arable areas as ecotopes would be a problem that varies from BRG to BRG. In BRG 8, for example, most non-rocky slopes under 12% slope are likely to fall into the "A" or "B" crop ecotopes, and those in bottomland situations are likely to be "I" ecotopes (refer to Table 4.1 for descriptions). However, in areas with a MAP of less than 750 mm, a wide range of ecotopes could be found, from well-drained apedal to duplex ecotopes. Ground truthing would be demanding, both in time and expertise.

* A continuous programme to update the information is essential. This will involve a checking process assisted by clients of the programme and staff members of the Department of Agriculture submitting queries on data and making suggestions for improvement. These problems, associated with both the maps and the inventories of the BRUs, will be investigated both as a desk-top exercise and by means of field inspections if necessary. An active process of testing the validity of the information has been initiated by the NRS. As remote sensing techniques become better understood and available, they will prove invaluable for testing and adapting the maps.

* Climate information needs to be updated continuously and extended. Additional information is required such as humidity, chill units and locality of possible hail zones.

* A computer routine is to be developed which will enable a client to submit the map co-ordinates of the farm or area that he/she is interested in, and the BRU and BRG codes will be accessed and the inventories produced.

* To date 29 crop yield models have been developed for use in the programme. These require constant testing and updating. It is the intention to extend the number of models as soon as the expertise becomes available. It has been found in the past that this type of expertise is not readily available.

* There is a great demand for information on alternative crops to those commonly grown. A study of the

growth requirements of agricultural and medicinal plants has commenced.

* The development of Agricultural Information Centres (AICs), based on the Bioresource Programme, has been commenced and these will be provided for important agricultural centres. Each AIC will have spatially based information for the agricultural area in which it is centred and this will be readily available to clients. The maps on display will be supported by pamphlets on the subject that they cover. Demographic and information other than that directly agricuturally based, will be included. Computers will be available for processing information. This information will be planned for use at the practical farmer, and not academic, level.

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Appendices

APPENDICES

Appendix 1 : Climate

All the official climate stations in this Appendix were used in the delineation of climate for the BRUs as described in Chapter 3. They are presented here as examples of conditions found in the BRGs. The 600 farmer stations are not included in the table.

Table A.1.1 : Climate stations used in the development of the Bioresource Programme

Superscript number	Station	BRG number	Latitude Degrees minutes	Longitude Degrees minutes	Altitude (m)
1	Cape St Lucia - VRT	1	28 30	32 24	107
2	Richards Bay	1	28 48	32 06	47
3	River View, Matubtuba	1	28 27	32 12	46
4	Empangeni Sugar Mill	1	28 45	31 15	90
5	Baynesfield Estate	3	29 45	30 20	808
6	Pietermaritzburg - PUR	4	29 36	30 26	613
7	Sun Valley, Weenen	21	28 50	30 05	680
8	Waterval, Weenen	21	28 25	30 04	1 067
9	Nchosa, Muden	21	28 58	30 22	793
10	Riversbend, Nkwalini	21	28 43	31 32	120
11	Double Diamond, Tala Valley	17	29 48	30 30	610
12	Ukalinga R S, Pmb	17	29 40	30 24	775
13	Cedara	5	29 32	30 17	1 076
14	Ladysmith - WO	13	28 34	29 46	1 078
15	Estcourt - TNK	13	29 00	29 53	1 148
16	Kokstad - Mun	9	30 32	29 26	1 349
17	Shaleburn, Underberg	8	29 48	29 21	1 614
18	St Lucia Lake Res Centre	1	28 11	32 25	18
19	Mandini	1	29 09	31 24	109
20	Mount Edgecombe	1	29 42	31 03	104
21	Port Shepstone - VRT	1	30 44	30 27	17
22	Ndumo G R	22	26 55	32 19	122
23	Makhathini R S	22	27 23	32 11	73
24	Mpila, Umfolosi G R	22	28 18	31 51	152
25	Eshowe - Mun	3	28 53	31 28	532
26	Paddock	3	30 49	30 13	514
27	Hazeyview, Kranskop	5	28 58	30 52	1 120
28	Pannar, Greytown	5	29 02	30 37	1 110

Table A.1.1 continued

Superscript number	Station	BRG number	Latitude Degrees minutes	Longitude Degrees minutes	Altitude (m)
29	Mispah, Greytown	6	29 09	30 37	914
30	Westlands, Harding	5	30 32	29 48	1 100
31	Sapekoe, Ngome	7	27 51	31 27	1 010
32	Cecilia, Newcastle	11	27 55	29 52	1 311
33	Hazeldene, Dannhauser	11	28 03	29 53	1 303
34	Beaulieu, Bergville	11	28 48	29 23	1 310
35	Glenisla, Winterton	11	28 52	29 31	1 067
36	Ivanhoe, Impendle	8	29 32	29 53	1 700
37	Emerald Dale, Eastwolds	11	29 57	29 58	1 158
38	Newcastle	12	27 44	29 55	1 235
39	Enhlanhleni, Pomeroy	12	28 32	30 24	1 372
40	Hazelhurst, Bergville	12	28 46	29 22	1 058
41	Dundee R S	14	28 10	30 19	1 219
42	Peckham, Southbroom	1	30 55	30 17	20
43	Kangela, Mtubatuba	1	28 24	32 12	50
44	*Sugar Mill, Amatikulu*	1	29 03	31 32	70
45	Sugar Mill, Sezela	1	30 20	30 35	160
46	Llanwarne, Magudu	22	27 38	31 46	274
47	Stoke, Mid Illovo	3	29 56	30 30	670
48	Camel Hoek, New Hanover	3	29 23	30 31	750
49	Waldecke, Hermannsburg	5	29 01	30 47	1 135
50	Ralford, Estcourt	13	28 49	29 45	1 036
51	Bokel, Blood River	14	27 51	30 32	1 234
52	Cathedral Peak	8	28 57	29 14	1 372
53	Tabamhlope R S	8	29 02	29 39	1 450
54	Cobham, Himeville	8	29 41	29 25	1 650
55	Weston, Mooi River	9	29 13	30 02	1 390
56	Kokstad R S	9	30 31	29 25	1 372
57	Mayfield, Stanger	3	29 12	31 09	610
58	Bloemendal, Bishopstowe	3	29 23	30 28	838
59	Elandshoek, Boston	5	29 37	30 04	1 450
60	Meshlyn, Kamberg	8	29 20	29 43	1 539
61	Gardenia, Newcastle	12	27 55	29 52	1 311
62	Riversmeet, Babanango	13	28 26	31 06	1 022
63	Bundu, Hluhluwe	22	28 08	32 17	91

1 The influence of climatic factors

Temperature and precipitation are considered to be the two most important climatic criteria when assessing agricultural potential. These factors also have a marked influence on the vegetation types that have developed.

1.1 Precipitation

The following is a brief discussion of precipitation in the physiographic regions defined in Section 3.3.4 and Table 3.3. Note that superscript numbers following a place name refer to weather stations and the names and details of these stations are provided in Table A.1.1 (Weather Bureau, 1988).The MAP of KZN is presented in Fig. 2.4. The physiographic regions below are defined in Section 3.3.5.

1.1.2 **Coastal region** (< 450 m altitude)

BRG 1 (Moist Coast Forest, Thorn and Palm Veld), has a MAP range of 820 mm to 1 423 mm, the latter figure being recorded at Cape St Lucia. This BRG has one of the highest, best distributed and reliable rainfall patterns of all the BRGs. While high rainfall is recorded on both the north and south coast, with several stations recording in excess of 1 000 mm, the highest winter rainfall in the Province is recorded in the area from Richards Bay[2] (39%) to Cape St Lucia[1] (44%). The average number of raindays in the mid-winter months, June and July, is 14 days. Inland of the immediate coastline area, the proportion of winter rain is lower, but still relatively high in relation to the rest of the Province. River View (Mtubatuba)[3], receives 35% and Empangeni[4] 34% of the total rainfall in winter. On the South Coast, the average percentage winter rainfall from six stations is 31%. This winter rainfall affects the growth of crops and veld in that the winter months in BRG 1 are generally warm enough to promote growth if sufficient moisture is available.

The effectiveness of the high rainfall in this BRG, much of it resulting from frontal activity, is to a degree offset by high maximum temperatures, an effect which in turn is counteracted by atmospheric humidity levels higher than in the rest of the Province. Thunderstorms are experienced on an average of 22 days per year (eight stations). Hail is a rare occurrence, being recorded on an average of 0.6 days, while fog, or mist, is expected on an average of 3.1 days per year.

Most of the rainfall in BRG 22 (Lowveld), which has an average rainfall range of 559 mm to 750 mm, results from thunderstorms. High temperatures and low atmospheric humidity mean that the effectiveness of the rainfall in this area is likely to be low. The mean percentage winter rainfall from 5 stations is 23.6% with 3.6 raindays in mid-winter (June and July). Precipitation in the form of thunderstorms occurs on an average of 34 days per year (recorded at Makhathini[23] and Ndumo[22]) and hail is rare, occurring on average on one day per year.

1.1.3 **Lowland region** (Coast hinterland, 450 m to 900 m altitude)

There is great variation in precipitation in this zone which will be discussed with reference to the BRGs. Information from BRG 3 (Moist Coast Hinterland Ngongoni Veld) has been used in the discussion on this ecological region and seven climate stations were available. The average MAP for these stations is 1 039.9 mm and generally irrigation is not used for sugar cane, the main crop of the BRG. There are, on average, 119 raindays in BRG 3 with an average of 6 raindays in the months of June and July.

Aspect plays an important role in this BRG, which has steep slopes and both the north-facing slopes and valley areas can lie in rain-shadow areas. An example of a rain-shadow valley area is Baynesfield Estate[5], which has a MAP of 791 mm, well below the mean for the BRG. Mist, which occurs on high lying ground in the spring and summer, does play a role in supplying moisture, although the actual effect is unclear. Approximately 34 days of mist are recorded per year, compared with 3.1 days in BRG 1. Results from a mist meter at Cedara will be discussed under BRG 5, which lies in the upland region.

Rain is the result of both frontal activity and thunderstorms and there are an average of 18.5 thunderstorms per year. Hail storms are infrequent, with an average of only 0.5 storms per year having been recorded.

In BRG 4, the Dry Coast Hinterland Ngongoni Veld, only three climate stations were available, including farmer records. The MAP for these stations was 744 mm, with 104 raindays per year, 4 raindays in the mid-winter months of June and July, and with 20% of the rain falling in winter. This would indicate that rainfall will be a limiting factor in the cultivation of sugar cane, an important crop in the BRG, and that supplementary irrigation should play an important role in management practices.

In the major valleys of the Valley Bushveld (BRG 21), the rain-shadow effect is more apparent than in any other BRG. The valleys tend to run from west to east, which is largely at right angles to the direction of the rain-bearing winds, which blow from the south-east and south-west. The steep valley slopes to the south of the rivers (north-facing slopes) are shielded from the rain-bearing winds and thus lie in a rain-shadow. As a result, xerophytic vegetation will be found growing on these north-facing slopes. This can be seen in the Kranskop area where the high buttress area near Kranskop shields the north-facing valley slopes from frontal rain. The slope to the north of the river (south-facing), is a cool moist slope, or mesocline, and whereas the Valley Bushveld vegetation extends to the escarpment south of the river, a change to a moister vegetation type, or BRG, occurs at a much lower altitude north of the river. A similar situation is found in the Mkhomazi River valley in the Josephine Bridge area between Richmond and Ixopo. Possibly the best example of this situation can be seen in the Otto's Bluff-Albert Falls Dam valley. South of the river the xerophytic vegetation of the Coast Hinterland Thornveld grows from the Mgeni River to the escarpment at Otto's Bluff. The dominant species are *Acacia karroo, A. nilotica* and *A. sieberiana.* Duplex soils, typical of dry situations, are common. North of the river both the soils and vegetation change. Deep, well-drained apedal soils dominate, and the vegetation is an Ngongoni (*Aristida junciformis)* dominated grassland free of *Acacia* species. Crops such as sugar cane and avocado grow close to the river, and well below the escarpment, moist forests occur. Apart from the rain-shadow effect, the increased insolation on the north-facing slopes contributes to the xeric conditions on these slopes.

Valley Bushveld stretches from the coastal belt to the upland region, but the largest areas lie in the lowland region. Three climate stations in the mid-Thukela River valley, two of which lie in the Weenen [7&8] area and

one at Muden[9], have a MAP of 689 mm with an average of 87 raindays per year. The percentage of the total rainfall that falls in the winter months is 15.7% and there is an average of 2.3 raindays in the mid-winter months of June and July. The low percentage of winter rain compared with that of the coastal belt which has a range of 25% to 44% winter rain, is likely to be due to the rain-shadow effect.
In contrast to the Thukela River valley, the Nkwalini [10] valley on the Mhlatuze River, has a MAP of 684 mm and receives 24.0% of the annual precipitation in winter. While this valley also has the high-lying Eshowe plateau to the south, it is open to the effects of moisture pushing up the valley from the Empangeni area, and which receives 34% of its rain in the winter.

Two climate stations in the Coast Hinterland Thornveld (BRG 17), have a MAP of 680 mm per year from 106 raindays. There are, on average, 4 raindays in mid-winter and 23.0% of the precipitation falls in the winter months. This contrasts with the lack of winter rain in the Weenen and Muden areas, possibly because these stations, Double Diamond [11] in the Tala Valley and Ukulinga [12], are exposed to a greater extent to the cold front activity in the winter months.

1.1.4 **Upland region** (900 m to 1 400 m altitude)

BRG 5, the Moist Midlands Mistbelt, lies mainly on eastern and south-facing aspects and as such receives frontal activity during the winter, spring and early summer, while thunderstorms occur frequently in the summer and autumn months, with an average of 60 days per annum of thunderstorms at Cedara [13]. As its names implies, mist is a major feature of this BRG, occurring particularly in the spring and summer, although it can be experienced in the autumn as well. According to Phillips (1973), mist is an important source of moisture for plants. This applies particularly to areas where a physical obstruction occurs and the moisture is trapped. In these areas forests occur, such as the Ingeli, Karkloof, Qudeni and Nkandhla forests.

