INVESTIGATION INTO THE PLANT ECOLOGY

OF THE

KARSTLAND AREA IN NAMIBIA

WITH PARTICULAR REFERENCE
TO THE PROPOSED LARGE-SCALE ABSTRACTION
OF GROUNDWATER

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Thesis submitted for an MSc degree in Botany
to the University of Cape Town

October 1992

ACKNOWLEDGEMENTS

I wish to express my sincere thanks to the following parties :

Professor Eugene Moll and Professor William Bond, for their assistance and guidance,

The Department of Water Affairs in Namibia, for granting permission to use official information gathered during a Departmental investigation,

Steve Crerar, for his advice and encouragement in times of stress.

ABSTRACT

The planned large-scale abstraction of groundwater from the Karst area in northern Namibia prompted concern with respect to possible negative effects on the plant ecology of that area.

Although it was thought improbable that the lowering of the groundwater table would result in the deterioration of the vegetation, it was considered necessary to examine the existing vegetation status in order to establish a pre-abstraction baseline datum.

It was thus important to establish a broad overview of the current vegetation, any changes in its condition within a two years period, and also the prevailing environmental factors in the Karst area.

This was achieved through both manual and photographic monitoring of selected representative transects within the proposed abstraction area during 1986 and 1987. The manual monitoring exercise included the usual measures of density cover and frequency of all species, whereby a full inventory of the transects was established.

The environmental conditions were assessed through the collection and evaluation of data on rainfall, groundwater levels and soil conditions, both within the transects and for the area as a whole. Below average rainfall during and prior to the baseline study years, resulting in poor recharge to the groundwater table, was recorded for most of the karst area.

Both the vegetation and environmental data were utilized in two ways. Firstly, the 1986 and 1987 vegetation data were analysed, and those aspects indirectly related to the vegetation's vitality status, were then evaluated. A comparison of the parameters such as the quantity of dead material, and the number of standing dead trees, reflected a general decline in vitality over the two year period. In view of the poor rainfall conditions, this decline was interpreted as that which can be expected under natural adverse climatic conditions.

Secondly, in order to establish and critically examine the possible relationships between the vegetation data and components of the environmental data, a Canonical Correspondence Analysis was performed. Despite a large amount of "noise" caused by the broad nature of the environmental data, it was possible to identify a number of species which occur within precisely defined environmental conditions. A change in abundance or distribution of these species can in the future first be investigated in terms of their defined vegetation-habitat relationships, and thereafter in terms of any other introduced factors which may be suspected of having an influence.

Infra-red aerial photography was another monitoring technique used to obtain a pre-abstraction record of the vitality status of the vegetation. Two surveys were carried out during the baseline period and counts made of stressed and dead trees. A comparison of the counts reflected an increase in stress within the vegetation over this period, thus supporting the findings of the manual surveys.

Selected sections of vegetation at various points of interest within the transects, were monitored using fixed point photography on a bi-annual basis. Although these photographic records reflected small changes, these were not considered significant. The main purpose of this method is to provide a pre-abstraction record of vegetation at potentially "sensitive" points with which future surveys could be compared.

The usefulness and cost-effectiveness of the three central monitoring methods were evaluated, and an indication provided of how monitoring may continue in the long term as large-scale abstraction goes ahead.

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PART 1

1. INTRODUCTION

The large-scale abstraction of water from the limestone aquifer in the vicinity of Grootfontein in the north of Namibia is planned as phase three of a national water supply project, which was initially scheduled to be put into operation in mid-July 1987. The aim of this project is to ensure a secure long-term water supply to the central area of the country.

At the outset of monitoring in 1984, the pre-implementation groundwater table in some areas was relatively shallow. Concern was expressed that a lowering of the groundwater table as a result of abstraction may have an adverse effect on the plant ecology in the area. However, sustained large-scale abstraction had already taken place at several mines in the area with little apparent adverse effect, and thus it was considered improbable that the groundwater table would have an important bearing on the vegetation status. However, in order to be able to assess this objectively in the future, it was considered necessary to examine the existing vitality status of especially the larger woody component, the composition of the vegetation communities, and the species distribution. The information obtained during the then pre-implementation period (1986 and 1987) would be the input for the baseline data.

1.1 WATER IN NAMIBIA

1.1.1 BACKGROUND

Namibia is situated on the south-west coast of Africa, and has the Atlantic Ocean as its western border. The climate is governed by the country's geographic position in the southern tropics and by the cold Benguela Current.

Namibia is regarded as one of the most arid regions of the world, and has scarce water resources due to the low rainfall and high evaporation. The availability of water is thus a critical factor affecting prosperity and economic development.

An increase in the standard of living, socio-economic and mining development, as well as the high average population growth rate of at least 3% per annum, have increased the demand for potable water at an average rate of 12% per annum since 1970. From the available information, it is estimated that the annual water demand will increase from 68 Mm^3 in 1985, to 250 Mm^3 by the year 2000.

The total assured yield of both surface and underground water resources is estimated at 500 Mm^3 per annum, and 20% of this potential is already being used for human, animal, industrial, and agricultural purposes.

1.1.2 HYDROLOGY

The mean annual precipitation (MAP) in the country ranges from less than 50 mm at the coast, to more than 700 mm in the north-east. The average deviation in rainfall is as high as 80% of the MAP in the dry south-western area to as little as 20% in the north-east. Precipitation occurs mainly during the summer months between November and April by means of very intense, scattered thunderstorms.

The climatic extremes such as high evaporation and high temperatures all contribute to a unique and extreme hydrological cycle in Namibia. It is estimated that on average, 83% of the total rainfall evaporates almost immediately. Of the remaining 17%, 1% recharges groundwater sources, 14% is lost through evapotranspiration, and only 2% results in surface runoff (Secretary for Water Affairs, 1989). The flow in rivers in the interior of the country is thus irregular and unreliable, and the potential of the surface water sources (ephemeral rivers) is limited. The perennial border rivers in the north of the country have as yet not been utilized to any great extent, but development of these resources is dependant on international water rights issues which have yet to be finalised. The Orange River on the border with South Africa has already been developed to a large extent by South Africa and can probably only be considered for utilization in the southern region.

1.1.3 GEOHYDROLOGY

Practically all water available as groundwater originates from rainfall, whether from recent or prehistoric times (Secretary for Water Affairs, 1989). Groundwater sources are, however, sensitive to exploitation and are exhaustible. Where they are continually replenished by natural recharge, they can be utilized for almost unlimited periods provided that extraction does not exceed the long term recharge potential. Protection and efficient management of these water sources are therefore of vital importance to Namibia.

The availability of groundwater depends on a combination of sufficient rainfall and appropriate hydrological conditions. The occurrence of groundwater in Namibia is associated with six major geological environments, of which only carbonated rocks are of relevance to this study.

Carbonate rocks, including marble, limestone and dolomite, which generally have solution cavities, can contain large quantities of groundwater. These cavities are formed by carbonic acid which results from the dissolution of carbonate by percolating rainwater. These develop more readily along joints, faults and bedding planes. The dolomitic karst area in the Grootfontein-Otavi-Tsumeb triangle is a good example of such a groundwater source. Figure 1.1 shows the location of the Karst area in Namibia.

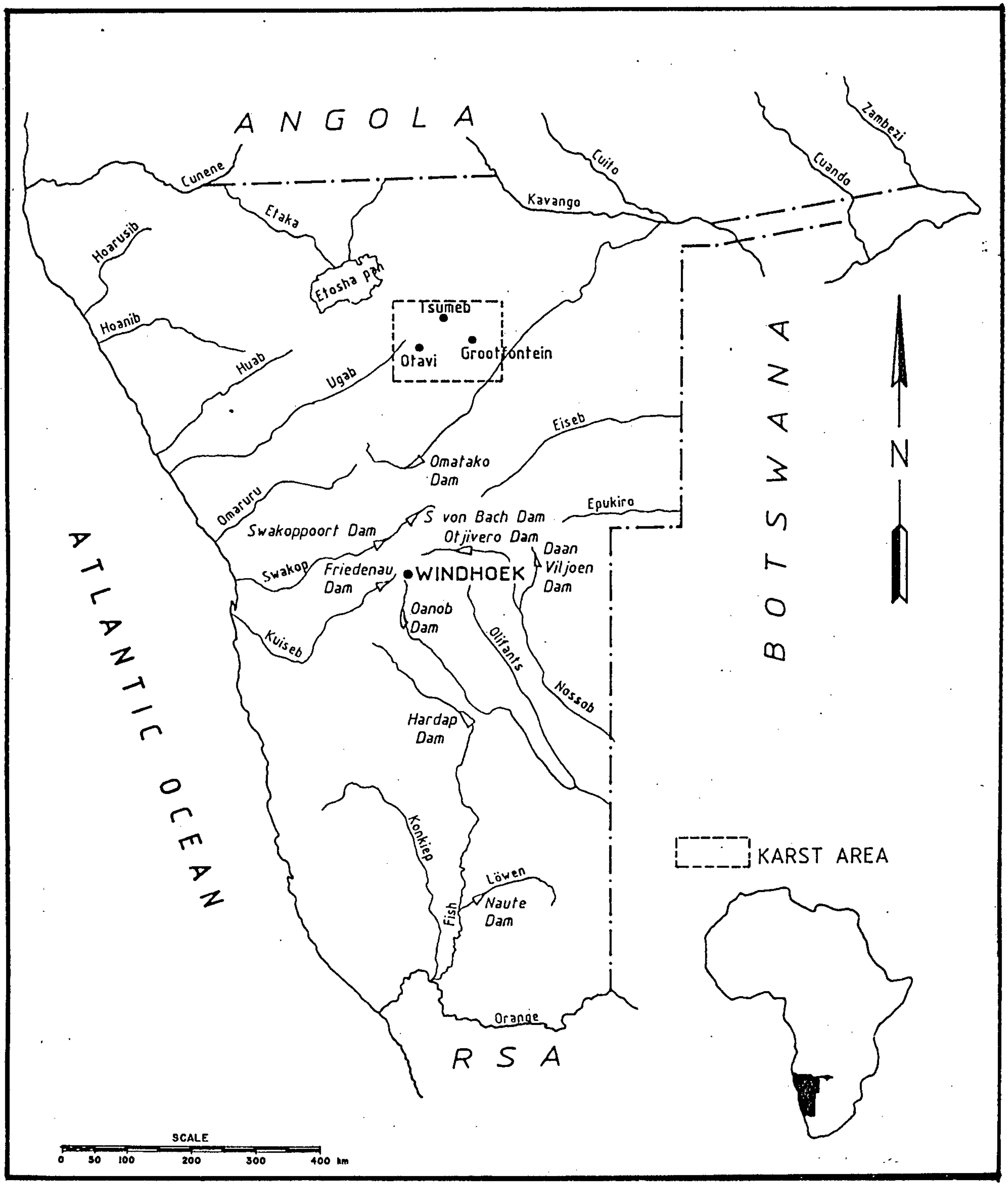


FIGURE 1.1 : LOCATION MAP SHOWING KARST AREA IN NAMIBIA

1.1.4 WATER SUPPLY POLICY

Due to the high cost of developing water supply schemes in an arid environment, the major responsibility for water supply infrastructure rests with the Government. Development of major urban areas together with industrial and mining development has taken place mainly in the central areas. However, the central area of the country has limited water resources. The planning of the country's water supply must therefore be aimed at integrating the available, local resources with one or more of the perennial border rivers.

The Department of Water Affairs is thus responsible for location and development of water resources, establishment and operation of bulk water schemes on a national and regional basis, as well as the long-term planning of water projects.

The principle applied in the development of water sources for specific consumers is that local water sources must be utilized first, then regional water sources further away, and finally a national water source which can supply water to several regions.

1.1.5 THE EASTERN NATIONAL WATER CARRIER

The largest, single water project is the Eastern National Water Carrier (ENWC), which is still to be completed. The purpose of the water carrier is to import 60 Mm^3 of water per annum from the Okavango River on the north-east border of Namibia to augment water supplies in the central area of the country. This project is being developed in phases according to the water demand and the availability of capital funds.

Investigations carried out as early as the 1970's indicated that the estimated water demand, as a result of existing and possible development in the central area of the country, would be supplied only in the short and medium term, by the available local water sources.

The risk of water shortages during the long drought periods experienced in the country, is an ever present threat. The only way to solve this problem was to develop the water potential in the central area optimally, and for the long term to build a water scheme which would bring in water from one of the perennial rivers. A Master Water Plan for the country was tabled in 1974 after further investigation and planning, and the recommendation was made to implement the ENWC.

The ENWC scheme has been completed between the central area of the country and the dolomitic groundwater area in the Karstveld, in the vicinity of Grootfontein. The construction of the 250 km long Grootfontein - Omatako Dam canal, links the Karstland Borehole Scheme with the Central area's water needs.

The Karstland Borehole Scheme is thus a very important interim source of water for the ENWC. The judicious large-scale abstraction of groundwater in the Karst area is to be carried out by means of a large number of boreholes and a network of pipelines.

1.2 INVESTIGATION OF THE KARSTLAND PLANT ECOLOGY

At the outset of the groundwater abstraction investigation in the Karst area, there was considerable concern that large-scale abstraction, leading to a decline in groundwater table, may result in detrimental environmental changes. As these changes may include disturbances to the vegetation in the area, it was considered fundamental to establish what the existing status of the vegetation was in terms of species diversity, distribution, and vitality, before any large-scale pumping began.