Cedara records an average of 46 days of mist per year. Smithers and Schulze (1994) recorded mist by the placement of wire gauze mist interceptors made to standard specifications at two stations in the Cedara Hydrological Research Catchment. Interception at the lower station, at an altitude of 1 058 m, averages 140 mm per year. The average for the months of October to March exceeded 15 mm per month and February, the highest month on record, received an average of 23 mm for the month. At the higher altitude station situated at 1 445 m, the average contribution of mist was 2 581 mm for the year, which is nearly double the average rainfall for the station. Eight months of the year recorded mean monthly fog contributions of over 100 mm and six months of the year recorded values in excess of 200 mm per month. At this higher station, mist intercepted was highest in January at 353 mm.

Hail storms occur, mainly in the summer and autumn. The contribution to total precipitation is not known, but is unlikely to be of significance. There is an average of 4 days per year with hail at Cedara. Snow occurs rarely and then mainly on the highest lying ground. The contribution to the total precipitation is not significant.

The average rainfall for eight stations in BRG 5 is 953 mm per year with 127 raindays per annum and an average of five raindays in the mid-winter period of June and July. The CV for this region averages 20.7%, which would give a range in rainfall from 855.7 mm to 1 150.3 mm. This would indicate that this area has a reliable rainfall for most forms of farming. The maximum temperatures are relatively low and the main cause of moisture stress is Berg winds which blow mostly in the spring. The effect is felt particularly on north-facing slopes which are directly exposed to these desiccating winds. On southern slopes, reduced intensity of insolation contributes to the effectiveness of precipitation in this BRG which is generally regarded as high potential farming land.

BRG 11 lies mainly along the foothills of the Drakensberg except in the south where a spur, lying between the Mkhomazi and Mzimkhulu rivers, runs south-east from the southern Drakensberg. This spur, which extends from Impendhle to Lufafa Road, has an average of 126 raindays per year and 4 raindays in the winter months of June and July. Seven climate stations, lying from Newcastle in the north to Loskop in the south, average only 78 raindays per year of which 4 occur in June and July. The southern area is particularly exposed to frontal activity and receives an average of 19% of its rain in the winter, compared with an average of 16% in the north.

BRG 13 (Dry Tall Grassveld) and BRG 14 (Sour Sandveld), have similar climates and are discussed together. A MAP of 735 mm per year is recorded from eight stations with a total of 79 raindays per year and 2.6 raindays in the months of June and July. Most of the rain in this area is received in the form of thunderstorms with an average of 63 days per year recorded at Ladysmith [14] and 56 days at Estcourt [15]. Mist plays a minor role in the precipitation of the region, with an average of 14 days mist from the stations at Ladysmith and Estcourt. An average of 3 days with hail per annum has been recorded.

1.1.5 Highland region (1 400 m to 1 800 m altitude)

Two BRGs are found in this region; BRG 8, the Moist Highland Sourveld and BRG 9, the Dry Highland Sourveld. The latter has a MAP range of 620 mm to 816 mm and is found in the Charlestown-Groenvlei area in the north of the Province, in the Dundee and Mooi River areas, with the largest area being in East Griqualand. Low maximum temperatures accompany the low rainfall in BRG 9, reducing evaporation. This increases the effectiveness of the rainfall and has a significant effect on the vegetation of the area which is relatively "sour", becoming unpalatable in late summer, whereas in the hot Lowveld which has the same rainfall, but hot summers and warm winters, the vegetation is "sweet", being palatable throughout the year.

The MAP for four stations in BRG 9 is 727 mm, with 88 raindays, three of which are in the mid-winter months of June and July. The percentage winter rainfall is 19%. Much of the precipitation comes in the form of thunderstorms, which occur at Kokstad [16] on an average of 45 days per annum. An average of three days with hail and 26 days with mist per annum were also recorded at the four climate stations in BRG 9.

BRG 8 has a reasonably reliable rainfall and here too, low maximum temperatures increase the effectiveness of the rainfall. The range in MAP is from 800 mm to 1 265 mm and 10 stations were analysed which have a mean of 1 015 mm between them.

Mist contributes to the precipitation with one station, Shaleburn [17], recording an average of 28 days of mist in the year. Thunderstorms were recorded on an average of 66 days and hail on 6 days. While hail does not contribute appreciably to the precipitation of an area, considerable damage can be done to crops and trees. Snowfalls occur every two to three years in the months of May to September (Moll, 1971). Heavy falls that are sufficiently deep to close roads and isolate areas occur on occasions. Damage to plantations can be extreme, in some cases resulting in plantations having to be clear-felled prematurely. Snow can make a major contribution to the moisture content of the soil.

1.1.6 Montane region (> 1 800 m altitude)

According to Edwards (1967), the MAP for the Montane region varies from 1 501 mm to 2 000 mm. Within this range in rainfall, gauges recorded 1 589 mm at 1 980 m altitude and 1 609 mm at 2 926 m altitude. Thunderstorms in the summer are frequent and often violent.

Mist makes an important contribution to the precipitation and snow occurs annually, an important feature in this BRG which has been designated as a priority area for water conservation.

1.2 Temperature

The effects of temperature on species distribution can play an important role in the mapping of land systems. Certain species, such as *Euphorbia ingens*, which grows in dry areas, will not tolerate frost. In the Valley Bushveld this species grows on ridges and not in valley bottomlands into which cold air sinks on winter nights, resulting in frost. American bramble (*Rubus cuneifolius*), will only flower and set fruit successfully in areas where frost occurs. Below the altitude at which frost can be expected (approximately 900 m), this plant is found only in valleys into which cold air sinks from the high-lying ground above. A map of temperature zones of KwaZulu-Natal is presented in Fig. 2.5.

1.2.1 Coastal region (< 450 m altitude)

The coastal region has a subtropical climate with hot summers and warm winters as indicated by the temperature records for the northern areas in Table A.1.2 and for the southern areas in Table A.1.3. For superscript numbers refer to Table A.1.1.

Table A.1.2 : Temperature records from stations in the northern areas of BRG 1 - Moist Coast

Station	Lake St Lucia [18]	Richards Bay[2]	Mandini[19]
Mean daily	21.6°C	21.7°C	21.7°C
Mean maximum - month	>29°C - Jan - Mar	29.2°C - Jan	29.3°C - Jan
Mean of coldest month	17.0°C - July	17.6°C - July	17.6°C - July
Climate category	Subtropical	Subtropical	Subtropical
Mean minimum - month	11.3°C - June	12.3°C - July	11.0°C - July
Absolute maximum	43.5°C - Dec	42.5°C - Nov	41.6°C - Dec
Absolute minimum	2.0°C - June	4.0°C - July	4.0°C - July
Highest range - winter*	11.3°C - June	10.7°C - June	13.1°C - July
Highest range - summer*	8.8°C - Feb	8.9°C - Dec	8.6°C - Dec

* This refers to the mean daily range in temperature.

The warm summers are indicated by the mean temperatures exceeding 29.0°C for three months of the year. Winters are warm and the absolute minimum temperature of 2.0°C indicates that this is generally a frost free area.

Table A.1.3 : Temperature records from stations in mid and southern BRG 1 - Moist Coast

Station	Mount Edgecombe[20]	Port Shepstone[21]
Mean daily	20.3°C	20.3°C
Mean maximum - month	27.3°C - Feb	26.5°C - Feb
Mean of coldest month	16.5°C - July	16.8°C - July
Climate category	Subtropical	Subtropical
Mean minimum - month	16.5°C - June	12.3°C - July
Absolute maximum	38.7°C - Oct	35.4°C - Dec
Absolute minimum	6.8°C - July	5.0°C - July
Highest range - winter*	11.2°C - June	9.2°C - June
Highest range - summer*	8.6°C - Dec	5.9°C - Dec

* This refers to the mean daily range in temperature.

The figures in Tables A.1.2 and A.1.3 indicate that the temperatures in general decrease, as can be expected, as one moves southward. This is significant in that while BRG 1 can be regarded as having a subtropical climate, the decrease in temperature can affect the potential for subtropical fruit and other crops.

The three stations in Table A.1.4 are from the Lowveld (BRG 22) and have also been considered from north to south, although the difference in latitude is not as great as that in BRG 1.

Table A.1.4 : Temperature records from stations in BRG 22 - Lowveld

Station	Ndumo[22]	Makhathini[23]	Mpila[24]
Mean daily	23.0°C	22.3°C	22.1°C
Mean maximum - month	32.5°C - Jan	32.2°C - Jan	30.0°C - Jan
Mean of coldest month	18.6°C - July	16.9°C - June	18.3°C - June
Climate category	Tropical	Subtropical	Tropical
Mean minimum - month	12.2°C - June	8.7°C - June	12.5°C - June
Absolute maximum	44.5°C - Jan	44.2°C - Dec	43.5°C - Feb
Absolute minimum	6.2°C - July	0.1° - July	6.0°C - June
Highest range - winter*	13.2°C - July	16.4°C - June	11.7°C - June
Highest range - summer*	11.1°C - Feb	11.0°C - Dec	10.7°C - Dec

* This refers to the mean daily range in temperature.

Wolstenholme (1976) classified a tropical climate as having a mean temperature of the coldest month exceeding 18°C. It can be seen that Ndumo and Mpila can be classed as tropical stations, but Wolstenholme considered the conditions to be so marginal that the planting of coconuts, cashew nuts and other tropical crops would require special economic justification before planting. Makhathini has a mean minimum temperature in June of 8.7°C and an extreme minimum temperature of 0.1°C. This implies that occasional frosts could provide a setback for frost-sensitive crops.

The diurnal range in temperature in winter at low altitudes of the coastal region is relatively low, ranging from 10.7°C at Richards Bay[2] in BRG 1 to 13.2°C at Ndumo[22] in BRG 22, while at Makhathini[23] it is higher that the other stations at 16.4°C. The diurnal range in temperature in summer for BRG 1 is from 5.9°C at Port Shepstone[21] to 8.9°C at Richards Bay and in BRG 22 it ranges from 10.7°C to 11.1°C, showing little variation and a small range.

1.2.2 **Lowland region** (450 m - 900 m altitude)

Table A.1.5 presents a comparison of climate stations in BRGs 3, Moist Ngongoni Veld (MNV) and 4, Dry Ngongoni Veld (DNV) . The abbreviated BRG name is given in brackets after the station name in Table A.1.5.

Table A.1.5 : Temperature records from stations in BRGs 3 (MNV) & 4 (DNV)

Station	Eshowe[25] (MNV)	Pietermaritzburg[6] (DNV)	Paddock[26] (MNV)
Mean daily	19.1°C	18.5°C	18.1°C
Mean maximum - month	26.5°C - Jan	28.2°C - Jan	25.0°C - Feb
Mean of coldest month	15.6°C - June, July	12.6°C - June	15.3°C - July
Climate category	Subtropical	Temperate	Subtropical
Mean minimum - month	10.0°C - July	2.9°C - June	10.2°C - July
Absolute maximum	40.5°C - Nov	41.6°C - Dec	39.0°C - Nov
Absolute minimum	1.0°C - July	-4.4° - June	2.1°C - July
Highest range - winter*	11.2°C - June	19.6°C - June	10.2°C - July
Highest range - summer*	9.4°C - Dec	11.5°C - Dec	8.1°C - Dec

* This refers to the mean daily range in temperature.

The mean annual temperature in Pietermaritzburg is lower than that of Eshowe and Paddock, and the mid-winter mean temperature, the absolute minimum temperature recorded and the range in diurnal temperatures differ considerably. Pietermaritzburg lies in a hollow with high-lying and very much cooler areas immediately above it. This results in a down-flow of cold air from the high-lying ground during the winter nights. Moderate frosts, with the occasional severe frost, are experienced in Pietermaritzburg while at the other two stations frost would be a rare occurrence. The mean date of the first frost in Eshowe[25] is 28 June and the mean last date is 28 August. Generally light ground frosts are experienced and the mean period in which frost can occur is 57 days. Eshowe and Paddock lie at lower, transitional altitudes of the region, accounting for the climate at those stations being much warmer than the climate in Pietermaritzburg.

The largest area of BRG 21, the Valley Bushveld, lies in the Lowland region. The figures for three stations are given in Table A.1.6 for comparative purposes.

Table A.1.6 : Temperature records from stations in BRG 21 - Valley Bushveld

Station	Weenen[7]	Muden[8]	Nkwalini[10]
Mean daily	19.6°C	19.0°C	21.0°C
Mean maximum - month	31.2°C - Jan	29.5°C - Jan	30.1°C - Jan
Mean of coldest month	11.9°C - June	12.5°C - June	16.0°C - July
Climate category	Temperate	Temperate	Subtropical
Mean minimum - month	1.6°C - June	3.5°C - June	8.0°C - June
Absolute maximum	41.5°C - Dec	41.1°C - Jan	44.4°C - Nov
Absolute minimum	-5.0°C - July	-4.0°C - June	-0.6°C - Aug
Highest range - winter*	20.6°C - June	17.8°C - June	16.2°C - June
Highest range - summer*	14.0°C - Dec	13.3°C - Dec	11.2°C - Dec

* This refers to the mean daily range in temperature.

The two inland stations, Weenen and Muden, have summer temperatures similar to the coastal valley of Nkwalini, but there is a considerable difference in the mean temperatures of the coldest winter month, cold air drainage into the valleys results in mean temperatures of 11.9°C at Weenen and 12.5°C at Muden for the coldest month of June, while at Nkwalini the July mean minimum temperature is 16.0°C. Despite the hot summers in the Thukela River valley, this area (Weenen and Muden), is classified as having a temperate climate because of the cool winters. Sun Valley[7], on the Thukela River in BRG 21, has a mean first to last date of frost that extends from 31 May to 6 August, a period of 67 days. Moderate frosts are recorded every year. The mean frost season length at Muden is 49 days, with the 13th June to the 1st August being the mean first to last dates for frost.