An investigation was launched to determine the "before abstraction" status. The collection of floristic and environmental data would form part of the baseline activities. The baseline data collected during the period of 1986 and 1987 before abstraction, serves to define the vegetational situation under "normal" conditions.

The vegetation in the study area is classified as Mountain Savanna and Karstveld. The Karstveld, ie. the regions with recent surface limestone deposits and shallow soil, often supports *Combretum imberbe*, *Dichrostachys cinerea* and *Terminalia prunioides*. The Mountain Savannas are characterized by trees such as *Kirkia acuminata*, *Gyrocarpus americanus*, *Berchemia discolor*, *Pachypodium lealii*, *Croton* spp. and others. In the depressions, *Sclerocarya birrea*, *Spirostachys africana*, *Peltophorum africanum*, *Acacia ataxacantha* and several species of *Ficus* occur (Müller, 1984).

Having established a thorough description of the area prior to pumping, it would then later be possible to re-assess the status objectively, and compare the two temporal evaluations.

However, due to the fact that temporary and/or even permanent deterioration of the vegetation may be taking place as a result of natural factors other than a decline in water table, it was important to establish and understand the natural relationships between the vegetation and the environment.

By establishing these natural relationships, it should be possible in the future to examine observed changes in vegetation in terms of environmental factors. If changes can not be explained satisfactorily in terms of environmental factors, then attention can be focused on limiting and controlling abstraction in such a way as to minimise possible deterioration of the plant ecology.

This study therefore has two broad objectives.

Firstly, to establish through a combination of methods, a broad overview of the Karst area in terms of the current vegetational status and the external factors on which the vegetation depends, and to note the seasonal changes taking place over the two year baseline period.

Secondly, to examine, and as far as possible to establish, the relationships between the karst vegetation and the environmental factors which may play a role in these seasonal changes.

The first objective was achieved through the following approaches :

- The evaluation of long-term norms such as mean annual precipitation over the area.

- The evaluation of the groundwater table throughout the area for the pre-abstraction period.

- The determination of the soil status and the various characteristics which accompany different soil types.

- The monitoring of the vegetation using both ground-based sampling techniques, as well as photographic techniques.

The full data sets, including photographs, fill many volumes and run to considerable length. Much of the data collected is not considered central to this document, but is included in a full report (Chivell, 1989) submitted to the Department of Water Affairs. This report also includes detailed discussions of the logistics behind carrying out the investigation, and serves as a reference work for the Department. It is available on request, but is not essential reading.

The second objective was achieved by establishing the baseline relationships involved in classifying the vegetation in the selected transects, and making an evaluation of their distribution and abundance with respect to certain environmental variables. This was carried out using a statistical technique known as canonical correspondence analysis (CCA). A computer programme entitled CANOCO, which is an extension of the Cornell Ecology Programme, DECORANA (M.O.Hill, 1979), was written by C. J. F. Ter Braak for this type of application, although it is usually used on much smaller data sets.

PART 2

2. STUDY AREA

2.1 BACKGROUND TO INVESTIGATION

The target area for the abstraction of groundwater is located between Otavi, Tsumeb and Grootfontein. This area is referred to as the Karstveld, and covers an area of 2 000 km². Topographically, this area forms part of the Otavi Mountainland rising from 1 500m to more than 1 800m above sea level. Geological investigations have shown that potential aquifers with large quantities of groundwater appear to be confined to four synclinal dolomitic structures. Based on these findings, the target abstraction area is referred to as Areas I, II, III, and IV. These Areas are shown in Figure 2.1. The groundwater investigation into the eastern most part of Area I was given priority, and hence the plant ecological investigation was also confined to this part, in addition to a small portion of Area II, the Berg Aukas Mine area. Area I would be the first to be pumped when the scheme was completed, and Area II at the Berg Aukas Mine had been pumped by the mine for many years.

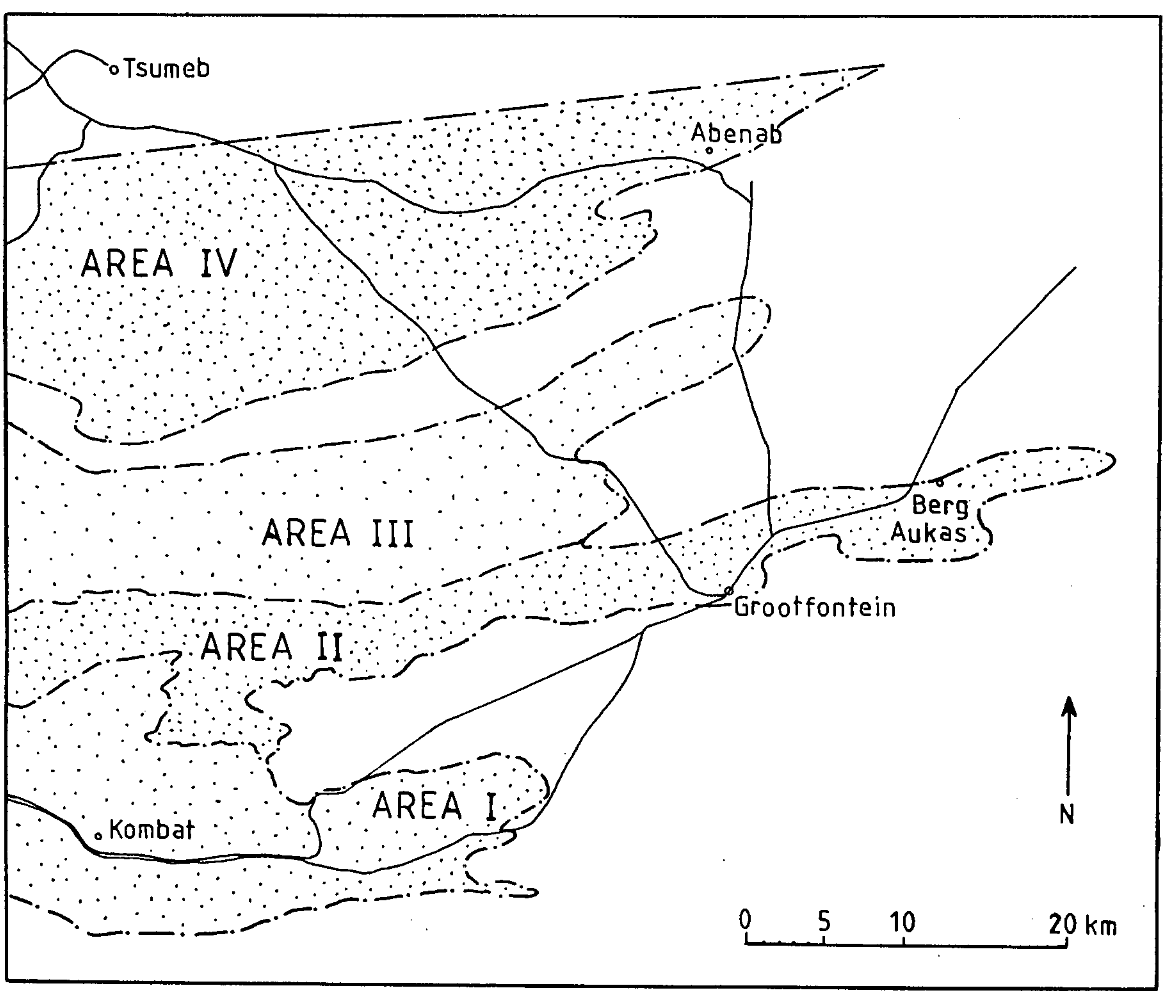


FIGURE 2.1 : FOUR SYNCLINAL AREAS IN THE KARST AREA

On initiation of the plant ecological investigation in 1986, a map of groundwater level contours was drawn up showing the groundwater table status as it was in 1984, in metres below the soil surface. Various data were included on this map for the purpose of identifying the localities of the sensitive zones with respect to vegetation relative to the groundwater table. The sensitive zones within Area I were identified as those areas where the water table was less than 20 metres below the soil surface, and hence also where extraction points (boreholes) were situated. The majority of extraction points are located along or near contact zones which occur within the sensitive zone areas. Contact zones are zones of higher permeability, which because of a thick layer of calcrete, absorb a large amount of the surface water. The contact zone is characterised in the field by a prominent band of vivid green vegetation.

These sensitive zones were to be the areas examined for any vegetational disturbances. The 20m groundwater level depth was chosen as the limiting depth, as it was considered that the woody vegetation would not be affected by a deeper water table. Of the total Karst area under investigation, only 13% fell within the sensitive zone restriction at the time of commencement. The specific study sites in Area I were selected from within this 13% area, according to set criteria.

2.2 SITE SELECTION WITHIN AREA I AND II

At the outset of the investigation in 1986, it was necessary to choose a vegetation monitoring/sampling method in which all possible variations in plant communities occurring in the area where abstraction was to take place, could be checked and noted. The method of sampling would dictate what type of sites were to be selected from within the 13% delineated area.

It was not certain which species would be influenced by abstraction, but the assumption was made that the woody species on the contact zones would probably be affected first. However, it was also possible that species furthest away from the contact zones might be more sensitive to or may be unable to adapt to new conditions, and may also be affected by the lowering of the groundwater table. As there is a readily observable gradation of vegetation in relation to a marked environmental gradient, ie. the contact zone, the transect approach to sampling was chosen.

The main monitoring method decided upon for baseline data collection was that of the belt transect approach. This involves selecting and marking off strips of representative vegetation. These strips of vegetation (transects) are divided up into a series of plots, within which the usual measures of density cover and frequency of all the plant species can be employed, for the description of the transect.

The criteria for the selection of the transects were as follows :

- The (belt) transects should be located within sensitive zones ie. in areas where the groundwater was less than 20m from the soil surface.
- Transects should where possible cross over/traverse the contact zone, to ensure that contact vegetation transition should be present.
- Transects should be located near production boreholes and/or water level recorders.
- Transects should include different plant communities, in order to obtain a good species variation.

Ten transects were initially selected as potential study sites. This number included one at each of the mines, Kombat Mine in Area I and Berg Aukas Mine in Area II. Of these ten, nine were finally chosen as being representative of the areas, and out of these, five were specifically selected for detailed sampling purposes.

It was important that these belt transects should be permanently marked so that the same monitoring techniques could be repeated on the same sites in the future, for example after abstraction.

The nine transects were then physically marked off on the ground using poles to indicate one side of the base line of each transect. The poles followed a straight line and were spaced at 50m or 100m intervals, depending on the accessibility and density of the vegetation. Seven of the transects were initially 1000m in length, and the other two were 750m and 300m in length. The width of the belt area was set at 5m.

The transects were laid out in an approximately north/south direction, crossing the east-west lying contact zone where possible. Details of the transects are provided in Table 2.1.

TABLE 2.1 : DETAILS OF TRANSECTS.

TRANSECT NO.	FARM NAME	TRANSECT LENGTH	TRANSECT DIRECTION	WATER TABLE DEPTH (m from soil surface)
1	Brandwag/Uitkomst	300m	NNW - SSE	0 - 5
2	Urupupa	1000m	N - S	0 - 5
3	Urupupa	-	-	5 - 10
4	Buschbrunnen	1000m	N - S	5 - 10
5	Kombat/Asis	1000m	N - S	10 - 15
6	Okambongora	1000m	NNW - SSE	10 - 15
7	Buschbrunnen	1000m	N - S	15 - 20
8	Buschbrunnen	1000m	N - S	15 - 20
9	Kombat Mine	1000m	N - S	30 - 50
10	Berg Aukas Mine	750m	N - S	25 - 30

Transects 9 and 10 were to serve as case studies, as groundwater had already been extracted from these areas for 20 - 30 years. These mining areas seem to confirm that no catastrophic effects need be anticipated.

The locations of the transects in Areas I and II are shown in Figures 2.2 and 2.3 respectively.