Apart from the physiographic differences between the Lowveld bushveld (BRG 22) and the Valley Bushveld (BRG 21), there is an important difference in temperatures recorded. The mean daily temperatures in BRG 22 range from 22.1°C to 23.0°C while those of BRG 21 range from 19.0°C to 21.0°C. The major difference however, is in the winter temperatures. The mean temperatures of the coldest month in BRG 22 range from 16.9°C to 18.6°C, while those of BRG 21 range from 11.9°C to 16.0°C with the absolute minimum temperatures ranging from - 0.6°C to - 5.0°C. In BRG 22 the absolute minimum temperatures are 6.0°C and 6.2°C for Mpila[24] and Ndumo[22] respectively. Makhathini[23] has an unusually cold absolute minimum temperature of 0.1°C.

The difference in the range in winter diurnal temperatures is significant, with those of BRG 22 being from 11.7°C to 16.4°C and those of BRG 21 being from 16.2°C to 20.6°C. This wide range is due to the downflow of cold air from the cool high-lying ground above the deep valleys.

1.2.3 Uplands region (900 m to 1 400 m altitude)

Table A.1.7 compares the temperatures of three stations in relatively close proximity to one another while Table A.1.8 compares BRG 7, lying in the north, with BRG 5, in the midlands area of the Province. The BRG number is given in brackets after the station name in Tables A.1.7 and A.1.8.

Table A.1.7 : Temperature records from stations in BRG 5 and BRG 6

Station	Kranskop[27] (5)	Greytown[28] (5)	Mispah[29] (6)
Mean daily	17.0°C	16.9°C	16.7°C
Mean maximum - month	24.5°C - Jan	26.2°C - Jan	27.8°C - Jan
Mean of coldest month	13.3°C - July	11.1°C - June	9.8°C - June
Climate category	Subtropical	Temperate	Temperate
Mean minimum - month	8.5°C - June	2.7°C - June	0.2°C - June
Absolute maximum	36.0°C - Jan	42.0°C - Jan	40.0°C - Jan
Absolute minimum	0.1°C - June	-5.7°C - July	-10.8°C - Jun
Highest range - winter*	10.4°C - June	16.8°C - June	20.8°C - June
Highest range - summer*	9.5°C - Dec	11.2°C - Dec	13.4°C - Dec

* This refers to the mean daily range in temperature.

Table A.1.8 : Temperature records from stations in BRG 5 and BRG 7

Station	Cedara[13] (5)	Harding[30] (5)	Sapekoe[31] (7)
Mean daily	16.2°C	16.3°C	18.1°C
Mean maximum - month	25.2°C - Jan	23.1°C - Jan	26.5°C - Jan
Mean of coldest month	11.0°C - June	12.1°C - July	14.4°C - June
Climate category	Temperate	Temperate	Subtropical
Mean minimum - month	3.2°C - June	6.7°C - July	10.1°C - June
Absolute maximum	37.3°C - Nov	34.5°C - Jan	43.0°C - Jan
Absolute minimum	-4.2°C - June	0.5°C - July	-4.0°C - May
Highest range - winter*	15.8°C - July	10.8°C - July	8.6°C - June
Highest range - summer*	10.1°C - Jan	8.3°C - Dec	10.0°C - Dec

* This refers to the mean daily range in temperature.

The mean daily temperature of BRG 5 is approximately 16.6°C (Table A.1.8), which is lower than the mean of 18.6°C for the adjacent, and lower-lying, BRG 3 (Table A.1.5) in the Lowland region, the difference being caused by the increase in altitude from BRG 3 to BRG 5. The major difference between the two regions can be seen in the mean temperatures of the coldest month and in the absolute minimum temperatures. The temperatures of the Lowlands region indicate that light frost would be experienced. The Upland region has minimum temperatures that would indicate moderate frost with the occasional severe frost. This is particularly so in Greytown, which lies in a frost hollow and at Mispah, which lies in a defined valley and cold air drainage area. The mean length of the frost season in Greytown is 87 days, from the mean first date of 24 May, to the mean last date of 19 August.

Kranskop lies immediately above the deep valley of the Thukela River which drains cold air from the upland areas. The mean minimum temperature for June is well above the mean of the other stations in the Upland region. Sugar cane, the most important crop in the Kranskop district, is grown successfully with little indication of cold or frost damage as occurs elsewhere in BRG 5 (refer to Table A.1.7).

Sapekoe lies in BRG 7, which is also a mistbelt area similar to BRG 5 in many respects. It lies on a steep, southerly slope which is well-drained of cold air. With a mean daily temperature of 18.1°C compared with a range of 16.2°C to 17.0°C for BRG 5 and a mean minimum temperature for June of 10.1°C compared with 0.2°C to 8.5°C, it can be seen that BRG 7 is much warmer than BRG 5. The lack of frost together with a mean annual precipitation of 1 447 mm, makes this area suitable for tea production, an important crop in the area.

BRG 11 has a climate which is similar to the climate of BRG 5. Mist is a common occurrence in both BRGs. The major difference is the range in diurnal temperatures. The mean winter diurnal temperature in BRG 11 is 18.2°C (Table A.1.9) and in BRG 5 it is 15.1°C. The difference in the summer diurnal temperature range is 13.6°C in BRG 11 and 10.7°C in BRG 5. The reason for this is that BRG 11 lies at a higher altitude (1 067 m to 1 311 m for seven stations recorded), than BRG 5 (914 m to 1 135 m for six stations recorded). At higher altitudes the insolation by day and radiation by night are higher than at lower altitudes. The high-lying ground receives more sunshine in winter (less cloud cover recorded) than the lower altitude areas and heat loss by radiation is greater on clear, calm nights. Thus high altitude areas tend to warm up rapidly during the day and cool down rapidly at night. Six stations recorded in BRG 11 are given in Tables A.1.8 (northern areas) and A.1.9 (central and southern areas).

Dannhauser[33] has a mean frost season length of 90 days, extending from a mean first date of 6 June to a mean last date of 9 August. Donnybrook[37] (Emerald Dale) has a longer frost season of 90 days which extends from 27 May to 25 August.

Table A.1.9 : Temperature records from stations in northern areas of BRG 11 - Moist Transitional Tall Grassveld

Station	Newcastle[32]	Dannhauser[33]	Bergville[34]
Mean daily	17.4°C	17.6°C	18.2°C
Mean maximum - month	27.2°C - Jan	27.7°C - Dec	30.2°C - Dec
Mean of coldest month	11.6°C - June	12.1°C - June	12.7.°C - June
Climate category	Temperate	Temperate	Temperate
Mean minimum - month	3.2°C - June	3.7°C - June	3.1°C - June
Absolute maximum	38.1°C - Nov	38.0°C - Sep	41.0°C - Jan
Absolute minimum	-6.5°C - June	-4.0C - July	-4.0°C - June
Highest range - winter*	16.8°C - June	16.8°C - June	19.3°C - June
Highest range - summer*	11.9°C - Dec	12.8°C - Dec	16.5°C - Dec

* This refers to the mean daily range in temperature.

Table A.1.10 : Temperature records from stations in central and southern areas of BRG 11 - Moist Transitional Tall Grassveld

Station	Winterton[35]	Impendhle[36]	Donnybrook[37]
Mean daily	17.9°C	14.9°C	15.9°C
Mean maximum - month	30.8°C - Dec	25.7°C - Dec	25.0°C - Jan
Mean of coldest month	10.5°C - June	8.8°C - June	11.1.°C - July
Climate category	Temperate	Temperate	Temperate
Mean minimum - month	0.2°C - June	0.5°C - June	3.1°C - July
Absolute maximum	44.0°C - Jan	37.0°C - Jan	38.4°C - Jan
Absolute minimum	-8.5°C - June	-7.5C - July	-5.5°C - Aug
Highest range - winter*	22.7°C - July	18.0°C - June	16.0°C - July
Highest range - summer*	16.3°C - Dec	12.4°C - Dec	11.7°C - Dec

* This refers to the mean daily range in temperature.

BRGs 11, 12 and 13, lie mainly in the interior basin of the Thukela River and can be regarded as transitional stages from a moist to a dry phase of Tall Grassveld. As such, the rainfall shows significant differences, but temperature changes are more gradual. Tables A.1.11 and A.1.12 provide temperature data for available climate stations in BRG 12 and BRGs 13 and 14 respectively. Table A.1.13 is a comparative table to illustrate the differences between these BRGs.

Table A.1.11 : Temperature records from stations in BRG 12 - Moist Tall Grassveld

Station	Newcastle[38]	Pomeroy[39]	Bergville[40]
Mean daily	17.8°C	17.5°C	17.6°C
Mean maximum - month	29.1°C - Jan	26.1°C - Jan	29.8°C - Jan
Mean of coldest month	11.1°C - June	12.5°C - June	10.4.°C - June
Climate category	Temperate	Temperate	Temperate
Mean minimum - month	2.2°C - June	7.6°C - June	0.4°C - July
Absolute maximum	38.5°C - Nov	36.8°C - Nov	41.0°C - Jan
Absolute minimum	-5.8°C - July	0.5°C - July	-7.5°C - Jun
Highest range - winter*	17.9°C - July	10.0°C - July	20.9°C - June
Highest range - summer*	12.8°C - Jan	10.6°C - Dec	14.6°C - Dec

* This refers to the mean daily range in temperature.

Table A.1.12 : Temperature records from stations in BRG 13 and BRG 14

Station	Dundee Res St[41] (14)	Ladysmith[14] (13)	Estcourt[16] (13)
Mean daily	16.8°C	18.1°C	17.0°C
Mean maximum - month	27.5°C - Dec	29.5°C - Jan	27.7°C - Jan
Mean of coldest month	10.3°C - June	11.1°C - June	10.6°C - June
Climate category	Temperate	Temperate	Temperate
Mean minimum - month	1.3°C - June	2.0°C - June	2.2°C - June
Absolute maximum	37.5°C - Nov	39.3°C - Dec	37.5°C - Jan
Absolute minimum	-8.5°C - July	-6.8C - July	-5.4°C - Jun
Highest range - winter*	18.3°C - June	18.2°C - June	16.9°C - July
Highest range - summer*	13.3°C - Dec	12.7°C - Jan	12.0°C - Jan

* This refers to the mean daily range in temperature.

Frost dates for the Dundee Research Station give a mean frost season of 94 days, extending from a mean first date of 22 May, to a mean last date of 24 August.

Table A.1.13 : A comparison of mean temperatures for BRGs 11, 12, 13 and 14

BRG	11	12	13 & 14
Mean daily	17.0°C	17.8°C	17.6°C
Mean maximum - month	27.8°C	28.3°C	28.3°C
Mean of coldest month	11.1°C	11.3°C	11.5°C
Climate category	Temperate	Temperate	Temperate
Mean minimum - month	2.3°C - June	3.4°C - June	3.1°C - June
Absolute maximum	39.4.°C	38.8°C	38.5°C
Absolute minimum	-6.0°C	-6.1°C	-5.3°C
Highest range - winter*	18.3°C	16.3°C	16.9°C
Highest range - summer*	13.6°C	12.7°C	12.9°C

* This refers to the mean daily range in temperature.

It can be seen from Table A.1.13 that BRG 11 is cooler than BRGs 12, 13 and 14 and has a higher range in diurnal temperature. The difference in the mean temperatures of BRG 12, 13 and 14 is only 0.2°C.

1.3 Evaporation

Evaporation is a useful index of plant growth potential because maximum growth is achieved when water supply equals or exceeds water demand, i.e. evapotranspiration. Comparative figures for some of the BRGs are presented in Table A.1.14. The evaporation figures for BRG 22 in the coastal region are the highest in the Province as a result of high mean annual temperatures of 22.3°C (Makhathini) and 21.2°C (Magudu) and relatively high windrun figures of 149 km/day and 138 km/day respectively. In addition, the daily sunshine hours at Makhathini are 7.9 hours, the highest on record in the Province. The mean annual evaporation for these stations is 1 983 mm and 2 040 mm respectively. In contrast, BRG 1 has an average mean annual evaporation figure for the six stations recorded of 1 601 mm. While these stations record cooler mean annual temperatures ranging from 19.7°C to 21.7°C, the major difference in the climate is the range in mean annual rainfall, ranging from 905 mm to 1 167 mm. Windrun figures are high and similar to those of BRG 22.

In the Lowland region, a similar trend can be observed. In the hot Valley Bushveld of BRG 21, the evaporation figures for the two inland stations at Weenen (Sun Valley) and Muden are 1 889 mm and 1 704 mm respectively. The rainfall ranges from 682 mm to 723 mm, the temperatures from 19.0°C to 19.6° mm and the sunshine hours at Muden are 7.2 hours per day, a high figure for the Province. In BRG 3, the mean annual evaporation figures range from 1 349 mm to 1 544 mm. Compared with BRG 21, the rainfall is higher, 791 mm to 884 mm, mean annual temperatures are lower, 17.4°C to 18.4°C and sunshine hours lower, 6.2 hours per day.

The greatest difference in the Uplands region exists between BRG 5 and BRGs13/14. BRG 5 has a range in evaporation for four stations of 1 479 mm to 1 649 mm and BRG 13/14 a range from 1 668 mm to

1 914 mm. The major difference in climate is the mean annual precipitation, BRG 5 having a range from 797 mm to 906 mm, and BRG 13/ 14 a range from 730 mm to 777 mm. The mean annual temperatures indicate that BRG 5 is cooler, ranging from 16.2°C to 17.0°C. The range in BRG 13/14 is from 16.8°C to 18.2°C.

The largest difference in mean annual evaporation is seen when comparing figures of the Highland region with those of the rest of the Province. In BRG 8, the mean annual evaporation figures for four stations range from 1 384 mm to 1 601 mm. Rainfall figures for these stations range from 1 035 mm to 1 230 mm per annum, but the low mean annual temperatures range from 13.7°C to 16.1°C.

Table A.1.14 : Evaporation in the physiographic regions and BRGs and the climatic factors that influence the rate of evaporation

	Station	MAP (mm)	MAT °C	Sunshine Hours	Windrun km/day	M.A.Evap (mm)
Coastal						
BRG 1	Southbroom[42]	1 167	20.4	-	118	1 486
	Kangela[43]	907	22.0	-	-	1 419
	Empangeni[4]	1 125	21.5	-	161	1 833
	Amatikulu[44]	1 061	21.7	6.9	132	1 783
	Sezela[45]	905	19.7	6.7	174	1 484
BRG 22	Makhathini[23]	687	22.3	7.9	149	1 983
	Magudu[46]	559	21.2	-	138	2 040
Lowland						
BRG 3	Mid Illovo[47]	884	18.3	-	114	1 349
	Baynesfield[5]	791	17.4	6.2	77	1 424
	New Hanover[48]	855	18.4	-	92	1 544
BRG 21	Sun Valley[7]	723	19.6	-	110	1 889
	Muden[9]	682	19.0	7.2	85	1 704
	Nkwalini[10]	684	21.0	6.2	99	1 630
Upland						
BRG 5	Kranskop[27]	797	17.0	-	-	1 630
	Hermannsburg[49]	815	16.5	-	161	1 505
	Greytown[28]	906	16.9	6.9	116	1 642
	Cedara[13]	869	16.2	7.5	143	1479
BRG 11	Newcastle[32]	895	17.4	-	135	2 002
	Winterton[35]	840	17.9	-	52	1 560
	Eastwolds[37]	860	15.9	-	96	1 467
BRG 13	Estcourt[50]	732	18.2	-	104	1 725
BRG 14	Blood River[51]	730	17.2	6.5	81	1 668
	Dundee R. S.[41]	777	16.8	7.2	163	1 914
Highland						
BRG 8	Cathedral Peak[52]	1 230	16.1	-	75	1 601
	Tabamhlope[53]	1 088	13.8	7.1	147	1 543
	Impendhle[36]	1 035	13.8	-	91	1 384
	Cobham[54]	1 183	13.7	7.1	100	1 597
BRG9	Kokstad R. S.[56]	762	14.8	7.0	100	1 712
	Weston[55]	706	15.0	6.8	80	1 543

1.4 Wind

Weather station records of wind are very limited, and those available are presented in Table A.1.15. Wind is measured as windrun in kilometres per day and recorded as average windrun per month and per year. BRG 1, on the coastal plain, has the highest average for the Province with a mean for the year from four stations of 138.0 km/day. The figures range from 117.6 km/day to 173.9 km/day, the latter, recorded at Sezela, being the highest figure in the Province.

Three stations in the Lowveld (BRG 22), which also lies on the coastal plain, give an average yearly figure of 128.9 km/day, which is the third highest figure for BRGs in the Province. The Dry Highland Sourveld (BRG 9), has the lowest figure, although only two stations were found which record windrun. Here the mean value for the year is 90.0 km/day. It appears that topography, and positioning of the station, plays a major role in determining the amount of wind recorded, with variations within a BRG being almost as great as the variations between BRGs. Baynesfield, in BRG 3, has a relatively low figure of 77.4 km/day, possibly because, situated in a valley, it is protected from wind. Cathedral Peak, lying in a deep, sheltered valley in BRG 8, has the lowest figure for the Province of 74.9 km/day although the mean for the BRG, at 113.9 km/day, is the fourth highest in the Province. The weather station at Cedara, in BRG 5, is situated on an unsheltered slope where it is exposed to the northerly winds and has a high figure of 142.7 km/day. BRG 5 has the second highest mean figure for the BRGs of 134.4 km/day.

Table A.1.15 : Windrun in km/day from stations in KwaZulu-Natal

Region and BRG	Months above average	Highest month	Yearly average km/day
Coast			
BRG 1			
Richards Bay[2]	Aug to Jan	October	105.9
Sezela[45]	Sept to Dec	October	173.9
Southbroom[42]	Aug to Dec	October	117.6
Amatikulu[44]	Aug to Jan	October	131.6
Empangeni[4]	Aug to Jan	October	161.0
Lowland			
BRG 3			
Baynesfield[5]	July to Nov	September	77.4
Mid Illovo[47]	Aug to Jan	October	114.3
New Hanover[48]	July to Dec	September	91.9
Stanger[57]	Aug to Dec	October	105.6
Bishopstowe[58]	Aug to Jan	November	111.9
Upland			
BRG 5			
Cedara[13]	Aug to Dec	October	142.7
Greytown[28]	Aug to Dec	Sept - Nov	116.2
Hermannsburg[49]	July to Dec	September	161.0
Boston[59]	Aug to Dec	September	121.9
Highland			
BRG 8			
Cathedral Peak[52]	June to Oct	Sept	74.9
Tabamhlope[53]	Aug to Dec	October	146.9
Kamberg[60]	Aug to Dec	September	133.1
Impendhle[36]	Aug to Dec	September	90.5
Cobham[54]	July to Nov	September	100.3
Himeville	Aug to Jan	September	113.9
BRG 9			
Kokstad R. S.[56]	Aug to Dec	September	99.9
Weston[55]	Aug to Dec	September	80.1
BRG 11			
Newcastle[32]	Aug to Dec	September	135.3
Winterton[35]	Aug to Dec	September	51.6
Eastwolds[37]	June to Oct	September	96.2

Table A.1.15 continued

Region and BRG	Months above average	Highest month	Yearly average km/day
BRG 12			
Newcastle[61]	Aug to Nov	September	125.2
Bergville[40]	Aug to Dec	November	85.9
Upland			
BRGs 13 & 14			
Estcourt[50]	Aug to Jan	November	103.9
Babanango[62]	July to Dec	September	79.3
Blood River[51]	Aug to Dec	September	81.4
Dundee R.S.[41]	Aug to Dec	October	162.6
Lowland			
BRG 17			
Tala Valley[11]	Aug to Jan	Sept/Oct	76.8
Ukulinga[12]	Aug to Dec	October	127.2
BRG 21			
Sun Valley[7]	Sept to Jan	November	109.7
Muden[9]	July to Dec	September	84.6
Nkwalini[10]	Aug to Jan	October	98.6
Weenen[8]	Aug to Dec	September	114.9
Coast			
BRG 22			
Makhathini[23]	Aug to Jan	September	149.1
Magudu[46]	Aug to Jan	September	137.8
Hluhluwe[63]	Aug to Dec	September	99.9

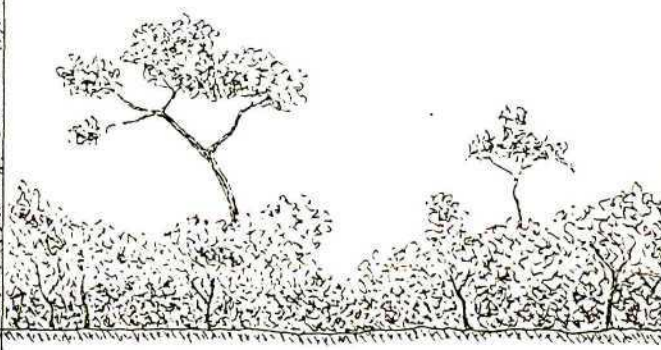
Appendix 2. Table A.2 Corresponding Vegetation Types of the BRGs, Phillips (1973), Edwards (1967), Acocks (1953) and Moll (1971)

Bioresource Group	Phillips BCG (1973)	Edwards (1967)	Acocks (1953)	Moll (1971)
Number - name	Number	Name	Number - name	Name
1 - Moist Coast Forest, Thorn & Palm Veld	1	Coast Vegetation	1 - Coast Forest & Thornveld	Coast Forest
2 - Dry Coast Forest, Thorn & Palm Veld	1	Coast Vegetation	1 - Coast Forest & Thornveld	Coast Forest
3 - Moist Coast Hinterland Ngongoni Veld	2	Semi-coast Secondary Grassland	5 - Ngongoni Veld	*Acacia sieberiana* Wooded Grassland Secondary *Aristida junciformis* Grassland
4 - Dry Coast Hinterland Ngongoni Veld	2	Semi-coast Secondary Grassland	5 - Ngongoni Veld	*Acacia sieberiana* Wooded Grassland Secondary *Aristida junciformis* Grassland
5 - Moist Midlands Mistbelt	3	Mistbelt Secondary Grassland	45 - Natal Mistbelt Ngongoni Veld	Moist Transitional *Themeda-Hyparrhenia* Grassland Mistbelt *Themeda-Aristida* Grassland
6 - Dry Midlands Mistbelt	3	Mistbelt Secondary Grassland	45 - Natal Mistbelt Ngongoni Veld	Moist Transitional *Themeda-Hyparrhenia* Grassland Mistbelt *Themeda-Aristida* Grassland
7 - Northern Mistbelt	3	-	8 - North-Eastern Mountain Sourveld	-
8 - Moist Highland Sourveld	4a - e	Highlands Grassland	56 - Highland Sourveld	Highland Grassland
9 - Dry Highland Sourveld	4f	Northern Highlands Grassland Highlands Grassland	56 - Highland Sourveld	Highland Grassland
10 - Montane Veld	5	Subalpine Fynbos and Grassland	58 - *Themeda-Festuca* Alpine Veld	-
11 - Moist Transitional Tall Grassveld	6	Moist Transitional Grassland	65 - Southern Tall Grassveld 64 - Northern Tall Grassveld	-
12 - Moist Tall Grassveld	6	*Themeda-Hyparrhenia* Grassland	65 - Southern Tall Grassveld 64 - Northern Tall Grassveld	-
13 - Dry Tall Grassveld	8	*Themeda-Hyparrhenia* Grassland	65 - Southern Tall Grassveld 64 - Northern Tall Grassveld	-
14 - Sour Sandveld	8	*Tristachya-Digitaria* Grassland	66 - Natal Sour Sandveld	-
15 - Moist Lowland Tall Grassveld	6	-	64 - Northern Tall Grassveld	-
16 - Dry Lowland Tall Grassveld	8	-	64 - Northern Tall Grassveld	-
17 - Coast Hinterland Thornveld	2	Dry Coast Thornveld	5 - Ngongoni Veld	*Acacia sieberiana* Wooded Grassland Dry Valley Scrub Bushland Mosaic
18 - Mixed Thornveld	8	Interior Thornveld	65 - Southern Tall Grassveld	-
19 - Moist Zululand Thornveld	9	-	6 - Zululand Thornveld	-
20 - Dry Zululand Thornveld	9	-	6 - Zululand Thornveld	-
21 - Valley Bushveld	10	Valley Vegetation	23 - Valley Bushveld	Dry Valley Scrub Bushland Mosaic
22 - Lowveld	10, 11	-	10 - Lowveld 11 - Arid Lowveld	-
23 - Sandy Bushveld	10	-	10 - Lowveld	-

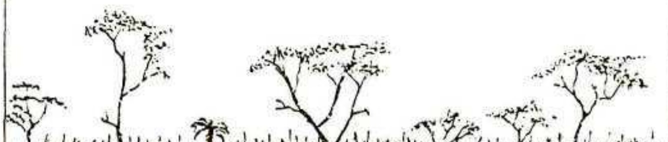
Appendix 3 : Figure A3: A brief description and illustration of the physiognomic types of the Bioresource programme (after Edwards, 1983).

Forest : A closed stand of trees, of one or more stories, with an interlaced upper canopy varying in height from 7 m to 40 m. Ground cover is dominated by herbs and shrubs, and lianes and epiphytes are characteristic. Grass cover is absent or consists of shade-tolerant species.

Scrub forest : Similar to forest but with very few tall trees, the latter existing as emergents. Usually the end result of disturbance, mainly timber extraction.

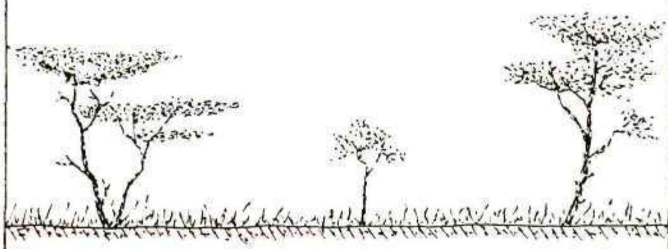


Bushland : Land supporting a mixture of trees and shrubs, often dominated by the latter, but with trees being conspicuous; trees usually do not exceed 7 m in height except for occasional emergents. Grass cover is reasonable to poor. Fires are infrequent and of low intensity. Cover canopy exceeds 20%.

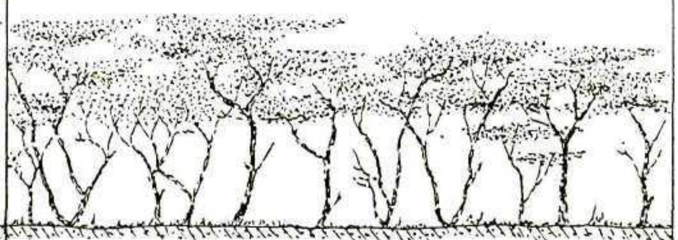


Bushland thicket: This is an extreme form of bushland having a closed canopy cover. Grass cover is absent or very sparse, providing little or no grazing. Fires infrequent and of low intensity.

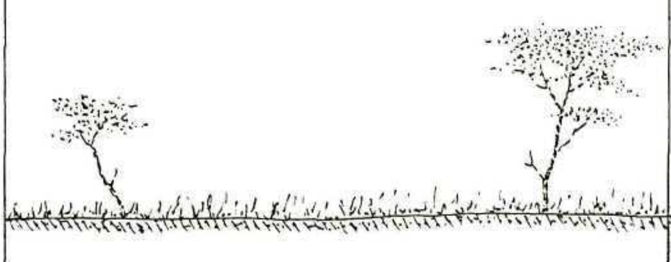
Woodland: Land supporting a stand of trees up to 20 m high. The canopy may be thinly interlaced or open and exceeds 20% cover. Shrubs may be present but contribute less than 10% canopy cover. Grass cover is reasonable and fires may occur frequently.



Woodland thicket: An extreme form of woodland having an interlaced canopy. Grass cover is sparse and fires are infrequent and of low intensity.

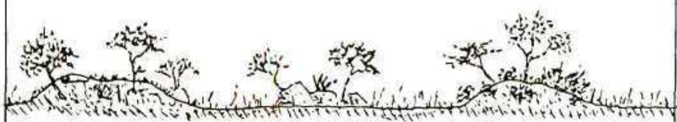


Wooded grassland: Grassland with scattered trees or groups of trees which have a combined canopy of under 20%. Grass cover is good and fires occur frequently.