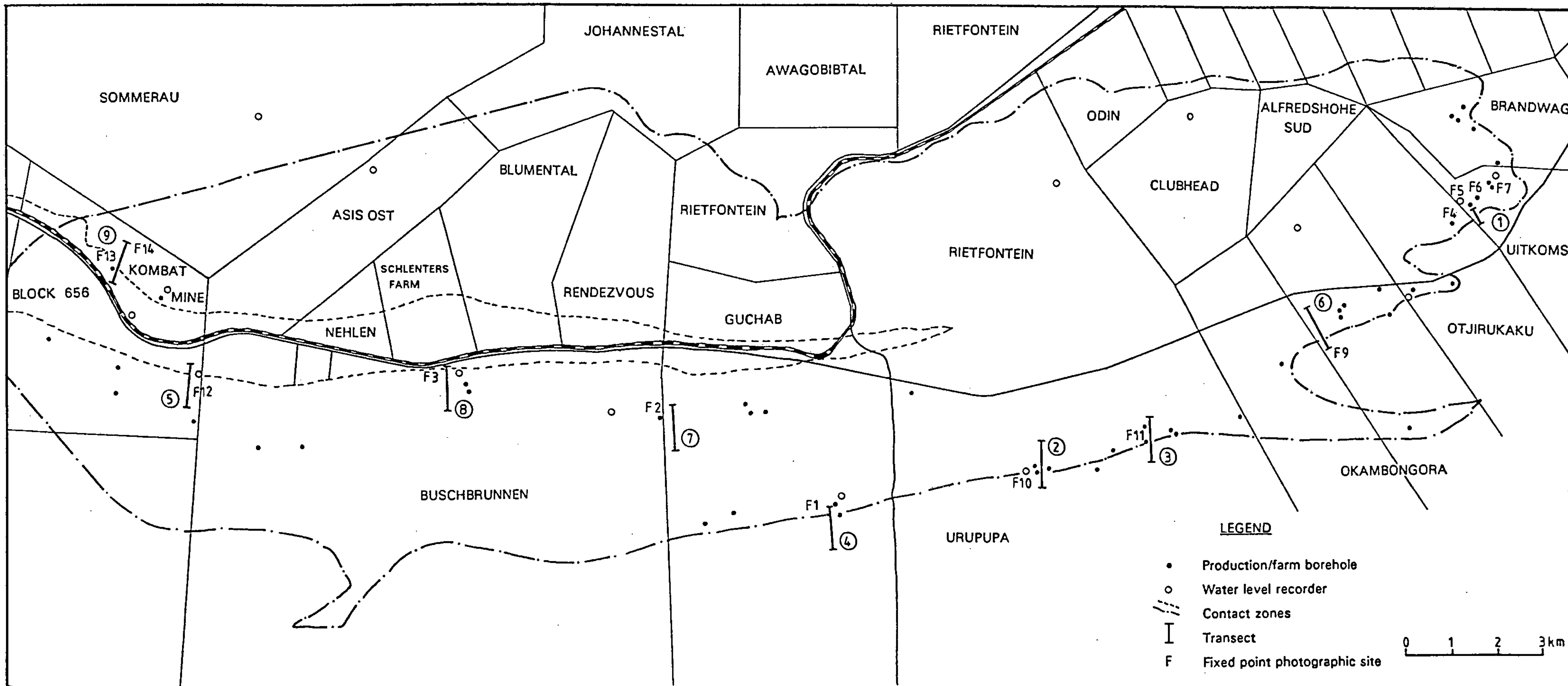


FIGURE 2.2 : TRANSECT SITES IN AREA I

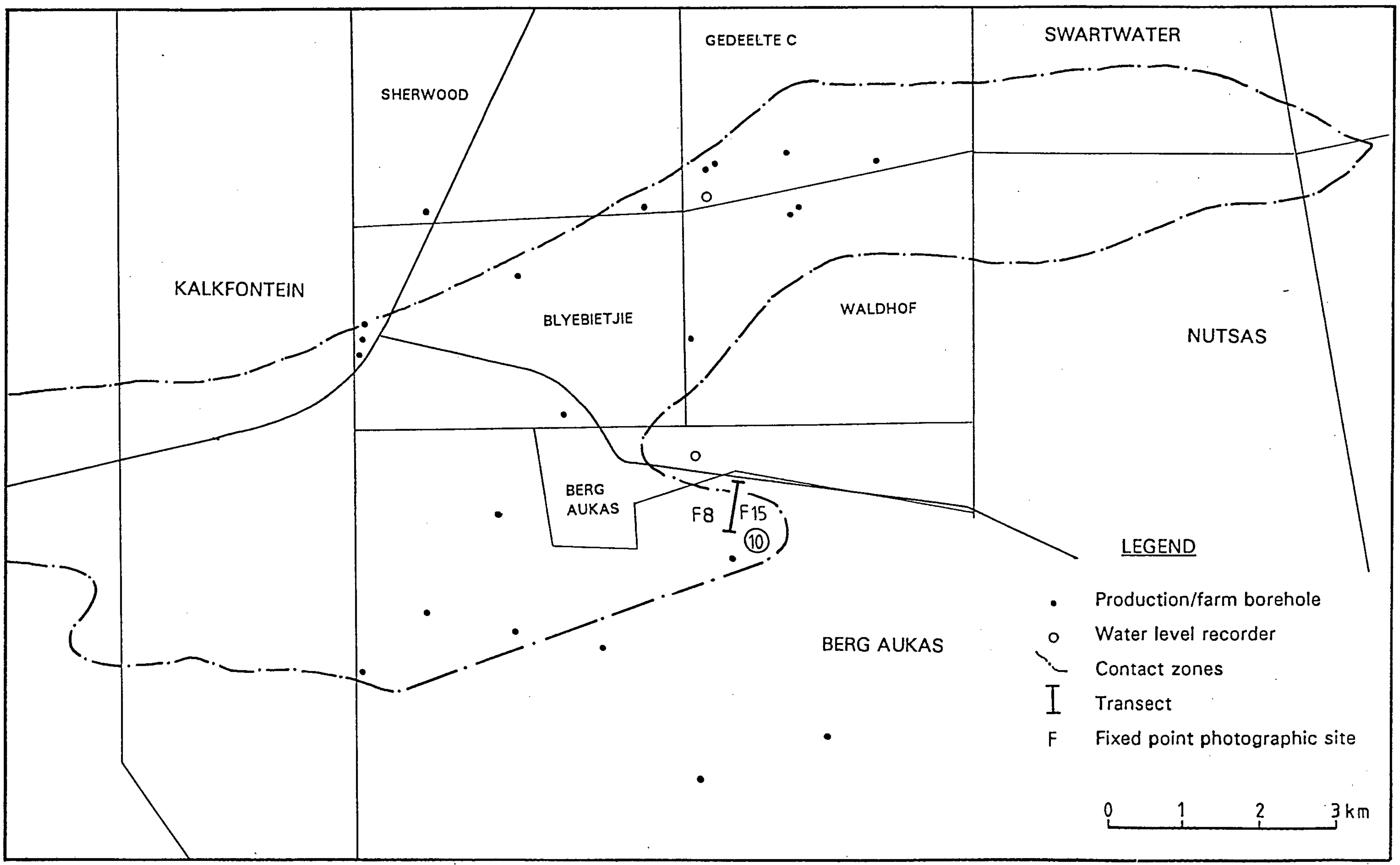


FIGURE 2.3 : TRANSECT SITE IN AREA II

2.3 MAPPING OF SITES

2.3.1 VEGETATION MAPS OF TRANSECT STRIPS

Detailed, large-scale vegetation maps of each of the nine transects, were produced after the first infra-red (IR) aerial photographic survey had been carried out in 1986. The mapping of natural vegetation has long been an assessment method of environmental status. The mapped area covers the same area in size as photographed, and included the actual belt transect strips, as well as the adjoining 250 metres of vegetation on either side, and ran the full length of each transect. The mapping of the vegetation adjacent to the transects was important so that a broader view of the area, and any drastic changes in vegetation pattern, could be noted. This width also allows more scope for interpretation. The scale of these detailed vegetation maps was the same as that of the infra-red aerial survey, 1 : 1667.

The various vegetation groups as well as any land uses were detailed onto the photographs and traced onto transparencies, which then became the final vegetation sliced maps. Sliced maps (Khan, 1954), are in essence simply a series of overlays, and are systematized to include a schematic use of colours and/or symbols. The maps of a set, ie. each transect strip of which three overlays made up the set, all cover the same area, and a particular feature is allotted to each of the maps in a set.

For mapping purposes, the vegetation groups were broadly classified according to their areal affinities relative to the topography. The classification groups are as follows :

- Contact zone community: this is the dense vegetation which occurs along the contact areas and is clearly distinguishable from the adjacent more sparse communities.

- Plain community: this more sparse vegetation occurs along the flat lying areas where drainage is fairly poor.

- Slope community: this slightly denser vegetation occurs along and down the slopes of hills and inclines.

- Mountain base community: this dense vegetation occurs at the mountain bases where surface water tends to collect after rainfall showers.

- Mountain community: this vegetation occurs on the steep mountain slopes.

Table 2.2 is a list of the species found in each of the mapped community types.

TABLE 2.2 : VEGETATION COMMUNITY TYPES ALONG TRANSECTS

SPECIES	TR 1				TR 2		TR 4		TR 5			TR 6		TR 7			TR 8			TR 9				TR 10			
	1	3	4	5	1	2	1	2	1	2	5	1	2	3	4	5	1	2	3	1	2	4	5	1	2	4	5
Acacia karroo	x	x			x	x	x	x	x	x		x	x	x			x		x	x							
A. tortilis									x	x				x			x	x	x	x	x				x		
A. mellifera	x	x	x		x	x	x	x	x	x		x	x	x	x		x	x	x	x	x			x	x	x	
A. reficiens	x	x			x	x	x	x	x	x		x	x	x			x	x	x	x	x	x		x	x		
A. hereroensis					x	x	x	x	x	x			x	x	x		x	x	x	x	x	x					
A. hebeclada		x												x				x		x	x						
A. erubescens					x	x														x	x						
A. nilotica			x		x												x	x	x	x	x						
A. nebrownii									x	x										x	x						
A. fleckii						x							x							x	x						
A. ataxacantha									x	x										x	x	x					
Barchemia discolor																											x
Boscia albitrunca		x			x	x							x				x		x								
Carissa edulis							x	x				x	x														
Cassine transvaalensis	x	x			x	x	x	x				x	x				x										
Catophractes alexandrii																			x								
Cissus juttae				x							x		x			x						x	x				x
Combretum hereroense		x				x	x	x				x	x	x			x	x	x					x			
C. imberbe		x	x			x	x	x					x	x	x		x	x	x	x	x			x	x		
C. molle						x							x				x	x	x			x	x				
C.apiculatum		x	x	x		x					x	x	x			x	x		x				x		x	x	x
Commiphora africana		x		x		x					x	x	x			x	x	x	x			x	x	x	x	x	x
C. pyracanthoides	x	x	x	x		x		x			x	x	x	x	x	x	x	x	x			x	x	x	x	x	x
C.angolensis				x												x											x
C.glaucescens				x	x						x				x	x	x						x				x
C.tenuipetiolata						x											x	x	x							x	x
Croton gratissimus	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x			x	x	x	x	x	x
Dichrostactys cinerea	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Diospyros lycioides	x	x				x	x	x				x	x				x										
Dombeya rotundifolia	x	x	x	x		x			x	x	x		x	x		x	x	x	x			x	x	x	x	x	x
Ehretia rigida		x			x	x	x	x				x	x	x			x		x					x	x		
Elephantorrhiza suffruticosa									x	x																x	
Erythrina decora																							x			x	x
Euclea undulata	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	
Euphorbia candalabra																											x
Ficus thoningii	x		x	x							x					x							x				x
F. cordata	x		x	x							x			x		x							x				x
F. sycomorus	x		x	x																							
Fockea multiflora																											x
Grewia flava	x	x	x		x	x	x	x	x	x		x	x	x	x		x	x	x	x				x	x	x	
G.flavescens	x	x	x		x	x	x	x	x	x	x	x	x				x			x	x	x	x	x	x	x	x
G. bicolor					x	x		x									x		x		x			x	x		
G. retinervis	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x								
G. villosa	x				x	x																			x		
Gyrocarpus americanus																											x
Kirkia acuminata			x	x							x				x	x						x	x	x	x	x	x
Lannea discolor																							x				
Lonchocarpus nelsii						x			x	x													x				
Maytenus heterophylla	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x						x	x	x	x	
M. senegalensis	x			x			x	x			x		x			x			x				x				
Mundulea sericea	x	x				x		x					x										x				
Obetia tenax																							x				x
Olea europaea	x	x			x	x	x	x				x	x														
Ozoroa insignis						x							x					x	x				x				
O. paniculosa																	x		x								x
Pavetta zeyheri	x	x																									
Peltophorum africanum			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x				x
Rhus lancea	x	x			x	x	x	x	x	x		x	x	x			x	x	x								
R. marlothii	x	x			x	x	x	x	x	x		x	x	x			x	x	x		x						
R. pyroides	x	x	x			x	x	x	x	x			x					x	x								
Securinega virosa		x		x			x	x	x	x	x	x	x			x	x	x		x	x		x		x	x	
Sclerocarya birrea			x	x							x		x		x	x		x	x				x		x	x	
Spirostachys africanum																								x	x	x	
Tarchonanthus camphoratus		x			x	x	x	x	x	x		x	x	x			x	x	x								
Terminalia prunioides		x	x																					x	x	x	x
Ximenia caffra	x	x		x	x	x	x	x			x	x	x			x	x		x								
X. americana							x	x																			
Ziziphus mucronata	x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				

1. CONTACT COMMUNITY 2. PLAIN COMMUNITY 3. SLOPE COMMUNITY
4. MOUNTAIN BASE COMMUNITY 5. MOUNTAIN COMMUNITY

Although these vegetation maps showing the plant communities along each transect area are static, they should prove to be very useful in the long term, as they present an inventory of the existing plant communities, their localities and the extent and geographic distribution in the area at that time. These maps are included as Figures 2.4a through to 2.12a at a reduced scale of approximately 1 : 7000 and serve as documentation of the research sites. These sliced maps are of particular use when measuring vegetational changes since they can be repeated and comparisons made with the originals over time.

2.3.2 SOIL MAPS OF TRANSECT STRIPS

As plants are affected directly or indirectly by the characteristics of soils in which they grow, these edaphic factors were also examined. Pits with dimensions of 1m x 1m x 1m were dug in the different soil types, and their soil profiles described.

The mapping of the soil types within the transects was carried out in the same manner as that of the vegetation maps, ie. using the 1986 infra-red aerial survey's photographs. This information was then transferred onto overlays to produce sliced soil maps of each transect area. These maps covered the same area on the ground as did the vegetation maps and are included as Figures 2.4b through to 2.12b.

A total of nine different soil types were encountered along the nine transects. They are Avalon, Clovelly, Glencoe, Glenrosa, Hutton, Katspruit, Milkwood, Mispah and Rensburg.

2.3.3 GEOLOGICAL MAPS OF TRANSECT STRIPS

The same infra-red aerial survey photographs were used to outline the geological formations occurring along the transect areas . Sliced geological maps covering the same area on the ground as did both the soil and vegetation maps were produced in the same way. These are included as Figures 2.4c through to 2.12c. The geological map of each transect area has the relevant geological features outlined, including contact zones, faults, rock formations and direction of synclines.

2.4 SITE DESCRIPTION

Each transect has a set of three sliced maps; a vegetation map, a pedological map, and a geological map. The contact zone and the direction of the synclines denoted by arrows, are shown on every map, while the transect lines are indicated only on the vegetation maps.

The different plant communities are identifiable from each other by different hatchings on the maps, and within each community type, the tree cover densities are also indicated. This should ensure that any major changes can be detected over the long term. Land uses have also been indicated on the vegetation maps, so that any additions or changes can also be noted over the long term.

The localities of the soil profile pits and the different soil types are shown on the pedological maps. The soil types are distinguishable from each other by different hatchings.

The geological formations, localities of water level recorders and production boreholes in the vicinity of each transect, are indicated on the geological maps. The direction of the dip or fold of the syncline's strata is also indicated on each map by means of arrows. Each transect strip is briefly described in the following pages.

Transect 1

Transect 1 is situated on the Brandwag/Uitkomst farm on the edge of Area I. It is 300m in length, and extends down the slope of a mountain. The transect line begins on the fringe of a mountain base community and crosses through a contact community, to a slope community. The contact community has a very dense tree cover, and is evident as a thick band of trees along the contact zone. The slope community has a less dense tree cover.

The whole of the transect strip is located on a Mispah soil type.

The geological map shows that the transect line starts on the fringe of dolomite, then crosses onto granite for the rest of the line. The two rock types meet at the contact zone. The strata on the southern limb of the syncline dip steeply northwards, indicated by straight arrows on the map. Both a production borehole and an observation borehole, with an installed water level recorder, are situated in close proximity to this transect.

The vegetation, soil and geological maps are shown in Figures 2.4a, b, c respectively.

Transect 2

Transect 2 is situated on the Urupupa farm in Area I. It is 700m long and runs parallel to the farm-camp fence. Initially, this transect was 1000m long, but 300m were "lost" to cultivation. The transect line begins in a plain community, crosses through a contact community and again enters a plain community. The plain communities have tree cover densities varying from very dense to moderately dense. The contact community is a very dense strip of vegetation.

The transect line crosses over three soil types. The first plain community and contact community occupy a Mispah, while the second plain community mostly occurs on a Hutton, and at the end of the line on a Glenrosa.

The geological map shows that the transect begins on phyllite, and crosses onto dolomite after the contact zone. The strata on the southern limb of the syncline are overfolded. An observation borehole installed with a water level recorder, is situated close to this transect.

The vegetation, soil and geological maps are shown in Figures 2.5a, b, c respectively.

Transect 4

Transect 4 is situated on the Buschbrunnen farm in Area I, and is 1000m in length. The transect line begins in a plain community, crosses through a contact community, and again enters a plain community. Both plain communities have varying degrees of tree cover density. The contact community occurs on the slightly raised terrain of the contact zone, and has a very dense tree cover.

Three soil types are present in this area. The transect line begins on the fringe of a Hutton and Mispah, and the tree cover is not dense at all. There is some evidence of a land use disturbance in this area. The contact community occupies a Mispah, and the plain community a Rensburg.

The geological map shows that both dolomite and phyllite are present in this area. The former begins at the contact zone and extends northwards, while the latter extends from the contact zone southwards. The syncline strata are steeply overfolded, as shown by the arrows. An observation borehole, installed with a recorder, is situated close to the beginning of the transect.

The vegetation, soil and geological maps are shown in Figures 2.6a, b, c respectively.

Transect 5

Transect 5 is situated on the Kombat/Asis farm, in Area I. It is 1000m long, and runs parallel to a gravel road which passes the Kombat Mine's slimes dam. The transect line crosses from a plain community into a contact community, and again enters a plain community. The plain communities have varying degrees of tree cover densities, from dense to sparse. The contact community is evident as a band of dense vegetation.

Two soil types occur along the transect. The transect line begins on an Avalon, crosses onto a Hutton, and again enters an Avalon. Both the plain and contact communities occur on the Avalon, while the Hutton is occupied by only plain community.

The geological map shows that the transect line begins on phyllite and then crosses onto dolomite. The transition occurs at the concealed contact zone. The northern strata of the syncline dip steeply south. An observation borehole, installed with a recorder, is situated along the transect line on the contact zone.

The vegetation, soil and geological maps are shown in Figures 2.7a, b, c respectively.

Transect 6

Transect 6 is situated on the Okambongora farm in Area I. It is 1000m in length, and runs parallel to the camp fence. The transect line begins in a contact community and enters a plain community at the contact zone. Both contact and plain communities have tree cover densities varying from dense to moderately dense in the former, and from dense to very sparse in the latter. The contact community is a very broad strip of vegetation.

Two soil types occur along this transect. The transect begins on a Mispah, extends through a small patch of Milkwood, and again enters a Mispah. The Mispah supports both the contact and plain communities, while the Milkwood supports the plain community.

The geological map shows that the transect begins on phyllite and then crosses onto dolomite from the contact zone northwards. The strata on the southern limb of the syncline dip steeply north, as shown by the straight arrows.

The vegetation, soil and geological maps are shown in Figures 2.8a, b, c respectively.

Transect 7

Transect 7 is situated on the Buschbrunnen farm in Area I. It is 1000m long, runs parallel to a farm fence and service road, and extends northwards up a gradual slope towards the base of a mountain. The transect begins in a slope community and crosses into the mountain base community at the northern end. A contact zone and contact community are lacking in this area. The slope community's tree cover density varies from very dense to moderately dense.

Three soil types are present along this transect strip. The transect begins on a Clovelly, crosses through a Glencoe, and then continues into Mispah to the end, with the exception of a small patch of Glencoe within the last 400 metres. The mountain base community at the northern end, occurs on a Mispah, while the remaining part of the transect is made up of the slope community on Mispah, Clovelly and Glencoe.

The geological map indicates that the transect begins on dolomite, passes over a narrow band of limestone and phyllite, and continues onto dolomite again. This narrow band occurs at the crest of the slope and a production borehole is situated at the base of the mountain.

The vegetation, soil and geological maps are shown in Figures 2.9a, b, c respectively.

Transect 8

Transect 8 is situated on the Buschbrunnen farm in Area I, and is 1000m long. The transect line begins in a contact community, passes through a patch of slope community, continues through a plain community to a slope community, and then enters a contact community again. The two contact communities have varying tree cover densities, ranging from very dense to very sparse. The slope communities have moderately dense tree covers, while the plain community has very sparse tree cover, and the vegetation appears stunted. The latter community occupies an area within a slight depression where rainwater tends to collect, and the possibility of drowning is compounded by the poor drainage characteristics of the soil.

Three soil types are present in this area. The transect line begins on a Rensburg which supports the contact community, passes onto a Mispah supporting the slope and plain communities, crosses a patch of Katspruit occupied by the plain community, and ends on a Mispah, occupied by the second contact community.

The geological map shows that the transect line begins on phyllite, and continues onto dolomite after the first contact zone. From the second contact zone southwards, it continues on limestone and phyllite. The strata at the northern contact dip steeply southwards, while the strata on the southern contact dip steeply northwards. An observation borehole, installed with a recorder, is situated close to the transect on the first contact zone.

The vegetation, soil and geological maps are shown in Figures 2.10a, b, c respectively.

Transect 9

Transect 9 is situated in the Kombat Mine area, in Area I, and is 1000m long. It begins close to the main tarred road, crosses over a railway line, continues very close to an inhabited area, and ends in the mountains above the mine. The transect begins in a plain community, crosses through a contact community, continues into a mountain base community, and ends in a mountain community. The contact community has a moderately dense tree cover, but a fair amount of disturbance is evident where there are dwellings.

Three soil types are present along this transect strip. The transect begins on a Glencoe in the plain community, passes through a Clovelly in the contact and mountain base communities, and continues onto a Mispah in the mountain community.

The geological map indicates that the transect line begins on phyllite and crosses onto dolomite at the contact zone. The strata of the syncline dip steeply to the north. Two boreholes are situated close to the transect on the contact zone. The vegetation, soil and geological maps are shown in Figures 2.11 a, b, c respectively.

Transect 10

Transect 10 is situated in Area II on the Berg Aukas farm, very close to the Berg Aukas Mine. It is 750m long and extends from the main gravel road past the mine, and ends near the top of a mountain, just above the farm house. The line begins in a plain community, crosses into a very broad band of contact vegetation, enters a mountain base community, and ends in a mountain community. The tree cover is very dense north of the contact zone, and moderately dense south of the contact zone.

Two soil types occur along the transect. The middle section of the transect extends over a Clovelly, occupied by the plain community, while the beginning and end of the transect extend over a Mispah, occupied by the plain, contact, mountain base and mountain communities.

The geological map indicates that the transect begins on a granite formation, and at the contact zone crosses onto dolomite. The strata on the northern limb of the syncline dip steeply towards the south.

The vegetation, soil and geological maps are shown in Figures 2.12a, b, c respectively.

Legend for Vegetation Map

1	Contact Comminity
2	Plain Community
3	Slope Community
4	Mountain Base Community
5	Mountain Community

Land Uses :

A	cultivated land
B	cleared/disturbed land
C	roads and adjacent clearing
D	mining works
E	farm/natural reservoir
F	railway lines and adjacent clearing
G	farmstead/dwelling

Tree Cover Density :

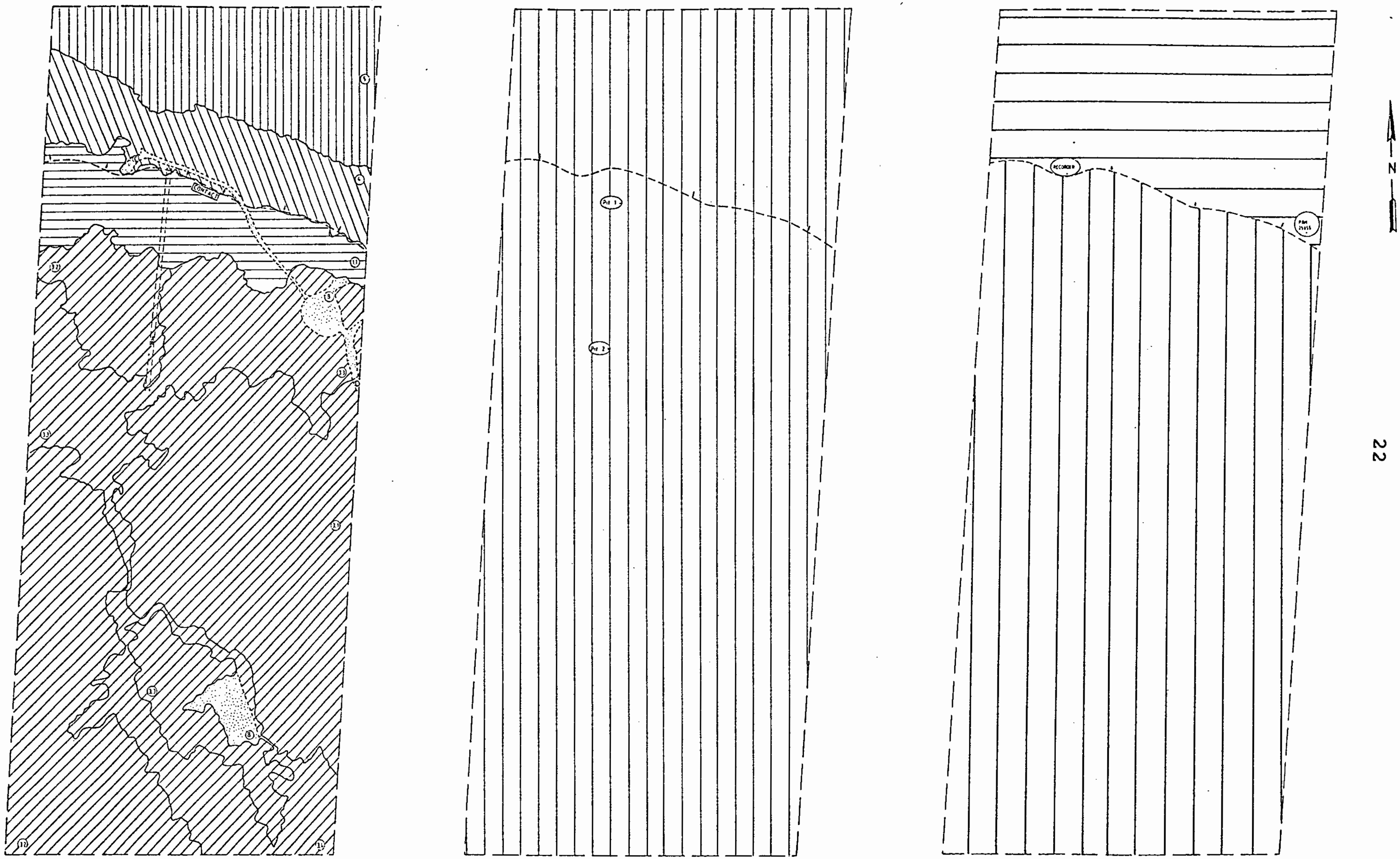
.1	very dense
.2	dense
.3	moderately dense
.4	sparse
.5	very sparse