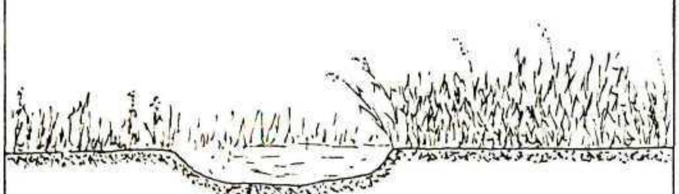
Bushed grassland: Grassland with scattered shrubs which have a combined canopy cover of less than 20%. Grass cover is good and fires occur frequently.

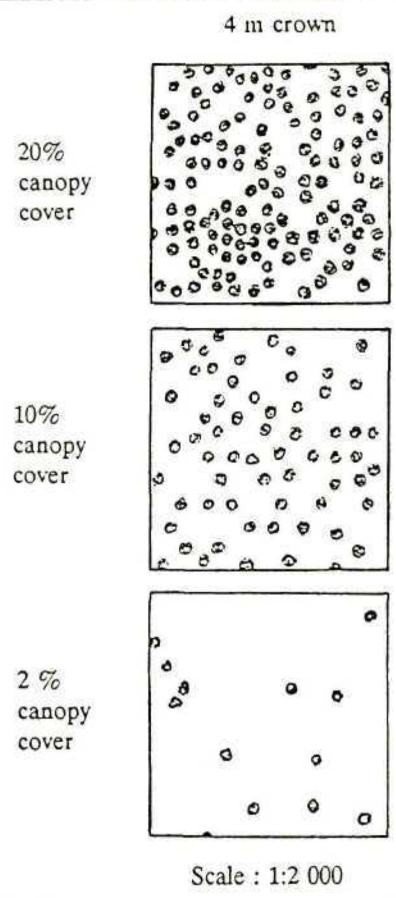
Bush clump grassland: Clumps of small trees or shrubs forming islands in grassland. These clumps are usually based on termitaria or rock outcrops. Grass cover is good and fires occur frequently.



Grassland: Land dominated by grasses and occasional herbs. Trees or shrubs may be scattered widely, either singly or in groups, but the canopy may not exceed 2%. Fires occur frequently.

Swamp: Land covered by permanent water and supporting various plant communities including reeds, sedges, rushes and other aquatic species.





Appendix 4 : Table A.4 : Corresponding descriptions of the second edition of the South African Soil Classification System and the first edition thereof, and the soil groups used for the description of crop ecotopes (Manson, 1995).

Soil Classification System			Soil groups for ecotopes	
Second Ed. (SCWG,1991) Soil form & family		Binomial (MacVicar *et al., 1977*) Soil form	Crop	Veld
Addo	Ad 1100	Oa, Cv	B	A
	Ad 1200	Oa, Hu	B	A
	Ad 2100	Oa, Cv	B	A
	Ad 2200	Oa, Hu	B	A
Augrabies	Ag 1100	Oa, Cv	B	A
	Ag1200	Oa, Hu	B	A
	Ag 2100	Oa, Cv	B	A
	Ag 2200	Oa, Hu	B	A
Askham	Ak	Cv	B	A
Arcadia	Ar	Ar	F	B
Avalon	Av	Av	D	A
Bloemdal	Bd	Hu	B	A
Bonheim	Bo	Bo, Sw, Va	F	B
Brandvlei	Br	Oa	B	A
Bainsvlei	Bv	Bv	B	A
Concordia	Cc	Lt	Podzol*	Podzol*
Cartref	Cf	Cf	E	D
Coega	Cg	Ms	H	S
Champagne	Ch	Ch, Ka	Vlei**	V
Constantia	Ct	Ct	B	A
Clovelly	Cv	Cv	B	A
Dresden	Dr	Ms	H	S
Dundee	Du	Du	C	A,P
Estcourt	Es	Es	J	D
Etosha	Et	Oa	B	A
Fernwood	Fw	Fw	B	A
Glencoe	Gc	Gc	D	A
Griffin	Gf	Gf	B	A
Groenkop	Gk	No equivalent	Podzol*	Podzol*
Gamoep	Gm	Oa	B	A
Garies	Gr	Hu	B	A
Glenrosa	Gs	Gs	H	A,S
Houwhoek	Hh	Hh	Podzol*	Podzol*

Table A.4 continued

	Second Ed. (SCWG, 1991) Soil form & family	Binomial Soil form	Crop ecotope	Veld ecotope
Hutton	Hu	Hu	B	A
Inanda	Ia 1000	Hu	B	A
	Ia 2000	Ia	A	A
Inhoek	Ik	Ik	F	B
Immerpan	Im	Mw	F	B
Jonkersberg	Jb	No equivalent	Podzol*	Podzol*
Katspruit	Ka	Ka	J	P
Kroonstad	Kd	Kd	I	D
Kinkelbos	Kk	Vf	C	A
Klapmuts	Km	No equivalent	J	D
Knersvlakte	Kn	Ms	H	S
Kranskop	Kp 1000	Gf	B	A
	Kp 2000	Kp	A	A
Kimberley	Ky	Hu	B	A
Longlands	Lo	Lo	E	D
Lamotte	Lt	Lt	Podzol*	Podzol*
Lusiki	Lu 1110	Sw	J	D
	Lu 1120	Va	J	D
	Lu 1210	Sw	J	D
	Lu 1220	Va	J	D
	Lu 2000	No equivalent	J	D
Magwa	Ma 1000	Ca	B	A
	Ma 2000	Ma	A	A
Molopo	Mp	Cv	B	A
Mispah	Ms	Ms	H	S
Montagu	Mu 1100	Oa, Cv	B	A
	Mu 1200	Oa, Hu	B	A
	Mu 2100	Oa, Cv	B	A
Montagu	Mu 2200	Oa, Hu	B	A
Milkwood	Mw	Mw	F	B
Mayo	My	My	F	B
Namib	Nb 1000	Fw, Cv	B	A
	Nb 2000	Hu	B	A
Nomanci	No 1000	Gs	H	A
	No 2000	No	A	A
Oakleaf	Oa	Oa	B	A
Oudtshoorn	Ou	Oa	B	A
Pinegrove	Pg	No equivalent	Podzol*	Podzol*

Table A.4 continued

	Second Ed. (SCWG, 1991) Soil form & family	Binomial Soil form	Crop ecotope	Veld ecotope
Pinedene	Pn	Pn, Cv	C	A
Prieska	Pr 1100	Oa, Cv	B	A
	Pr 1200	Oa, Hu	B	A
	Pr 2100	Oa, Cv	B	A
	Pr 2200	Oa, hu	B	A
Plooysburg	Py	Hu	B	A
Rensburg	Rg	Rg	G	B
Shortlands	Sd	Sd	B	A
Sepane	Se	Va	J	D
Steendal	Sn	Ik	F	B
Sweetwater	Sr 1000	Oa	B	A
	Sr 2000	No equivalent	A	A
Sterkspruit	Ss	Ss	J	D
Swartland	Sw	Sw	J	D
Trawal	Tr 1100	Oa, Cv	B	A
	Tr 1200	Oa, Hu	B	A
	Tr 2100	Oa, Cv	B	A
	Tr 2200	Oa, hu	B	A
Tsitsikama	Ts	Hh, Lt	Podzol*	Podzol*
Tukulu	Tu	Oa	B	A
Valsrivier	Va	Va	J	D
Vilafontes	Vf	Vf	C	A
Wasbank	Wa	Wa	E	D
Witbank	Wb	No equivalent	Man-made*	Man-made*
Westleigh	We	We	E	D
Witfontein	Wf	No equivalent	Podzol*	Podzol*
Willowbrook	Wo	Wo	G	B

* No ecotopes defined in KwaZulu-Natal due to the rarity of podzols and man-made deposits.
** The Champagne form has been excluded from crop ecotopes.

Appendix 5 : Table A.5 : The Plant Indicator Species of the Bioresource Groups of KwaZulu-Natal

Plant Indicator Species	**Bioresource Groups**
Grasses	
1 *Alloteropsis semialata*	5, 6, 7, 8, 9, 10, 14, 15
2 *Andropogon eucomus*	14,
3 *Aristida congesta*	12, 13, 21, 22
4 *Aristida junciformis*	1, 2, 3, 4, 5, 6, 17
5 *Bothriochloa insculpta*	12, 13, 21, 22
6 *Digitaria eriantha*	2, 3, 5
7 *Digitaria tricholaenoides*	5, 6, 8, 9, 14
8 *Diheteropogon filifolius*	8, 9
9 *Eragrostis gummiflua*	14
10 *Eragrostis superba*	13, 18, 21, 22
11 *Festuca costata*	8, 10
12 *Harpochloa falx*	5, 6, 7, 8, 9
13 *Hyperthelia dissoluta*	19, 20, 22
14 *Hyparrhenia hirta*	11, 12, 13, 15, 16, 18, 19, 20, 21
15 *Monocymbium ceresiiforme*	8, 9, 10, 14
16 *Panicum maximum*	17, 21, 22
17 *Pogonarthria squarrosa*	14, 23
18 *Setaria incrassata*	22
19 *Sporobolus pyramidalis*	1, 2, 12, 13, 17, 18, 19, 20, 21, 22
20 *Stiburus alopecuroides*	10
21 *Trachypogon spicatus*	8, 9
Trees and shrubs	
22 *Acacia burkei*	22, 23
23 *Acacia dealbata* (Silver wattle - alien)	5, 6, 7, 8, 9, 11
24 *Acacia karroo*	1, 2, 12, 13, 16, 17, 18, 19, 20, 21, 22
25 *Acacia mearnsii* (Black wattle - alien)	5, 6, 7, 8, 9, 11, 15
26 *Acacia nigrescens*	22
27 *Acacia nilotica*	1, 2, 12, 13, 16, 17, 18, 19, 20, 21, 22
28 *Acacia robusta*	1, 2, 21, 22
29 *Acacia sieberiana*	12, 13, 16, 17, 18, 19, 20
30 *Acacia tortilis*	16, 19, 20, 21, 22
31 *Acacia xanthophloea*	22
32 *Athanasia acerosa*	8, 10
33 *Berchemia zeyheri*	21, 22
34 *Boscia albitrunca*	21, 22
35 *Buddleja salviifolia*	8, 10
36 *Carissa macrocarpa*	1
37 *Combretum apiculatum & molle*	19, 20, 21, 22
38 *Cyathea dregei*	5, 6, 7, 10
39 *Dichrostachys cinerea*	16, 17, 18, 19, 20, 21, 22
40 *Euclea* spp.	21, 22
41 *Euphorbia ingens*	19, 20, 21, 22
42 *Euphorbia* spp. (tree species)	19, 20, 21, 22
43 *Felicia filifolia*	9, 21
44 *Greyia sutherlandia*	10
45 *Halleria lucida*	5, 6, 7, 8, 9, 10
46 *Hyphaene coriacea*	1, 2, 22, 23
47 *Lantana camara* (alien)	1, 2, 3, 4, 12, 15, 17, 19, 20
48 *Leucosidea sericea*	8, 9, 10
49 *Newtonia hildebrandtii*	23
50 *Olea europaea* subsp. *africana*	21, 22
51 *Phoenix reclinata*	1, 2, 15, 22, 23
52 *Podocarpus* spp.	5, 6, 7, 8, 10
53 *Protea* spp. (tree species)	3, 4, 8, 10
54 *Pteridium acqualinum*	5, 6, 7, 8, 10
55 *Rauvolfia caffra*	1, 2, 3, 4, 15, 19, 20
56 *Rubus cuneifolia* (alien)	5, 6, 7, 8
57 *Schotia brachypetala*	21, 22
58 *Sclerocarya birrea*	21, 22
59 *Syzygium cordatum*	1, 2, 3, 4, 15
60 *Solanum mauritianum* (alien)	3, 4, 5, 6, 7, 15
61 *Spirostachys africana*	21, 22
62 *Terminalia sericea*	22, 23
63 *Trichilia emetica*	1, 2, 22, 23
64 *Ziziphus mucronata*	13, 16, 17, 18, 19, 20, 21, 22
65 *Diospyros lycioides*	9, 11, 12, 13
66 *Strelitzia nicolae*	1, 2
67 *Albizia adianthifolia*	1, 2, 3

Appendix 6 : Table A.6 : Broad parameters used in the identification of the Bioresource Groups and the Bioclimatic Groups (Phillips, 1973).