Legend for Soil Map

- Mispah
- Rensburg
- Hutton
- Clovelly
- Katspruit
- Avalon
- Glencoe
- Glenrosa
- Milkwood

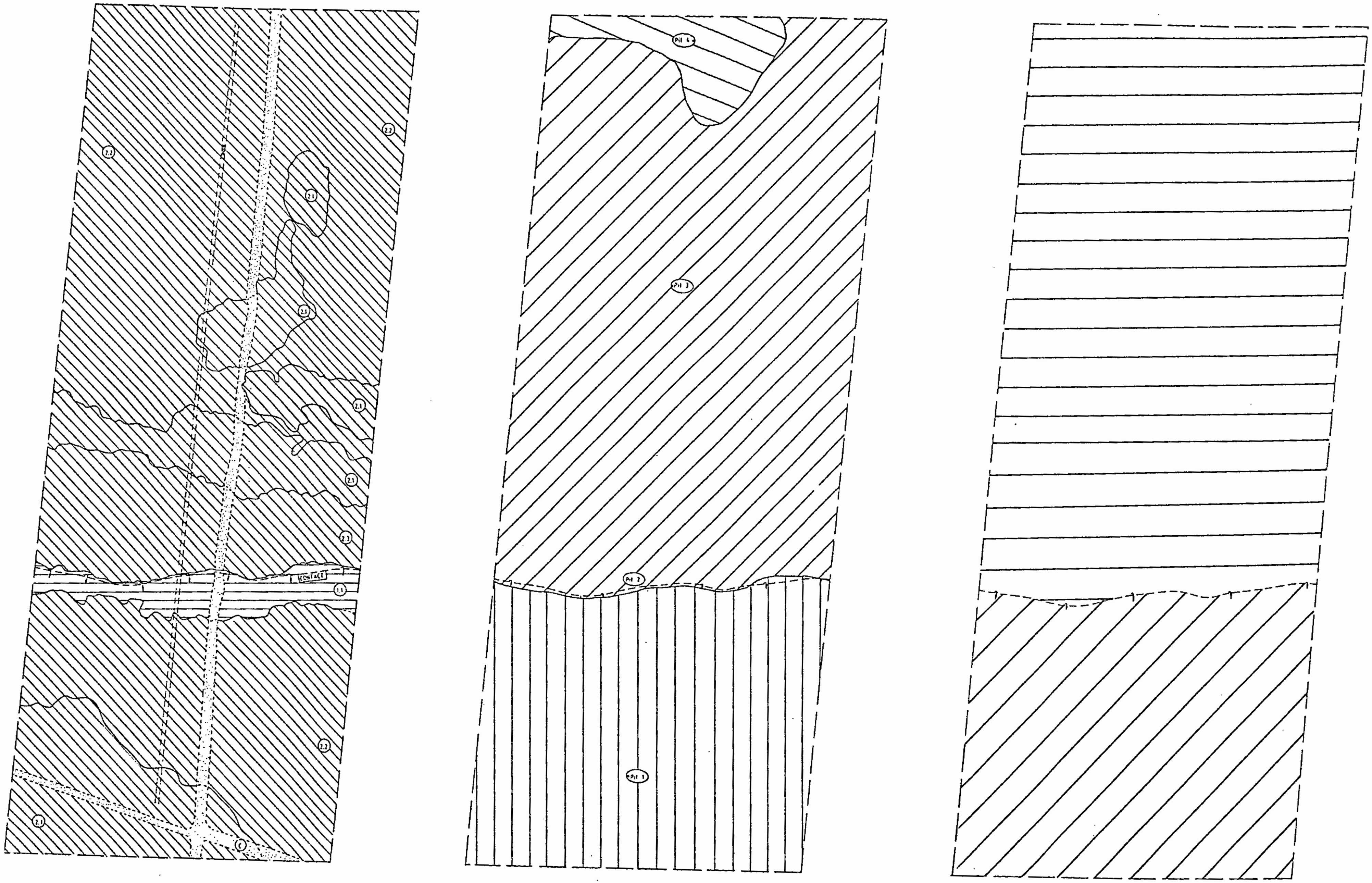
Legend for Geology Map

- Dolomite
- Phyllite (covered by loamy soil in places)
- Granite (covered by calcrete and soil)
- Limestone and phyllite (covered by calcrete and soil in places)



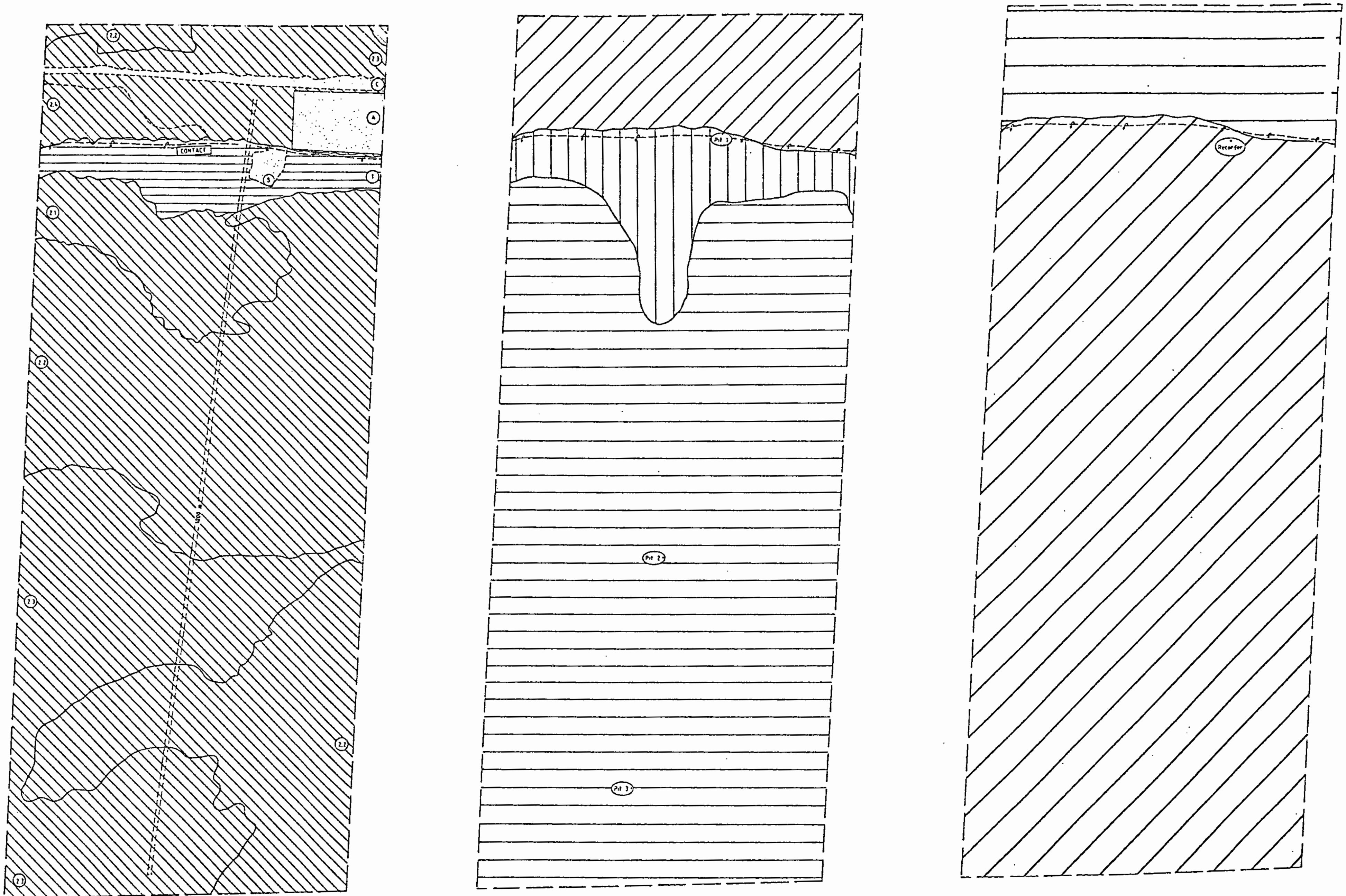
(a) Vegetation (b) Soil (c) Geology

FIGURE 2.4 (a,b,c) : DESCRIPTIVE MAPPING OF TRANSECT 1 AREA



(a) Vegetation (b) Soil (c) Geology

FIGURE 2.5 (a,b,c) : DESCRIPTIVE MAPPING OF TRANSECT 2 AREA

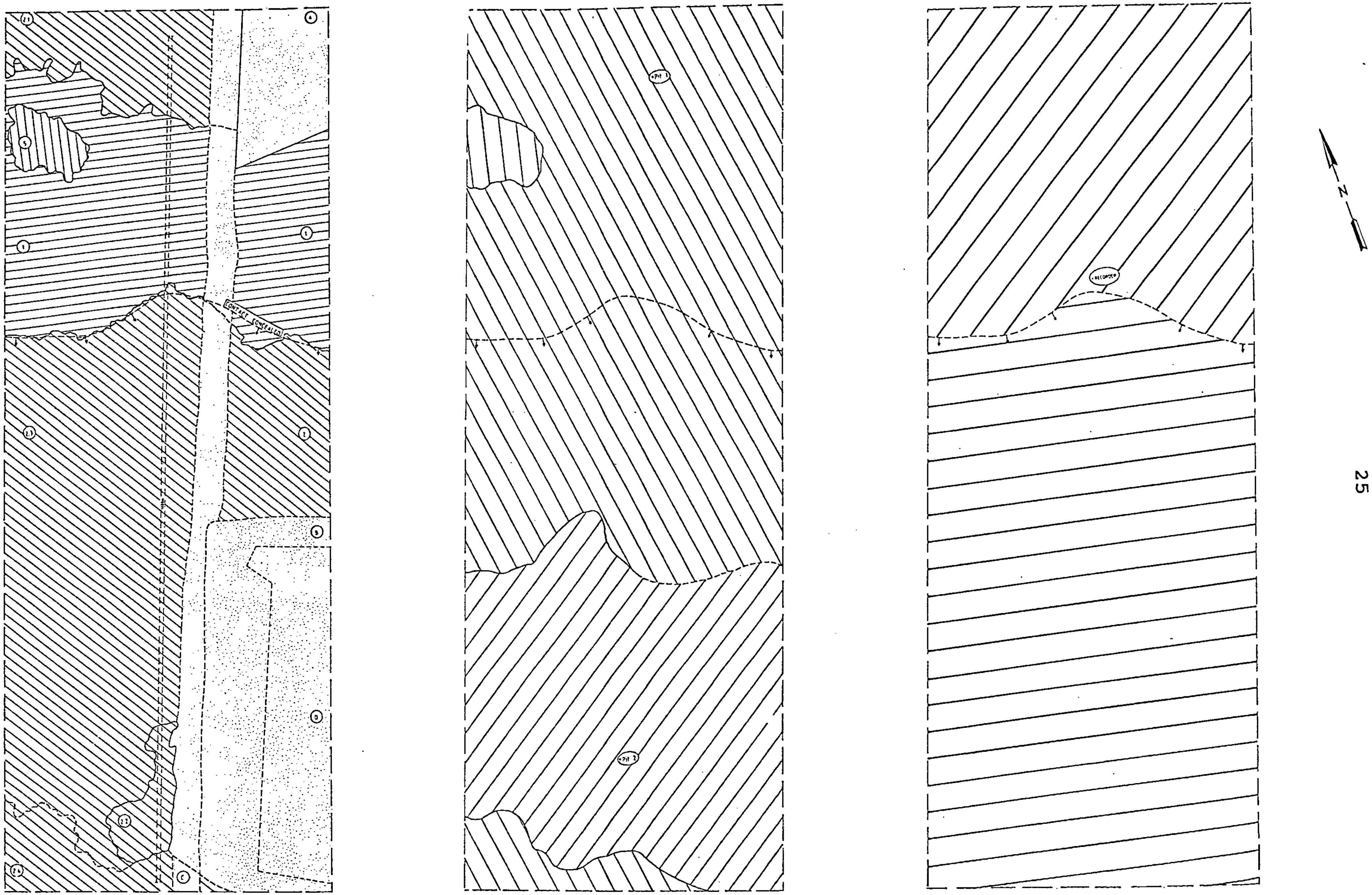


(a) Vegetation

(b) Soil

(c) Geology

FIGURE 2.6 (a,b,c) : DESCRIPTIVE MAPPING OF TRANSECT 4 AREA

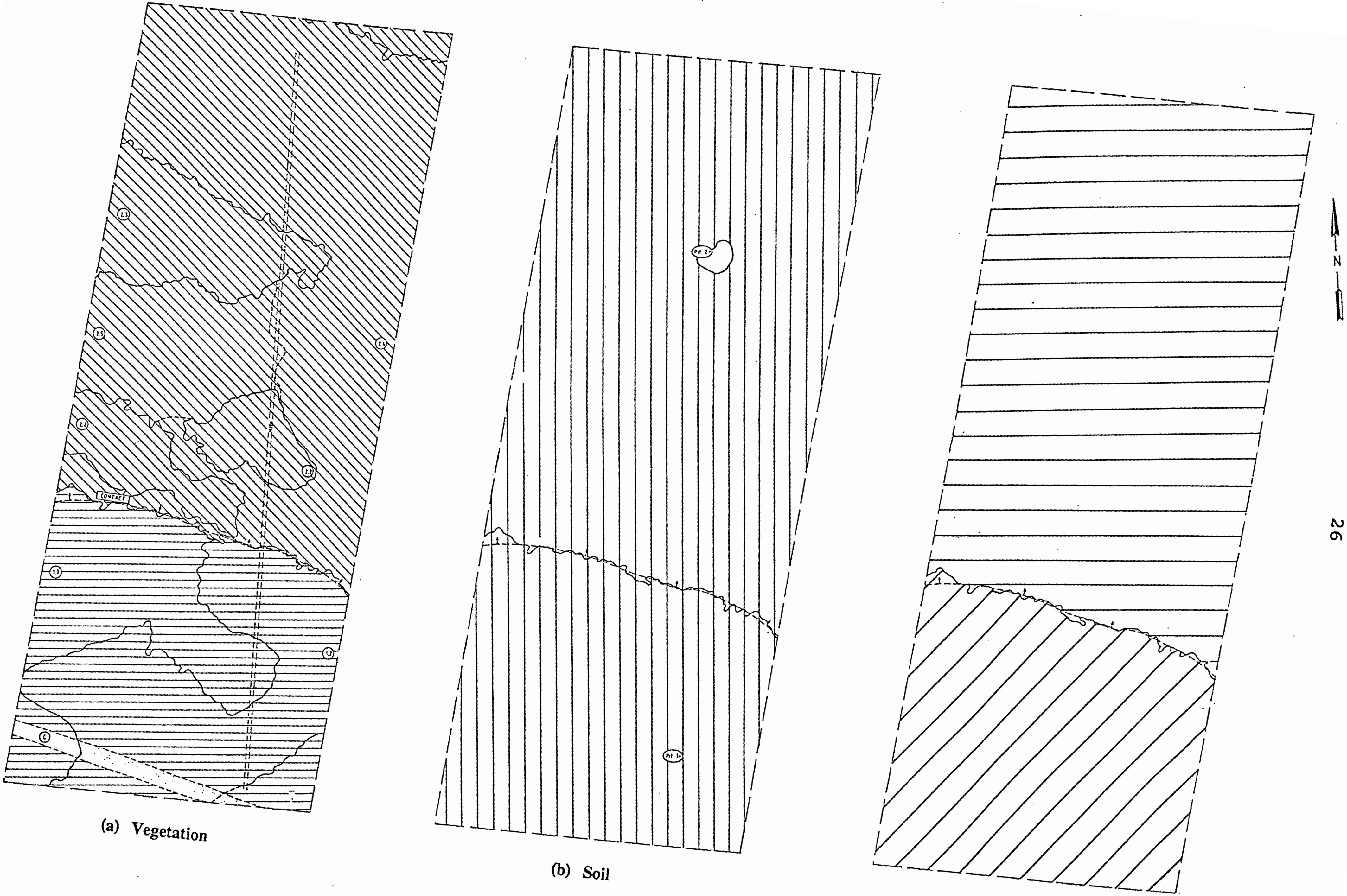


(a) Vegetation

(b) Soil

(c) Geology

FIGURE 2.7 (a,b,c) : DESCRIPTIVE MAPPING OF TRANSECT 5 AREA

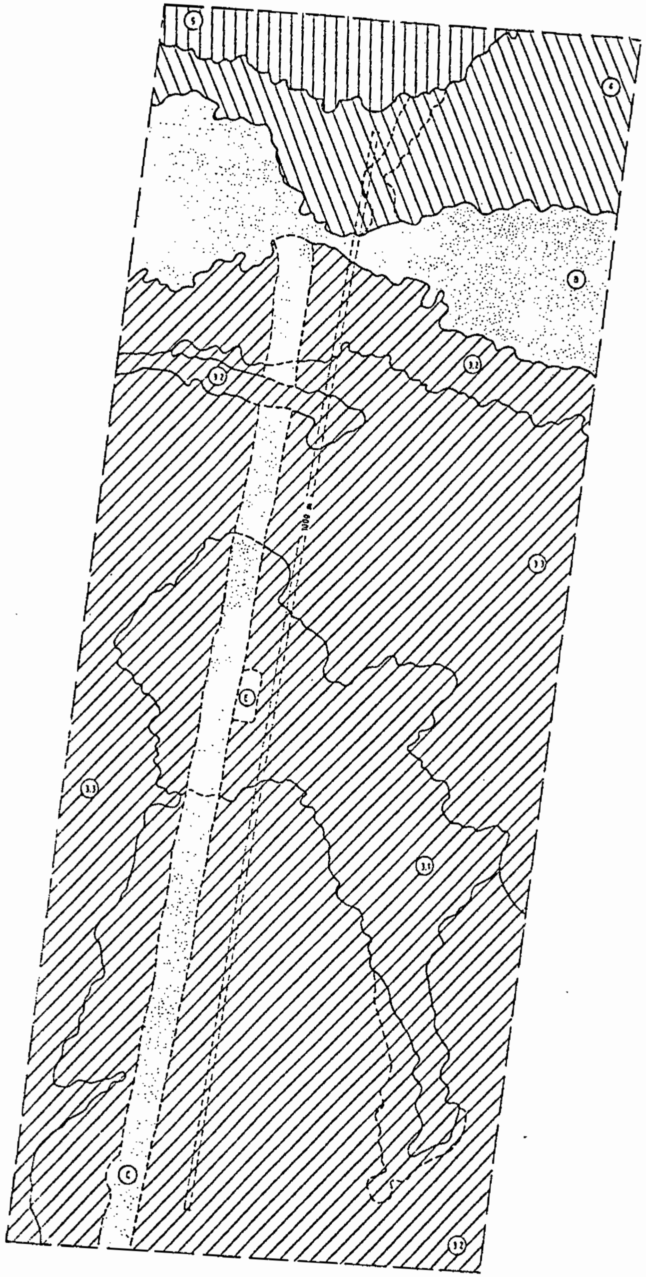


(a) Vegetation

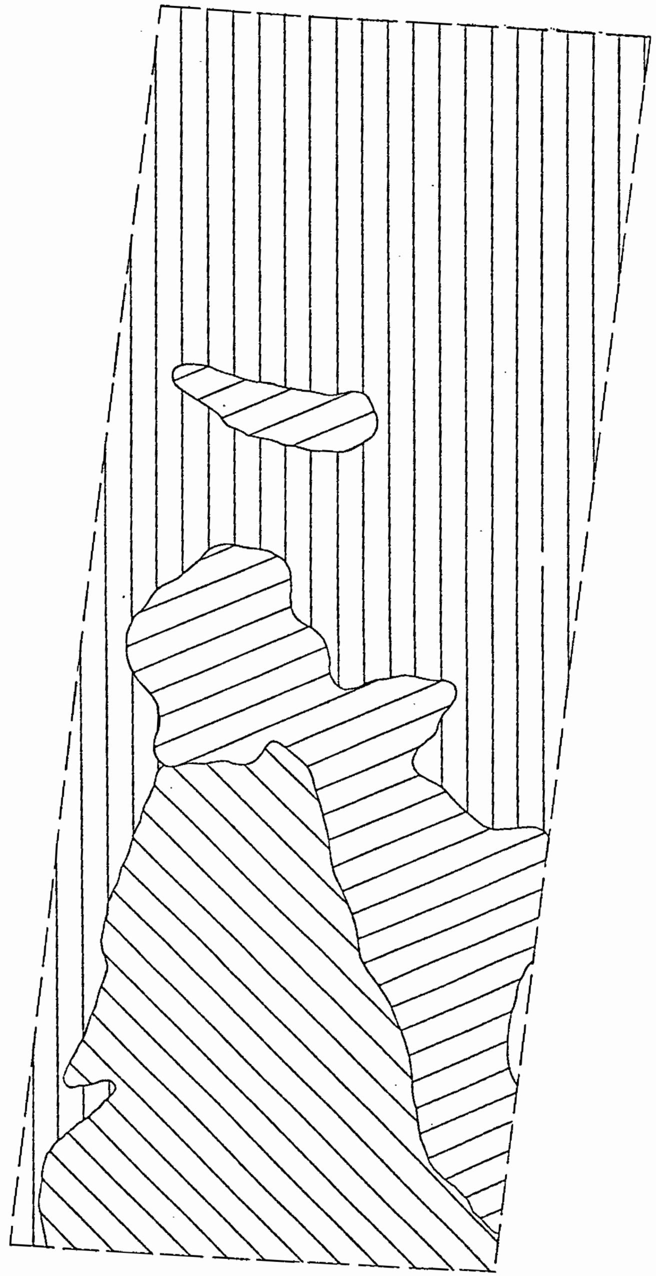
(b) Soil

(c) Geology

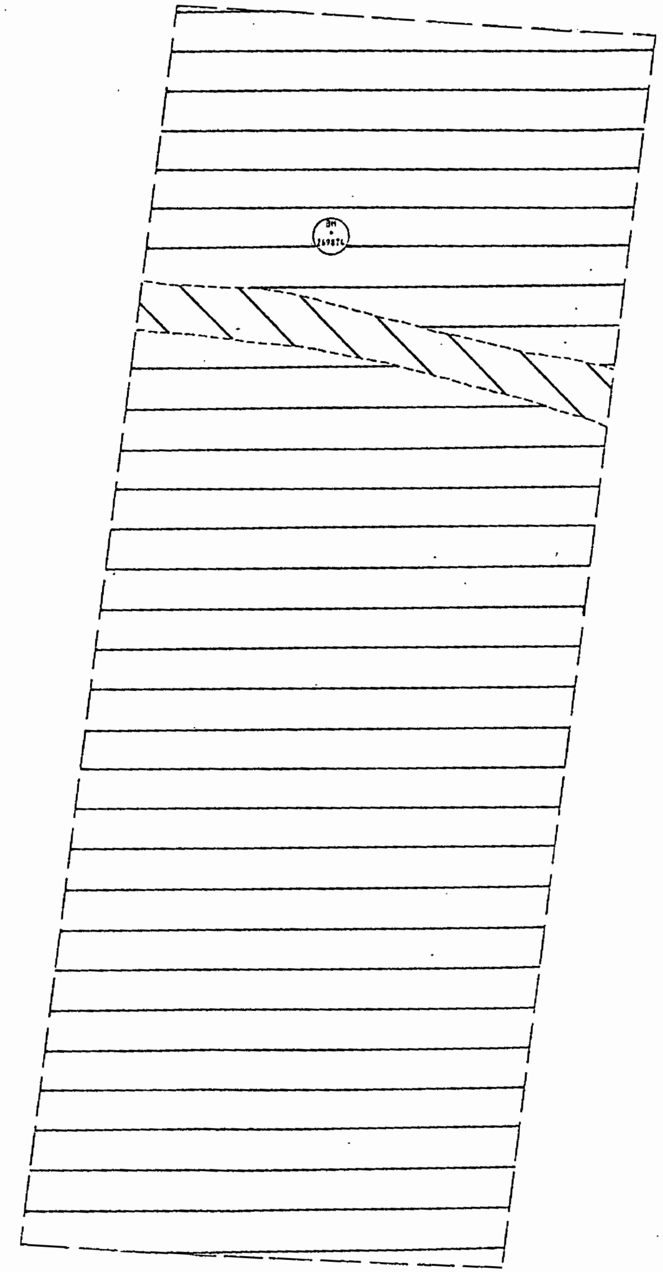
FIGURE 2.8 (a,b,c) : DESCRIPTIVE MAPPING OF TRANSECT 6, ARE