Bioresource Groups				Bioclimatic Groups - Phillips (1973)			
BRG no	Altitude (m.a.s.l.)	MAP* (mm)	MAT** (°C)	Bioclimate no	Altitude (ma.s.l.)	MAP (mm)	MAT (°C)
1	0 - 450	820 - 1 423	18.5 - 22.0	1	0 - 457	850 - 1 400	20.0 - 22.5
2	0 - 450	740 - 815	20.3	1	0 - 457	850 - 1 400	20 0 - 22 .5
3	450 - 900	800 - 1 160	17.9	2	457 - 915	850 - 1 300	17.5 - 20.0
4	450 - 900	756 - 780	17.6 - 19.2	2	457 - 915	850 - 1 300	17.5 - 20.0
5	900 - 1 400	800 - 1 280	17.0	3	915 - 1 372	800 - 1 600	16.0 - 18.0
6	900 - 1 400	738 - 825	16.9	3	915 - 1 372	800 - 1 600	16.0 - 18.0
7	900 - 1 400	980 - 1 123	16.7	3	915 - 1 372	800 - 1 600	16.0 - 18.0
8	1 400 - 1 800	800 - 1 265	14.1	4a - e	1 372 - 1 981	800 - 1 500	13.0 - 15.0
9	1 400 - 1 800	620 - 816	14.3	4f	1 372 - 1 981	800 - 1 500	13.0 - 15.0
10	1 280 - 3 350	900 - 1 400	11.5	5	1 372 - 3 353	1 500 - 2 017	<13.0
11	900 - 1 400	800 - 1 116	16.9	6	915 - 1 372	800 - 1 000	16.0 - 18.0
12	900 - 1400	712 - 805	17.1	8	915 - 1 372	600 - 800	16.0 - 18.0
13	900 - 1 400	666 - 745	17.3	8	915 - 1 372	600 - 800	16.0 - 18.0
14	900 - 1 400	645 - 737	16.0	8	915 - 1 372	600 - 800	16.0 - 18.0
15	450 - 900	800 - 1 000	19.5	6	915 - 1 372	800 - 1 000	16.0 - 18.0
16	450 - 900	700 - 800	19.4	8	915 - 1 372	600 - 800	16.0 - 18.0
17	450 - 900	644 - 838	18.4	7	305 - 610	700 - 800	17.0 - 18.0
17	450 - 900	644 - 838	18.4	2	457 - 915	850 - 1 300	17.5 - 20.0
18	900 - 1 400	650 - 786	17.1	8	915 - 1 372	600 - 800	16.0 - 18.0
19	< 450 - 560	760 - 846	21.1	9	152 - 457	700 - 850	21.0 - 22.0
20	450 - 900	768 - 788	20.4	9	457 - 1 067	700 - 800	21.0 - 22.0
21	150 - 900	595 - 830	19.0	10	152 - 915	600 - 700	18.0 - 23.0
22	< 450	587 - 750	21.9	10	152 - 915	600 - 700	18.0 - 23.0
22	<450	587 - 750	21.9	11	152 - 457	320 - 600	21.0 - 23.0
23	<450	635 - 729	21.8 - 22.0	10	152 - 915	600 - 700	18.0 - 23.0

* Mean annual precipitation ** MAT Mean annual temperature

Appendix 7 : Table A.7 : Corresponding altitude ranges of the Bioresource Groups and those of Acocks (1953) and Edwards (1967)

Bioresource Groups - Numbers and names		Acocks (1953) - Name and altitude range		Edwards (1967) - Name and altitude range	
Coastal plain : BRGs 1 & 2	0 - 450 m	Coast Forest and Thornveld	0 - 450 m	Coast Lowlands	0 - 450 m
Lowlands : BRGs 3, 4, 17	451 - 900 m	Ngongoni Veld	451 - 900 m	Coast Hinterland	457 - 1 066 m
Uplands : BRGs 5, 6, 7	901 - 1 400 m	Natal Mistbelt Ngongoni Veld	901 - 1 350 m	Midlands Mistbelt	1 067 - 1 372 m
Highlands : BRGs 8 & 9	1 401 - 1 800 m	Highland Sourveld	1 351 - 2 150 m	Highlands	1 373 - 1 981 m
Montane : BRG 10	1 801 - 3 353 m	*Themeda-Festuca* Alpine Veld	1 850 - 2 150 m	Mountain	1 829 - 2 134 m
Uplands : BRGs 11 & 14	901 - 1 400 m	Southern & Northern Tall Grassveld	1 050 - 1 350 m		
Lowlands : BRGs 15 & 16	451 - 900 m				
Coastal & Lowlands : BRGs 19 & 20	150 - 900 m	Zululand Thornveld	150 - 050 m		
Coastal - Uplands : BRG 21	150 - 900 m				
Coastal : BRG 22	150 - 450 m	Lowveld & Arid Lowveld	150 - 600 m		
Coastal : BRG 23	80 - 150 m				

Appendix 8 : THE BIORESOURCE UNIT INVENTORY

The BRU inventory consists of a combination of field recordings, crop and veld ecotope tables, and tables which record levels of productivity per ecotope gained by running the crop production models and using the climate and ecotope information.

An example of a BRU inventory is given below. Explanations of some of the features are provided below the inventory. (Inventories for BRUs are available from the Natural Resource Unit, Cedara, KwaZulu-Natal).

8.1 Example of an Inventory for a BRU

BRU 28 SCHEEPERSNEK WXc2

LOCALITY INFORMATION

Topography	
Topography type	Rolling
Altitude range	1219 - 1371 m
Slope	Gentle/Moderate
Extent of cultivation	Widespread
Vegetation	
Vegetation type	Moist Transitional Tall Grassveld
Physiognomic type	Grassland
Indicator species	*Hyparrhenia hirta, Acacia mearnsii*
Number of units	1

LOCALITY ON THE FRANKFORT-VRYHEID SHEET

Table A.8.1.1 : CLIMATE TABLE FOR BRU WXc2

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall													
Median rainfall (mm)		137	109	86	40	10	2	4	6	35	77	111	134
Mean rainfall (mm)	849	140	114	89	50	22	13	16	18	47	88	112	138
Temperature													
Mean (°C)	16.7	20.9	20.5	19.3	16.8	14.0	11.2	11.3	13.5	16.2	17.5	18.7	20.2
Maximum (°C)	23.4	26.8	26.4	25.2	23.4	21.4	19.1	19.3	21.2	23.3	23.9	24.7	26.4
Minimum (°C)	10.0	15.1	14.7	13.4	10.4	6.7	3.4	3.4	5.8	9.1	11.1	12.8	14.1
Heat units (base 4.4°C)		512	456	462	373	298	204	214	282	354	406	430	491
Heat units (base 5°C)		494	439	444	355	279	186	195	263	336	387	412	472
Heat units (base 10°C)		339	298	289	205	124	36	40	108	186	232	262	317
Evaporation													
A-pan (mm)	1837	198	163	159	132	117	102	114	137	163	177	178	199
Sunshine													
Sunshine													
Hours/day (Oct-Mar)	6.1												
Annual	6.5												

Note : The ecotopes listed in Tables A.8.1.2 and A.8.1.5 represent a sample of the ecotopes of BRU WXc2

Table A.8.1.2 : Inventory of crop ecotopes in BRU WXc2 (12 largest only)

Ecotope	Area (Ha)	Area % of BRU	Clay %	Depth	Slope	TU*	Soil form and series (see key for names)**
B.1.1	2021	20	35-65	0-1200	2-8	1,3	Cv17,Cv18,Gf12,Gf22,Hu17,Hu27,Sd11
B.2.1	2031	20	15-35	0-1200	2-8	1,3	Cv16,Cv17,Cv26,Gf12,Gf22,Hu16,Hu17,Hu26,Hu27,Sd11
B.3.1	352	4	6-15	0-1200	2-8	1,3	Cv13,Cv14,Cv15,Cv16,Cv26,Hu16,Hu26
D.2.1	558	6	15-35	800-1000	2-8	1,3	Av16,Av17,Av26,Av27,Av36,Pn17,Pn27
D.2.2	468	5	15-35	600-1000	2-8	1,3	Av16,Av26,Av36
D.3.1	508	5	6-15	800-1000	2-8	1,3	Av13,Av14,Av16,Av23,Av24,Av26,Av36,Gc14,Gc24
D.3.2	598	6	6-15	600-800	2-8	1,3	Av13,Av14,Av16,Av23,Av24,Av26,Av36,Gc14,Gc24
E.1.3	226	2	35-40	300-400	2-8	1,3	We13
E.1.4	226	2	35-40	200-300	2-8	1,3	We13
E.3.1	508	5	0-15	800-1000	2-8	3,5	Cf21,Kd11,Kd14,Lo20,Lo21,Lo22
E.3.2	508	5	0-15	600-800	2-8	3,5	Cf21,Kd11,Kd14,Lo20,Lo21,Lo22
I.2.2	226	2	15-35	500-800	2-8	5	Ka10,Lo22

* TU = Terrain unit - 1 = crest, 2 = scarp, 3 = midslope, 4 = footslope and 5 = bottomland

Table A.8.1.3 : Expected crop yields for the ecotopes in BRU WXc2 (Using a management factor of 70%) (NR indicates that the crop is not recommended for that ecotope)

Ecotopes	Soil type	Clay %	Depth mm	Cotton (t/ha)	Drybean (t/ha)	Groundnut (t/ha)	Maize (t/ha)	Sorghum (t/ha)	Soyabean (t/ha)	Sunflower (t/ha)
B.1.1	Well drained	>35	>800	NR	1.7	NR	6.7	5.0	2.7	2.4
B.2.1	Well drained	15-35	>800	NR	1.5	2.6	6.1	4.6	2.5	2.1
B.3.1	Well drained	<15	>800	NR	1.4	2.3	5.5	4.1	2.2	1.9
D.2.1	Rest. drainag*	15-35	>800	NR	1.5	2.6	6.1	4.6	2.5	2.1
D.2.2	Rest. drainage*	15-35	500-800	NR	1.2	2.1	5.0	3.7	2.0	1.7
D.3.1	Rest. drainage*	<15	>800	NR	1.4	2.3	5.5	4.1	2.2	1.9
D.3.2	Rest. drainage*	<15	500-800	NR	1.1	1.9	4.4	3.3	1.8	1.5
E.1.3	Poorly grained	>35	300-500	NR	NR	NR	NR	NR	NR	NR
E.1.4	Poorly drained	>35	<300	NR	NR	NR	NR	NR	NR	NR
E.3.1	Poorly drained	<15	>800	NR	1.1	1.9	4.4	3.3	1.8	1.5
E.3.2	Poorly drained	<15	500-800	NR	0.7	1.2	2.9			

Table A.8.1.4 : Expected pasture yields for the ecotopes in BRU WXc2 (Using a management factor of 70%)

Ecotope	Soil type	Clay (%)	Depth (mm)	Kikuyu (tons/ha)	E.curvula (tons/ha) 250kgN/ha	E curvula (tons/ha) 350kgN/ha	Ryegrass Plant Feb (tons/ha)	Ryegrass Plant Mar. (tons/ha)	K11 (tons/ha)
B.1.1	Well drained	>35	>800	10.5	11.5	14.8	18.2	13.7	10.6
B.2.1	Well drained	15-35	>800	10.5	11.5	14.8	18.2	13.7	10.6
B.3.1	Well drained	<15	>800	10.5	11.5	14.8	18.2	13.7	10.6
D.2.1	Rest. drainage*	15-35	>800	10.5	11.5	14.8	16.4	12.3	10.6
D.2.2	Rest. drainage*	15-35	500-800	10.5	11.5	14.8	12.8	9.6	10.6
D.3.1	Rest. drainage*	<15	>800	10.5	11.5	14.8	16.4	12.3	10.6
D.3.2	Rest. drainage*	<15	500-800	10.5	11.5	14.8	12.8	9.6	10.6
E.1.3	Poorly drained	>35	300-500	9.5	10.4	13.3	NR	NR	9.5
E.1.4	Poorly drained	>35	<300	7.4	8.1	10.3	NR	NR	7.4
E.3.1	Poorly drained	<15	>800	9.5	10.4	13.3	NR	NR	9.5
E.3.2	Poorly drained	<15	500-800	9.5	10.4	13.3	NR	NR	9.5

Table A.8.1.5 : Inventory of veld ecotopes in BRU WXc2

Ecotope	Area (ha)	Area % of BRU	Clay (%)	Depth (mm)	Slope (%)	TU	Soil form and series (see key for names)**
A.1.f.r	69	1	15-20	200-300	2-8	1,3	Ms10.Ms11
A.1.f.n	5248	52	15-65	200-1200	2-8	1,3	Av16,Av17,Av26,Av27,Av36,Cv16,Cv17,Cv18,Cv26,Gf12,Gf22,Hu16,Hu17,Hu26, Hu27,Pn17,Pn27,Sd11
A.2.f.r	205	2	6-15	200-400	2-8	1,3	Gs14,Ms10,Ms11
A.2.f.n	1769	18	0-15	400-1200	2-8	1,3,5	Av13,Av14,Av23,Av24, Cf21,Cv13,Cv14,Cv15,Du10,Gc14,Gc24
S.2.f.r	83	1	6-15	150-200	2-8	1,3	Gs14,Ms10,Ms11
D.1.f.n	694	7	15-40	200-1000	2-8	1,3	Lo22,We13,We22
D.2.f.n	804	8	0-15	600-1000	2-8	3	Kd11,Kd14,Lo20,Lo21
P.1.f.n	452	5	15-35	400-1000	2-8	5	Ka10,Lo22
P.2.f.n	201	2	0-15	600-1000	2-8	5	Kd11,Kd14,Lo20,Lo21
Rock	292	3					
Stream	201	2					

* Restricted drainage

Table A 8.1.6 : Veld production norms for BRU WXc2 (Camp & Smith, 1994)

Dry matter consumed/AU/yr (kg)	2500 Sourveld
Veld condition score (assumed)	70%
Current grazing capacity ha/AU (No soil limits)	2.1
Potential grazing capacity ha/AU (No soil limit)	1.5
Veld burning zone	Cool Moist Grassveld
Burning dates	1 August to 30 September
Grazing cycle (days)	30 days
Length of grazing season	250 days
Grazing cycles per grazing season	8.3
Period of stay in days for a four camp system	10
Period of absence in days for a four camp system	20
Recommended rest frequency	1 year in 4 years

Table A.8.1.7 : Grazing capacity and grazing days for BRU WXc2

Ecotope	Soil code	Clay (%)	Slope (%)	Rockiness	Current * grazing capacity (ha/AU)	Potential* grazing capacity (ha/AU)	Current* Grazing Days $ha^{-1}cycle^{-1}$	Potential* Grazing Days $ha^{-1}cycle^{-1}$
A.1.s.r	Well drained, > 200 mm	>15	>12	rocky	2.6	1.8	11	16
A.1.f.n	Well drained, >200 mm	>15	<12	not rocky	2.1	1.5	14	20
A.2.f.n	Well drained, >200 mm	<15	<12	not rocky	2.4	1.7	13	18
A.2.f.r	Well drained, >200 mm	<15	<12	rocky	2.6	1.8	11	16
S.2.f.r	Well drained, <200 mm	<15	<12	rocky	2.9	2.0	10	15
D.1.f.n	Duplex/plinthic	>15	<12	not rocky	2.7	1.9	11	16
D.2.f.n	Duplex/plinthic	<15	<12	not rocky	3.0	2.1	10	14
P.1.f.n	Poorly drained	>15	<12	not rocky	3.0	2.1	10	14
P.2.f.n	Poorly drained	<15	<12	not rocky	3.4	2.4	9	13

* All figures are based on the veld management norms presented in Table A.8.1.6. Note that grazing capacity is based on 250 days.

** **Key to soil forms and series**

Code	-	Soil form.Soil series
Av13	-	Avalon.Ashton
Av14	-	Avalon.Kanhym
Av16	-	Avalon.Ruston
Av17	-	Avalon.Normandien
Av23	-	Avalon.Villiers
Av24	-	Avalon.Leksand
Av26	-	Avalon.Avalon
Av27	-	Avalon.Bergville
Av36	-	Avalon.Soetmelk
Cf21	-	Cartref.Cartref
Cv13	-	Clovelly.Vidal
Cv14	-	Clovelly.Mossdale
Cv15	-	Clovelly.Soweto
Cv16	-	Clovelly.Oatsdale
Cv17	-	Clovelly.Clovelly
Cv18	-	Clovelly.Balgowan

Code	-	Soilform.Soil series
Cv26	-	Clovelly.Southwold
Du10	-	Dundee.(one series)
Gc24	-	Glencoe.Dunbar
Gf12	-	Griffin.Griffin
Gf22	-	Griffin.Ixopo
Gs14	-	Glenrosa.Platt
Hu16	-	Hutton.Hutton
Hu17	-	Hutton.Farningham
Hu26	-	Hutton.Msinga
Hu27	-	Hutton.Doveton
Ka10	-	Katspruit.Katspruit
Kd11	-	Kroontsad.Velddrif
Kd14	-	Kroonstad.Mkambati
Lo20	-	Longlands.Koppies
Lo21	-	Longlands.Umtentweni
Lo22	-	Longlands.Katarra

Code	-	Soilform.Soil series
Ms10	-	Mispah.Mispah
Ms11	-	Mispah.Klipfontein
Pn17	-	Pinedene.Kilburn
Pn27	-	Pinedene.Airlie
Sd11	-	Shortlands.Argent
We13	-	Westleigh.Sibasa
We22	-	Westleigh.Devon

8.2 Notes On The Bioresource Unit Inventory

The details of the information on the title page of the BRU inventory will be described under the different headings.

8.2.1 Title

At the head of the first page of each BRU inventory, a BRU computer number is given which accesses the BRU information in the computer. In the example above it is 28. This is followed by a name. Each BRU has been given a name taken from a prominent feature in the BRU such as a mountain, town or major farm in the area. The final information is the BRU code. In this example it is WXc2.

8.2.2 Locality information

Topography information :

Topography type :

This is a visual assessment made during field inspections and to a lesser extent from a study of the 1:50 000 topo-cadastral maps. As such it is not an exact measure. Categories are mountainous, broken, valley, rolling (undulating) or flat. Topography type can be described as one category, but frequently the topography varies considerably within a BRU. To indicate the variation and the frequency of the different patterns, a three part description is used as follows: Dominant/Secondary/Isolated. A BRU can therefore be described as "rolling". This would indicate that the dominant and only pattern of topography is one of rolling hills. "Rolling, broken" would indicate that there is an equal amount of rolling and broken topography in the BRU. "Rolling/broken" would indicate that rolling terrain dominates while there is a lesser extent of broken terrain, while "Rolling/-/broken"would indicate that the dominant pattern of topography is one of rolling hills with isolated areas of broken terrain. The term "rolling" refers to topography which has smooth slopes with gradual changes in slope. "Broken" refers to topography which has sharp ridges and sudden changes in slope, often changing at ridges and ledges.

Altitude range:

The range reflects a computer generated highest and lowest point in the BRU.

Slope:

Visual assessments and a study of the 1:50 000 topo-cadastral maps were used to determined the slopes as : gentle (0 - 5%), moderate (5 - 12%) or steep (>12%). The slopes within a BRU may fall within one or more categories and these categories are then indicated in the order of dominance, that is Dominant/Secondary/Isolated. Should a BRU be dominated by moderate slopes and have a secondary pattern of steep slopes and isolated areas of gentle slopes, it would be described as "moderate/steep/gentle". A BRU with an equal amount of gentle and moderate slopes would be described as "gentle, moderate". A BRU with gentle slopes and with small, isolated areas of steep slopes would be described as "gentle/-/steep".

The slope categories relate to the potential that slopes have for soil loss. A slope of 5% or less generally indicates that soil loss through water erosion can be readily contained by the use of basic water carrying conservation structures. Slopes of 6% to 12% are subject to serious soil loss unless stringent conservation practices, usually involving both structures and surface mulching, are incorporated to maintain soil loss within acceptable limits. Slopes exceeding 12% are generally considered to be non-arable for annual cultivation. Sugar cane is grown on slopes well in excess of 12% and while this crop is only replanted once in eight to twelve years, soil loss remains a problem with the current cultivation methods.

8.2.3 Extent of cultivation :

Estimates of the extent of cultivation are given at three levels. "Limited" refers to a BRU which has less than 10% cultivation. "Moderate" indicates that 10 to 50% of the area is cultivated, while "widespread" indicates that over 50% of the BRU is under cultivation. The term cultivation refers to all land that has been mechanically disturbed, or where the natural vegetation has been altered extensively and changed to alien plant cover. Commercial timber plantations would therefore be regarded as cultivated land. Fallow land which is temporally untilled, or has no cultivated crop on it, is regarded as cultivated land.

8.2.4 Vegetation

The description of the vegetation (physiognomic type) is a further indication of the potential and provides a basis for decisions on land management.

Vegetation type :

The vegetation type, or Bioresource Group, is recorded and this indicates that further information can be sought under the description of the relevant BRG.

Physiognomic type :

Physiognomy is the appearance, especially the external appearance, of the vegetation, partly resulting from, but not to be confused with, composition and function. For the purposes of the Bioresource programme, 11 different physiognomic types have been described. These are detailed in Appendix 3, the different types being both illustrated and given broad parameters to assist identification. The same procedure defined under terrain type and slope, that is, Dominant/Secondary/Isolated, is used to describe the general vegetation patterns in a BRU. In the Lowveld and Valley Bushveld for instance, a pattern of "bushland, bushland thicket", where these two patterns are usually co-dominant, is generally found.

In identifying physiognomic vegetation types, the aim was to arrive at a broad-scale descriptive system which could be easily applied using terminology generally used in KZN. This could be used in the field and would hopefully set a standard for common use when using the Bioresource programme information and for natural resource inventories, vegetation description and for mapping purposes. The various vegetation types should be easy to identify in the field by using remote sensing and aerial photographs in particular. As it is intended to be for general description purposes only, crown cover and height classes were simplified from the detailed description provided by Edwards (1983). This provides a structural classification based solely on vegetation characters, although it can generally be complementary to floristic habitat and ecological classifications of vegetation. For detailed surveys, Edwards (1983) provides a complete description which may be more suitable than the one used here. Pratt and Gwynne (1977) described seven physiognomic vegetation types for East Africa and some of these names proved to be acceptable for this Province. Additional types included are forest, scrub forest, bush clump grassland and swamp. The term thicket was added to woodland and bushland because both these types have great significance in KZN. Excluded was dwarf shrub grassland.

Plant Indicator species :

The term plant indicator species was used by Moll (1971). Certain species are regarded as being indicative of the veld type, or Bioresource Group, in which they are typically found. Most of the indicator species will be found in more than one BRG and it is not their presence alone that is indicative of a vegetation type, but rather the co-occurrence of a group of indicator species that gives a lead to the BRG. The plant indicator species are used in conjunction with other broad climatic parameters to identify a BRG. The plant indicator species are listed in Appendix 2.

8.2.5 Number of units

The BRUs may consist of a single unit of land, or two or more units. These additional units of land will all have the same inventories of natural resources, but are separated geographically. The separate units are identified by a lower case letter which is attached to the code for the BRU, for example, Yc6 has three separate units and these are identified as Yc6a, Yc6b and Yc6c.

Appendix 9 : THE BIORESOURCE GROUP INVENTORY

This BRG inventory consists of descriptions of BRG 8 as a whole and of BRG 8.12 - Kamberg, one of the separate units of BRG 8 found in the Kamberg area in the foothills of the Drakensberg.

BRG 8 - MOIST HIGHLAND SOURVELD

The name for this BRG is derived from the name Highland Sour Veld given to the vegetation type by Pentz (1945) and Acocks (1953).

Locality and description

The Moist Highland Sourveld (MHS), which is 876 049 ha in extent and the third largest BRG, generally occurs between 1 400 m and 1 800 m above sea level. The BRGs lying below the MHS are either the Moist Transitional Tall Grassveld or the Moist Midlands Mistbelt, while the Montane Veld lies adjacent, and at a higher altitude along the Drakensberg. Isolated sub-groups of the MHS found away from the Drakensberg are situated on the crests of the terrain and at altitudes exceeding 1 400 m above sea level. The topography is gently to moderately rolling over large areas, but much of it is mountainous terrain, rendering it suitable for extensive farming only. The largest areas of the MHS occur in the Underberg and Kamberg districts in the midlands of the Province, and in the Groenvlei area in the north of the Province.

Climate

The mean annual rainfall of this BRG ranges from 800 mm to 1 265 mm per year and approximately 80% of the rain falls in the summer months of October to March. Mist is a frequent occurrence, particularly at the higher altitudes, and snow occurs every two to four years (Moll, 1971). The frequency of snowfalls is greater on the highest ranges of the BRG. Considerable damage can be done to timber plantations during the heavy snow storms.

The mean annual temperature is 14.1°C, within a range of 11.5°C to 16.6°C.. Summers are moderately warm, with a December mean of 18.0°C. Winters are cold with the severity increasing from north to south. The mean minimum July temperature range of the sub-groups in the west and south is 0.1°C to 3.6°C, while those in the north and east are warmer, ranging from 1.8°C to 6.0°C. Severe frosts can occur over a six month period, particularly in bottomland areas. Light frosts may occur during the early and late summer months.

Wind has an effect on evaporation, as can be seen from the figures in Table 1.14 in Appendix 1 for Impendhle and Tabamhlope. These two stations have similar mean annual rainfall and temperature figures, but there is a big difference in the windrun figures. At Impendhle, the mean windrun is 91 km per day, and the mean annual evaporation is 1 384 mm per year. At Tabamhlope, the mean annual windrun is 147 km per day and the evaporation is 1 543 mm per year. The mean annual evaporation for the BRG ranges from 1 238 mm to 1 853 mm.

Vegetation

The vegetation is a fire maintained grassland, dominated by short bunch grasses up to 0.5 m in height. In the absence or reduction of fire, a development towards *Podocarpus* forest occurs, with grasses such as *Cymbopogon* spp. and tall *Hyparrhenia* spp., and the trees *Leucosidea sericea* and *Buddleja salviifolia* being the forest precursors.

Abundant grass species are *Alloteropsis semialata, Andropogon appendiculatus, Brachiaria serrata, Cymbopogon excavatus, Cymbopogon validus, Digitaria tricholaenoides, Diheteropogon amplectens, D. filifolius, Eulalia villosa, Harpochloa falx, Elionurus muticus, Eragrostis capensis, E. curvula, E. plana, E. racemosa, Heteropogon contortus, Microchloa caffra, Monocymbium ceresiiforme, Setaria nigrirostris, Sporobolus africanus, Themeda triandra, Trachypogon spicatus* and *Tristachya leucothrix.*

Soils derived from dolerite are structurally better suited to plant growth than soils derived from sedimentary rocks. Veld based on doleritic soils generally has a good basal cover and can withstand grazing pressure reasonably well and is usually dominated by *Themeda triandra* and *Heteropogon contortus*. On soils derived from sedimentary parent material, the cover is usually poorer than on doleritic soils and is relatively susceptible to disturbance, resulting in a dominance of *Eragrostis* species and *Sporobolus africanus*.

Veld in good condition is dominated by *Themeda triandra* and *Tristachya leucothrix*, while veld disturbed by overgrazing is dominated by *Eragrostis curvula, E. plana*, and *Sporobolus africana*. Veld that is selectively overgrazed (understocked for long grazing periods so that the palatable species are selectively utilised), frequently favours an increase in the wiregrass species *Elionurus muticus, Aristida junciformis* and *Diheteropogon filifolius.* On shallow soils the common species are *Microchloa caffra, Eragrostis racemosa* and *Heteropogon contortus*.

Aspect has a marked effect on both the species composition and the productivity of the grassland. On south-facing aspects, grass productivity is relatively higher than on north-facing aspects. The grass on these south-facing aspects, including *Festuca costata* and *Cymbopogon* species is, however, less palatable than grass on north-facing aspects, where *Themeda triandra* dominates. As a result, where cattle have uncontrolled access to veld, the north-facing aspects tend to be overgrazed, and deteriorate in condition, while the south-facing aspects are under-utilised. At the highest altitudes in the BRG, and on south-facing slopes, *Festuca costata* is a common and little-used species.

Forbs play an important role in the species composition and forbs such as some *Senecio* species, *Helichrysum aureonitens* and sedges, increase in relative abundance when veld is over-utilised, while *Pteridium aquilinum* (Bracken), increases with under-utilisation and with fire exclusion. The shrub *Felicia filifolius* (aster) dominates in veld, particularly on north-facing aspects, where severe overgrazing with resultant denudation has occurred. By resting such areas and building up a fuel load, this shrub can be destroyed in a hot, or high intensity fire, but such a treatment must be followed by resting of the area to build up the vigour of the grass plants. *Athanasia acerosa* (Curry's Post weed), invades veld that is overgrazed and this species can also be destroyed by the use of fires of high intensity.

Two groups of forbs occur. The spring aspect forbs flower in spring, growth commencing as soil temperatures rise following the cold of winter. They are mainly associated with disturbance and are found in areas that are regularly burned. Autumn aspect forbs are not common and are regarded as early indicators of under-utilisation. Annual burning, particularly in autumn and winter, is regarded as a reason for the paucity of these forbs in the veld. *Pteridium aquilinum* (Bracken), is the most widespread forb.

Isolated forest patches occur, mainly on the cooler and moister south-facing slopes, and particularly where they have been protected from fire. Most forests have been seriously damaged through exploitation for timber, and through fire, which burns into the forest margins, each fire diminishing the size of the forest. The destruction of forest margins has a seriously diminishing effect of the biotic diversity of this form of vegetation. *Podocarpus* forest occurs in areas where natural fire barriers are found. The Highland Sourveld has the lowest ratio of forest to grassland of any of the moist regions in the Province (Phillips, 1973).

Where fire has been excluded from the veld, bushes make an appearance, in particular the forest precursor species such as *Rhus* species and *Leucosidea sericea* and *Buddleja salviifolia*. Trees common to these forests include the yellowwoods *Podocarpus latifolius* and *P. falcatus*. Other trees include *Halleria lucida, Olinia emarginata, Calodendrum capense, Celtis africana, Rapanea melanophloeos, Kiggelaria africana* and *Ilex mitis*.