(a) Vegetation

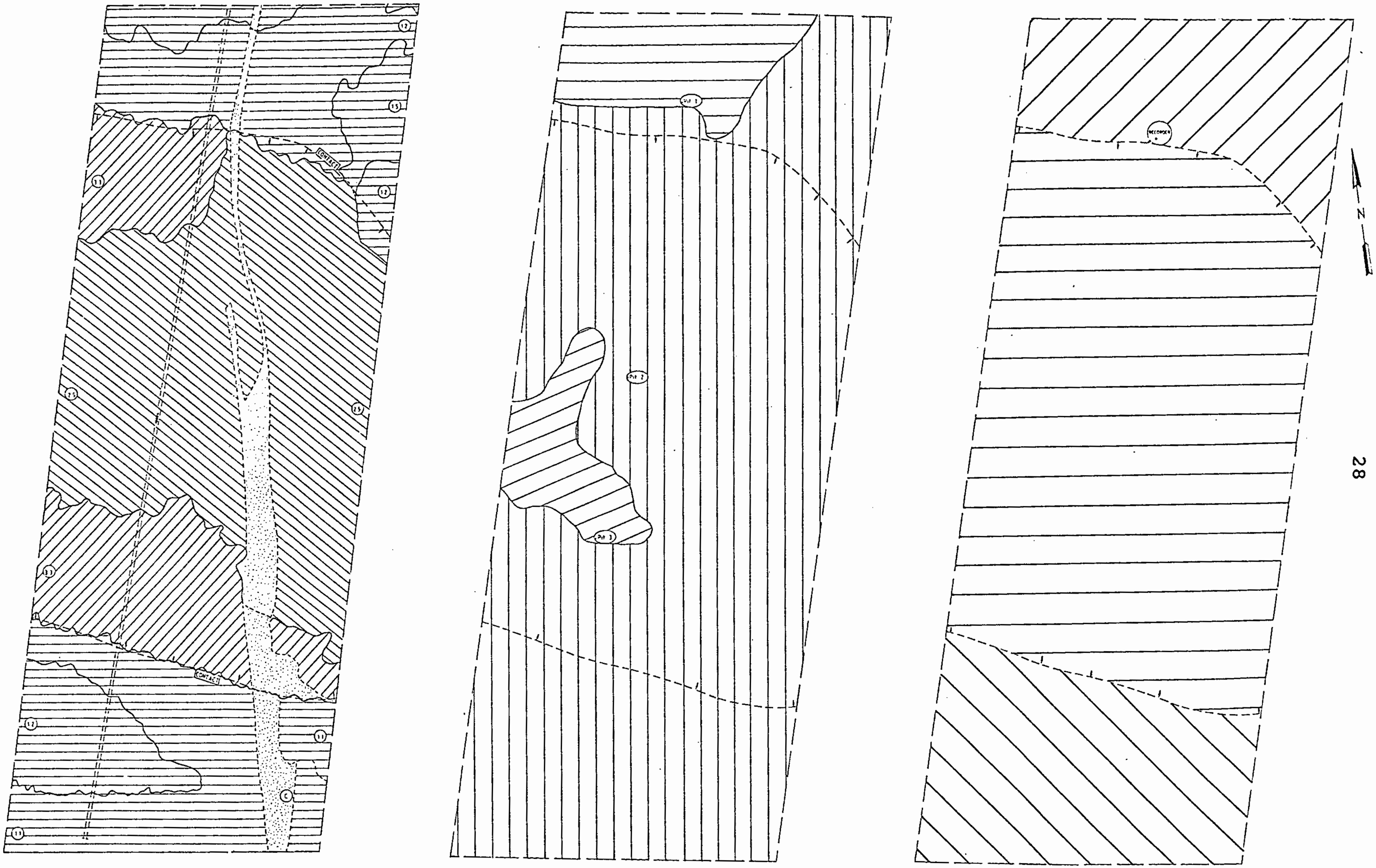


(b) Soil



(c) Geology

FIGURE 2.9 (a,b,c) : DESCRIPTIVE MAPPING OF TRANSECT 7 AREA

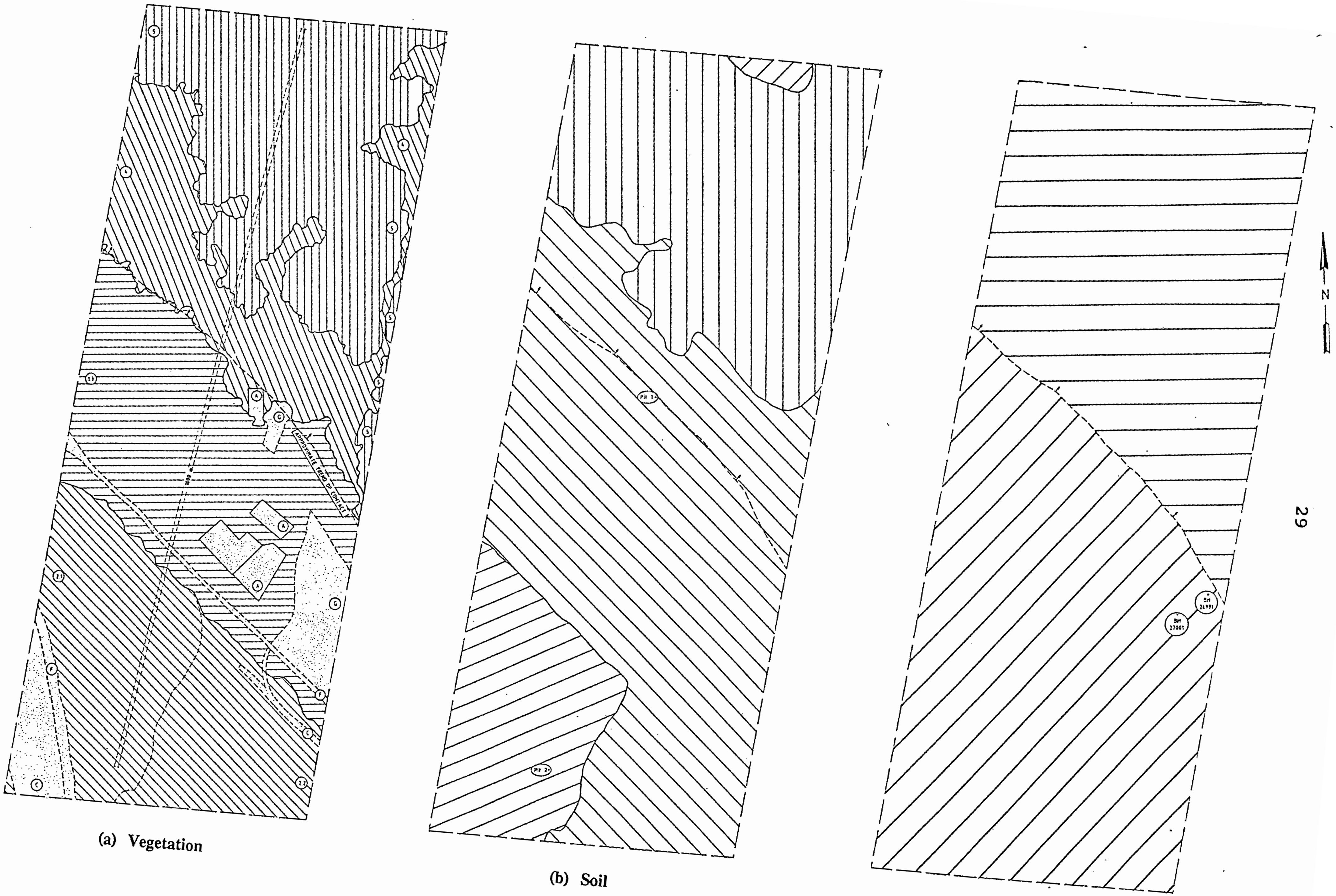


(a) Vegetation

(b) Soil

(c) Geology

FIGURE 2.10 (a,b,c) : DESCRIPTIVE MAPPING OF TRANSECT 8 AREA

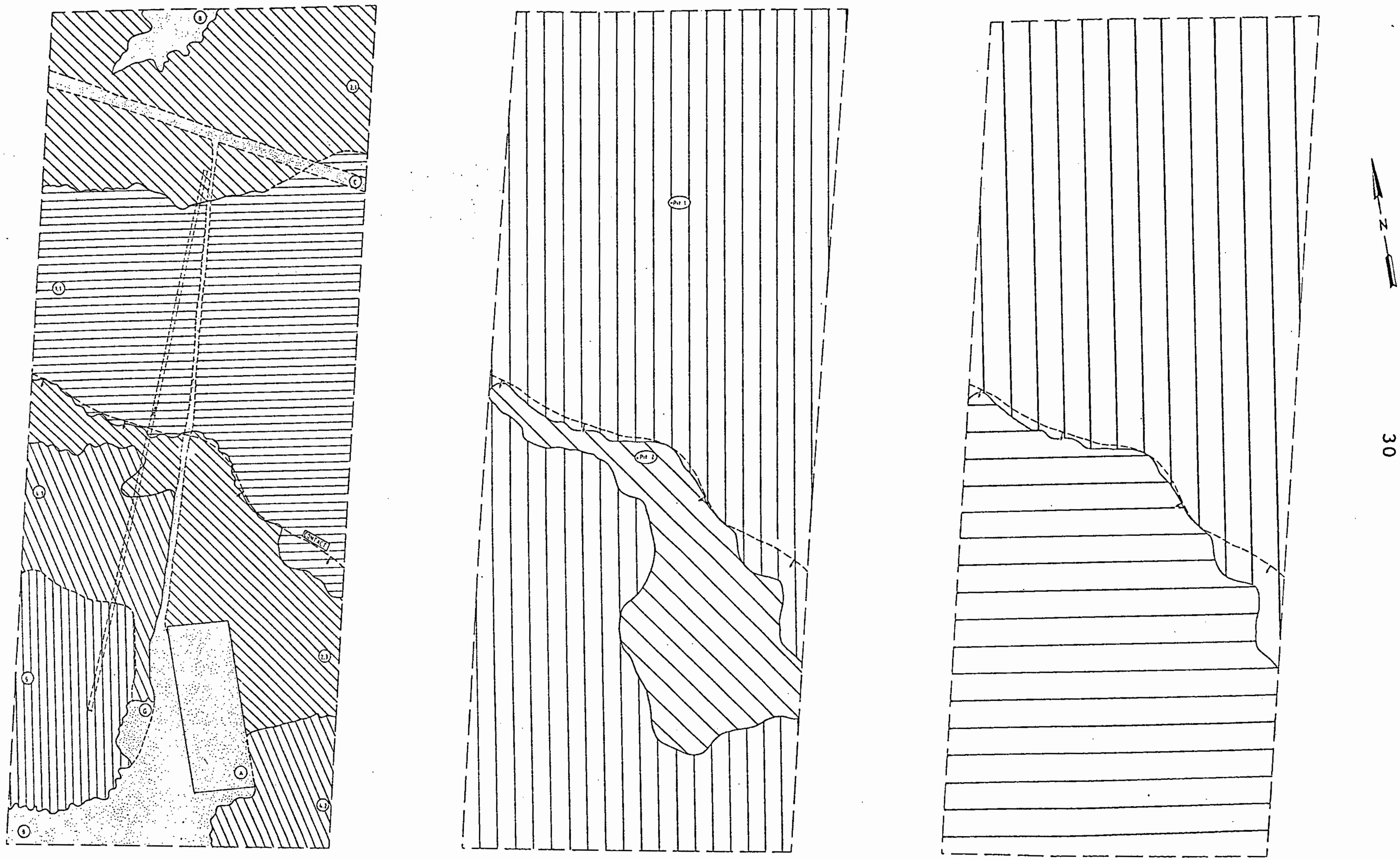


(a) Vegetation

(b) Soil

(c) Geology

FIGURE 2.11 (a,b,c) : DESCRIPTIVE MAPPING OF TRANSE



(a) Vegetation

(b) Soil

(c) Geology

FIGURE 2.12 (a,b,c) : DESCRIPTIVE MAPPING OF TRANSECT 10 AREA

PART 3

3. GROUNDWATER LEVEL MONITORING

3.1 BACKGROUND

3.1.1 TOPOGRAPHIC RELIEF

The rocks of the Otavi Mountainland consist mainly of dolomite and limestone of the Otavi Group of the Damara Sequence. The strata of the Otavi Mountainland have been folded into a number of synclines and anticlines, generally striking east to west. Owing to karstification, the area is characterised by a marked absence of well defined surface drainage systems. Karst features such as solution channels and sinkholes tend to develop along secondary structures such as joints, fractures, faults, shears and contact zones rather than being restricted to certain strata (Seeger, 1987).

The water-bearing dolomite and limestone are chiefly confined to the four major synclinal structures. The Karst area has been delineated and named according to these four areas, ie. Areas I, II, III, and IV, as mentioned previously. A syncline can be described as a structural basin in which the rock beds dip towards the axis of the trough in contrast to an anticline, being an upfolded arch where the rocks dip outward from the crest of the fold.

The primary hydrological porosity and permeability of the carbonate rocks are low, however the permeability and storage capacity have been increased considerably due to chemical solutions along secondary structures.

The initial groundwater investigation was confined to the eastern part of Area I, the Kombat-Uitkomst Area, where some 20 production boreholes are located. The Karstland Borehole Scheme will consist of some 60 production boreholes spread over the entire area, and connected by a pipeline network. The monitoring of the groundwater levels was started as early as 1983.

The geohydrological parameters within the various areas are largely controlled by the topographic relief of the dolomite synclines. The elevated areas with poorly developed courses are better drained than the flat lying areas, but the latter experience better infiltration rates of precipitation, and chemical solution of carbonate rocks is more intense. According to the gradient, the groundwater tends to flow from the central elevated arches outwards to the boundaries of the synclines, where the water is dammed up along the "rims", against semi-pervious and impervious phyllite and lava (Seeger, 1987).