Formerly wetlands of considerable size occurred in the Moist Highland Sourveld and these were important for maintaining the low flow of streams in dry periods. Many of them have been drained for cultivation and much of the winter pasturage is now grown on drained wetland sites. Many wetlands have been dammed to provide water for stock and irrigation. From a water conservation point of view, this may be preferable to the drainage of wetlands, but destroys the biotic diversity of a natural habitat. The conservation of threatened species, and the wattled crane in particular, depends on the maintenance of wetlands of appreciable proportions. In this case it is the owners of private land that will determine the conservation of these birds.

Poisonous plants include *Senecio* species and *Pteridium aquilinum* (Bracken). *Moraea* sp.(Tulip), is a poisonous plant in bottomlands, but more particularly so once these areas have been developed under cultivated pastures.

Common weeds of the veld are *Rubus cuneifolius* (American bramble), *Acacia dealbata* (silver wattle), *A. mearnsii* (black wattle) and *A. decurrens* (green wattle). Wattle trees, particularly along water courses, pose a serious problem. Water flow in streams is affected, and grass cover is destroyed by the trees, causing a loss in grass production and a soil erosion hazard.

A serious pest in this veld type is the ghost moth larva (*Dalaca rufescens*), which spins a dense web about 6 cm in circumference between grass tufts and just above, and horizontal to, the ground. These webs are not obvious because they become coated by soil and plant debris. The larvae eat the base of the grass tufts and can do considerable damage. The moth, which has a weak flight, is able to fly over short-grazed grass and the problem is therefore common in overgrazed veld.

The indicator species for this BRG are *Leucosidea sericea* and *Buddleja salviifolia*.

The benchmark for BRG 8 is given in Table 9.1.

Table A. 9.1 : Benchmark for BRG 8 - Moist Highland Sourveld

Groups and species	Relative abundance (%)
Increaser I	
Alloteropsis semialata	2
Eulalia villosa	1
Trachypogon spicatus	2
Tristachya leucothrix	20
Sub total	**25**
Decreaser	
Brachiaria serrata	1
Diheteropogon amplectens	1
Monocymbium ceresiiforme	2
Themeda triandra	45
Sub total	**49**
Increaser IIa	
Eragrostis capensis	1
Harpochloa falx	3
Heteropogon contortus	4
Sub total	**8**
Increaser IIb	
Eragrostis curvula	1
Eragrostis plana	1
Eragrostis racemosa	1
Hyparrhenia hirta	1
Sub total	**4**
Increaser IIc	
Microchloa caffra	1
Forbs	5
Sedges	1
Sub total	**7**
Increaser III	
Diheteropogon filifolius	2
Elionurus muticus	5
Sub total	**7**
Total	**100**

The categories of the benchmark reflect the utilisation that the veld has been subjected to:

Decreaser species dominate in relative abundance in veld that is in excellent condition.
Increaser I species increase in relative abundance in veld which that has been under-utilised.
Increaser IIa species increase in relative abundance in veld in the initial stages of over-utilisation.

Increaser IIb species are dominant in veld that has been over-utilised for a long period.
Increaser IIc species are high in relative abundance in veld that has been severely over-utilised for a long period.
Increaser III species increase in relative abundance in veld that has been selectively over-utilised.

Water resources

This BRG is generally rich in water resources. The mean annual rainfall is in excess of 800 mm and numerous streams rise in the area. Being to a large extent immediately below the Montane area, streams and rivers rising in the mountains flow through the BRG. Suitable sites for farm dams are common and building material is generally suitable. Sites for the planting of timber require particular attention because this BRG is a very important water source for the Province.

Soils

Soils are relatively deep, highly leached and strongly acid. Fertility is low, but physical properties are favourable.

Land use and potential

Twenty four percent of this BRG is arable, while 20% of the BRG has high potential soils. The prevailing climatic conditions make the MHS difficult to farm. The dry, cold and frosty winters result in a short growing season and consequently winter feed has to be provided for stock to cater for the deterioration in the quality of the veld in the winter. Hailstorms are a frequent occurrence in summer, jeopardising crop production. In addition to this, the soils are leached, requiring an expensive input of fertilizer. Despite these problems, this BRG is suited to intensive farming systems including beef, dairy, sheep and maize. Certain areas, such as Kamberg, are intensively farmed, including crops and livestock, while in others, notably Underberg, dairy farming is important. Potatoes are grown in the Underberg and Kamberg areas. Timber plantations are increasing in the Underberg area. High quality pastures are important to this BRG and an understanding of raising and maintaining soil fertility is essential.

The veld, relative to other BRGs, is in good condition, but the grazing season is curtailed by the long winter period, when winter feed in the form of pastures, hay or silage, is necessary. The supplementary feed requirements amount to 1 ton of dry matter per Animal Unit (AU) for the winter period. Beef ranching is an important enterprise and an annual mass gain of 120 kg per AU is possible. Sheep farming is less important, with sheep numbers declining. For good veld management and animal performance, sheep should be grazed in conjunction with cattle and at a ratio of 1:1, that is, approximately one cattle unit to six sheep. Game species which do well in this BRG are blesbuck, eland, common reedbuck, mountain reedbuck, grey rhebuck, oribi, common duiker and bushbuck (on forest verges).

The grazing capacity for veld in good to reasonable condition is 2.0 ha per AU, with a potential of 1.5 ha per AU. The recommended number of grazing days per ha per grazing cycle is 20 days, while that for the season is 166 days. The length of the grazing season, which depends largely on the management of the veld, is approximately 250 days. Based on a four camp grazing management system, the period of stay of a herd in the rotational should be 10 days and the period of absence 20 days. A short grazing cycle through the camps of 30 days, with one of the four camps resting, is necessary to maintain the quality of grazing. Veld should be rested at least every four years, but this depends on the management system applied (Camp & Smith, 1994). Should burning be followed by close and continuous grazing, particularly by sheep, it has been shown that the yield of palatable species can be reduced by as much as 45% to 52% in a season (Barnes & Dempsey, 1992). Heavily grazed veld should be rested in the following year to restore vigour. Burning is necessary to remove moribund material which may accumulate. Most of the veld in this BRG is burnt every year and this can be indicative of inefficient management of the veld. The recommended burning period is from the 1st of August to the 30th of October (Russell, 1993). The veld should be burnt as early as possible in this period and preferably as soon as possible after rain. Burning should be avoided once the palatable species have commenced growth as this has a deleterious effect on their vigour.

Table A.9.2 : Summary of the natural resources of BRG 8

BRG No	Total area (ha)	Arable soils		High potential soils		Mean annual precipitation (mm)	Mean annual temperature °C	Apan (mm)	Dom. veld ecotope		Dom. crop ecotope	
		Area	%	Area	%				Code	%	Code	%
8	876 049	237 104	27	164 640	19	800 - 1 265	11.5 - 16.6	1 238 - 1 853				
8.1a	10 863	3 366	31	2 700	25	933 - 1 000	13.8 - 15.0	1 795 - 1 853	A.1.f.n	24	B.1.1	14
8.1b	162 097	57 097	35	41 928	26	800 - 1 070	13.6 - 15.5	1 732 - 1 853	A.1.f.n	22	B.1.1	11
8.1c	3 226	861	27	477	15	800	14.4	1 836	Rocky areas	28	D.2.1	5
8.2a	109 524	25 369	23	13 531	12	849 - 1 111	13.8 - 15.5	1 752 - 1 836	Rocky areas	23	B.2.1	4
8.2b	5 342	1 260	24	901	17	891 - 923	15.2 - 15.6	1 803	Rocky areas	22	B.2.1	10
8.3	1 535	54	4	30	2	866	15.7	1 794	A.1.f.r	36	B.2.2	1
8.4a	4 680	2 548	54	1 711	37	821	15.0	1 720	A.1.f.n	60	D.2.1	13
8.4b	1 991	1 983	99	846	42	900	15.4	1 729	A.1.f.n	76	B.2.1	33
8.5	2 103	912	43	204	10	845	15.7	1 723	A.1.f.n	28	B.2.3	15
8.6	1 110	382	34	193	17	900	15.8	1 724	A.1.s.n	31	B.2.1	11
8.7	17 560	5 880	33	2 337	13	844 - 1 100	15.5 - 15.8	1 684 - 1 718	A.1.f.n	21	B.2.2	5
8.8a	503	13	3	0	0	800	16.2	1 781	a.1.s.r	56	H.2.4	1
8.8b	312	34	11	16	5	900	16.6	1 797	a.1.s.r	41	B.1.2	3
8.9	463	221	48	187	40	884	15.9	1 712	A.1.s.n	48	B.1.1	14
8.10	21 995	4 714	21	1 821	8	1 026 - 1 163	14.8 - 15.4	1 737 - 1 813	A.1.s.n	49	B.2.2	7
8.11a	6 608	1 386	21	776	12	1 081 - 1 263	15.2	1 713 - 1 754	A.1.s.n	49	H.2.3	6
8.11b	33 809	17 268	51	12 975	38	907 - 1 263	14.9	1 709 - 1 713	A.1.s.n	34	B.2.1	25
8.12	135 032	27 209	20	23 268	17	822 - 917	13.0 - 14.9	1 564 - 1 682	A.1.f.n	29	B.2.1	8
8.13	61 378	13 835	23	11 091	18	996 - 1 017	14.1	1 592 - 1 636	A.1.s.n	28	B.2.1	10
8.14	183 527	46 473	25	27 364	20	840 - 1 225	13.0 - 15.6	1 501 - 1 647	A.1.f.n	35	B.1.1	8
8.15a	19 412	7 126	38	3 109	16	828 - 867	12.3 - 13.6	1 492 - 1 601	A.1.s.n	22	B.2.2	10
8.15b & c	34 697	10 182	29	4 766	14	851 - 1 265	11.5 - 15.4	1 283 - 1 499	A.1.f.n	17	B.2.2	7
8.15d	23 783	3 078	13	1 854	8	827 - 949	12.3 - 14.1	1 238 - 1438	Rocky areas	23	B.1.2	2
8.15e	9 686	2 179	23	858	9	810 - 860	13.2 - 14.1	1 368 - 1 513	A.1.s.r	20	B.2.2	4
8.15f	24 813	3 674	15	1 697	7	811 - 859	12.6 - 13.9	1 393 - 1 538	A.1.s.r	22	B.2.2	3

Inventory for BRG 8.12 - KAMBERG

Locality

The western boundary of this sub-group runs along the foot of the Little Berg, from the entrance road to Giants Castle camp site and eMahlutshini in the north, down to Umgeni Vlei in the south. The northern boundary stretches to a point close to Lowlands in the east. An extended area in the south runs eastward to include Nottingham Road and the high-lying area between the Mooi River valley and the Mgeni River valley. This leg extends as far east as the Mount Alida area in the Rietvlei-Greytown district.

BRUs included: Wd8, Wd9, Wd14, Xd4, Yd16, Yd22, Yd23, Ye5

Total area of BRU	**135 032 ha**	
Arable area	**27 209 ha**	**20%**
High potential soil*	**23 268 ha**	**17%**

* High potential soils are moderately- and well-drained, over 500 mm deep, and have a clay percentage of over 15%.

Climate

The Umgeni Vlei area lies at a higher altitude than the rest of the sub-group and has a cooler climate. The figures for this area are given separately in brackets below.

Mean annual rainfall range	822 mm - 947 mm (917 mm)
Mean annual temperature range	14.2°C - 14.9°C (13.0°)
Mean January maximum temperature range	23.5°C - 24.3°C (21.9°C)
Mean July minimum temperature range	2.3°C - 2.9°C (2.2°C)
Incidence of frost	Severe frosts occur
Mean November temperature range	15.8°C - 16.3°C (14.2°C)
Heat units base 4.4°C range (May to Sept.)	1 026 - 1 155 (890)
Heat units base 5°C range (Full year)	3 363 - 3 614 (2 897)
Heat units base 10°C range (October to March)	1 238 - 1 337 (947)
Mean annual Apan evaporation range	1 612 mm - 1 682 mm (1 564 mm)

Vegetation

The major area of the sub-group is a grassland, with a species composition as describe in the introduction to the MHS. *Leucosidea sericea* and *Buddleja salviifolia* grow in areas of bushed grassland and on forest margins. Forests grow mainly on southern aspects where they receive some protection from fire. *Rubus cuneifolia* is a problem weed in some areas. The Umgeni Vlei is one of the most extensive vleis in the Province.

Table A.9.3 : Dominant veld ecotopes of BRG 8.12 - Kamberg

Ecotope	Area (ha)	Percentage of sub-group
A.1.f.n	39 712	29.4
A.1.f.r	12 662	9.4
A.1.s.n	32 037	23.7
A.1.s.r	18 442	13.7
Marsh	1 974	1.5
P.1.f.n	6 459	4.9
Rocky areas	10 4422	7.7
Streams	5 398	4.0

Water resources

Water resources are very good in this area. Numerous streams rise in, or flow through the area, including the Mgeni, Mooi, Little Mooi, Hlatikhulu and the Bushman's rivers. Farmers have built dams, mainly for irrigation purposes, and the intention is to build a State dam on the Mooi River. The Umgeni Vlei is the source of the Mgeni River which supplies water to the Pietermaritzburg and Durban areas.

Table A.9.4 : Dominant crop ecotopes of BRG A.9.4 - Kamberg

Ecotope	Area (ha)	Percentage of sub-group
B.1.1	5 296	3.9
B.2.1	10 830	8.0
B.2.2	4 247	3.2

Note : The codes A.1.1, A.1.2, A.2.1, A.2.2, B.2.1, B.2.2, C.1.1, C.1.2, C.2.1, C.2.2, D.1.1, D.1.2, D.2.1 and D.2.2 indicate high potential ecotopes (Du Pisani, 1983).

Land use and potential

Limited areas are extensively cultivated, particularly in the Kamberg district and in the eastern portion, where maize is grown and pastures and fodder crops are produced. The most important farming lines are beef, dairy and potatoes, with sheep of lesser importance. Timber has been planted recently.