The groundwater overflows the contact in a number of springs located along the contact between the basal dolomite and older rocks, and below the calcrete generally fringing the contact zone.

3.1.2 RECHARGE

Direct precipitation on the dolomite underlain areas is considered to the major or only source of recharge in the Karst area, while downward percolation of surface water is thought to be negligible. Recharge from rainfall is not merely dependent on the annual amount of precipitation, but also on the intensity, duration, and seasonal distribution. Other factors influencing recharge are topography, thickness of soil cover and depth of the water table.

The rate of recharge which involves vertical leakage of water through superficial deposits and secondary structures of the underlying carbonate rocks to the aquifer, may vary considerably from place to place. The recharge rate of the Karst Area is still unknown and will be established only once the pumping scheme has been put into operation.

In certain flat-lying areas there are indications that the infiltration rate probably exceeds 8% of the mean annual rainfall. It is assumed that the recharge is limited to that percentage of the annual precipitation that directly infiltrates the dolomite synclines and reaches the groundwater table, because the syncline lies topographically higher than the surrounding calcrete plain from where no inflow can take place.

3.2 METHODS

3.2.1 SELECTION AND DESCRIPTION OF BOREHOLE SITES

The groundwater level fluctuations in Area I and Area II were monitored on a regular basis. However, certain boreholes in these two Areas were selected for closer scrutiny in the ecological investigation. The selected boreholes were those in and around the transect areas, as specified by the site selection criteria. The borehole types were either production boreholes or observation boreholes, the latter often having water level recorders installed. This would ensure that groundwater level fluctuations in the transect areas could be checked and related where possible to soil moisture regimes, vegetation vitality and rainfall patterns.

A brief description of the selected borehole sites is provided relative to the farms on which they and the transects occur.

Transect 1 (Brandwag/Uitkomst farm area)

There are four production boreholes, and two observation boreholes fitted with water level recorders in this area. Monitoring of the water level began towards the end of 1985. Transect 1 is located in this area, as it was defined as a shallow water table area according to the 1984 groundwater table contour map.

Transect 1 (Otjirukaku farm area)

There are three boreholes in this area, one of which has a recorder installed. Monitoring of the water level began in 1983. These particular boreholes were selected for closer observation because this area too was defined as a shallow water area. This farm is situated approximately three kilometres to the southwest of Transect 1.

Transect 2 (Urupupa and Rietfontein farm areas)

Four boreholes, of which one has a recorder installed, are being monitored in this area. Monitoring began in 1983. Transect 2 is located in this area.

Transects 4, 7 and 8 (Buschbrunnen farm area)

There are five boreholes, one with a recorder installed, in this area. Three of the boreholes have deep water tables, while the other two have shallow water tables. Monitoring began in 1983. Three transects are located in this area, Transects 4, 7 and 8.

Transects 5 and 9 (Kombat/Asis farm area)

There are five boreholes, one of which is fitted with a recorder, in this area. Monitoring began in mid 1983. Two transects are located in this area, Transects 5 and 9. The latter is very close to the Kombat Mine.

Transect 6 (Okambongora farm area)

There are four boreholes in this area, one of which is located in a fairly shallow water table area. Monitoring began in 1983. Transect 6 is located in this area.

Transect 10 (Berg Aukas farm area)

This area has six boreholes, and monitoring began in 1984. Transect 10 is located in this area, close to the Berg Aukas Mine.

3.2.2 DATA COLLECTION AND PROCESSING

The groundwater tables are monitored and checked on a regular basis for each of the selected boreholes in Areas I and II. The water levels are expressed in metres below the top of the borehole casing. At most of the boreholes, the groundwater levels are measured manually on a quarterly basis, using a depth gauge. At those boreholes where water level recorders have been installed, water levels are automatically monitored on a continuous basis.

The analysis of groundwater data includes all the data available during the period 1983 to 1989, so that a longer record could be examined for any trends which might not be detectable if only the baseline period of two years was analysed.

3.3 RESULTS

The present Karstland groundwater level monitoring system was initiated in 1983/84. The most noticeable feature about the behaviour of the water table from 1983/84 to the end of 1989, was the general, continuous decline of water levels in most parts of the Karstland area. The decline is evident despite the fact that abstraction on a large scale has taken place only at isolated boreholes, namely, Kombat Mine, Brandwag (intermittently), Grootfontein (Municipality), and Berg Aukas (Otjituuo State Water Scheme).

The groundwater status for the selected boreholes for the period 1983 to 1989 was analysed relative to the study sites (transects). The results are briefly discussed according to the farms on which the boreholes and transects occur. The time-drawdown graphs and relating rainfall patterns for each of these areas, are shown in the Departmental Report (Chivell, 1989).

Transect 1 (Brandwag/Uitkomst farm area)

There was a clear downward trend in water levels in all six boreholes in this area, caused by natural discharge. Rainfall, which averaged 540,5mm over the 1985 -1988 period, was below normal (MAP =589,3mm) and was not sufficient to cause long-term recovery. Only small fluctuations were observable during abstraction and rainy seasons.

Transect 1 (Otjirukaku farm)

The long-term trend during 1983 - 1987 remained downward in all the boreholes, but the period between December 1988 and March 1989 showed an upward trend. This was due to recharge from rainfall.

Transect 2 (Urupupa and Rietfontein farms)

One of the four boreholes and a fountain appeared to have been in a stable condition during the period May 1983 to May 1989, indicating a maintained balance between natural recharge from rainfall and underground inflow, and natural discharge. However, in two of the boreholes a long-term downward trend was evident. Small fluctuations were caused by seasonal rainfall.

Transects 4, 7 and 8 (Buschbrunnen farm)

Three of the five boreholes showed a clear downward trend and only small fluctuations caused by rainfall were evident. The water levels remained stable in the other two boreholes, indicating a maintained balance between natural discharge and recharge.

Transects 5 and 9 (Kombat/Asis farm)

All five boreholes showed a general downward trend for the period May 1983 to December 1988. Some fluctuations occurred as a result of pumping in the mine shaft at Kombat Mine at the beginning of 1989.

Transect 6 (Okambongora farm)

For the period March 1983 to December 1988, a general downward trend was observed in all four boreholes. For the period December 1988 to March 1989, the groundwater level remained stable, with the exception of one of the four boreholes, where a clear recovery was evident. This was due to rainfall.

Transect 10 (Berg Aukas farm)

It was evident that the majority of boreholes in this area have shown recovery during the period 1983 - 1989. This trend has resulted since pumping ceased in the mine shaft in 1978. The water table had risen, filling the existing cone of depression. Only one of the boreholes showed a slight downward trend, and small fluctuations caused by rainfall, were observed.

3.4 DISCUSSION

The decline in water table in the whole of the Karst area, was firstly attributed to the rainfall pattern, which was below average for the 1983 - 1988 period. Secondly, because of the elevated terrain of the Karstland, ie. along the major watershed which controls the surface drainage and also the groundwater flow, the outflow of groundwater from this region had not been compensated by an inflow, and thus, the outflow largely exceeded the inflow.

However, the groundwater table in the Berg Aukas area (the easternmost part of Area I), appeared to be the exception. Since the mine ceased production in 1978, the extensive cone of depression was eliminated in March 1986, and the water table appeared to have attained stability. A substantial rise in groundwater level in excess of 2 metres was noted since the beginning of 1989. A similar rise was also recorded at Grootfontein. In all cases, small fluctuations were observed in many of the boreholes, but these fluctuations were caused by recharge from seasonal rainfall. Where the groundwater levels are stable, it indicated a maintained balance between natural discharge and recharge.

4. RAINFALL MONITORING

4.1 BACKGROUND

Rainfall in Namibia is strongly seasonal, and approximately 80% of the year's rainfall normally falls during the summer months, October through to March. Since the majority of recharge to the underground aquifers results from direct precipitation, rainfall is thus a very important factor in the Karstveld. The Karst area under investigation receives a rainfall of 500 - 600mm per annum. The absence of well defined surface drainage systems indicates that little water is lost to surface runoff, which is favourable for infiltration. This situation is characteristic of an area undergoing constant karstification.

4.2 METHODS

4.2.1 SELECTION OF RAINFALL STATIONS

At the outset of the study, rainfall stations in operation in the Karst area were selected for closer scrutiny. These stations would provide the necessary data for the continuous monitoring of the Karstland rainfall pattern. By monitoring the rainfall pattern within this large area over the long term, it may be possible to explain changes in the status of the vegetation and vitality, relative to the soil moisture regime and the groundwater table.

Of a total of 85 rain gauges in the whole of the Karstland area, 24 stations were chosen for the purpose of monitoring the rainfall pattern on a daily basis. The daily rainfall readings are sent to the Meteorological Office by farmers in that area. These 24 stations are located both within and outside of the four synclinal regions, so as to ensure a good coverage of the whole region. These particular stations were selected not only because they were still operational, but also because most of them had fairly long records. It was decided not only to look at the rainfall data from the inception date of the study in 1986, but also at the rainfall years prior to that year. The 1979/80 hydrological season was chosen as the point of departure, so as to have at least five years of observed data for analysis prior to the baseline activities. The locations of the 24 key stations are shown in Figure 4.1, and full details are provided in Table 4.1.

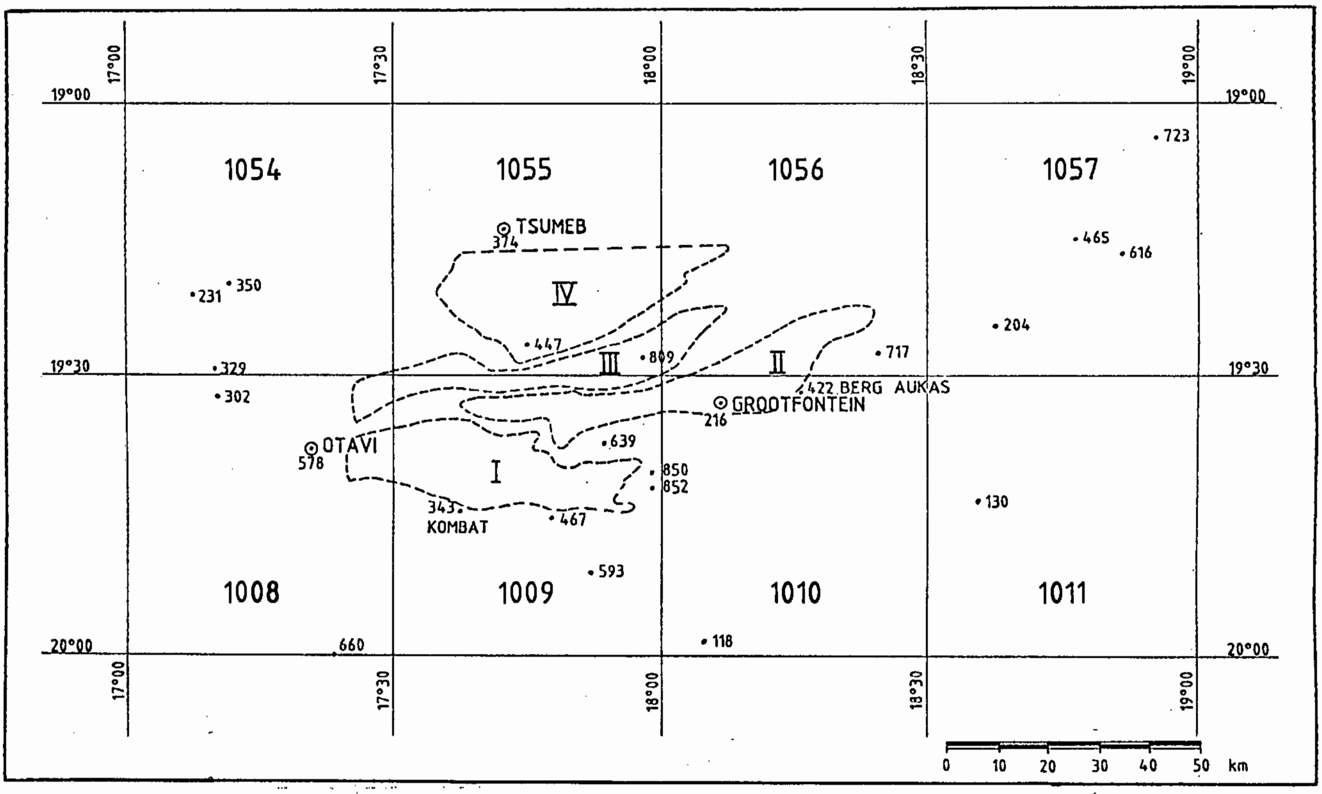


FIGURE 4.1 : LOCATIONS OF KEY RAINFALL STATIONS

TABLE 4.1 : KEY RAINFALL STATIONS USED IN KARSTLAND ANALYSIS

STATION NAME	STATION NO.	CO-ORDINATES LATITUDE	LONGITUDE	OPENING DATE OF STATION
Grootfontein	1010 216	19° 36'	18° 08'	05 - 1968
Berg Aukas	1010 422	19° 32'	18° 15'	01 - 1962
Gabasis	1010 118	19° 58'	18° 04'	01 - 1940
Rietfontein	1009 467	19° 47'	17° 46'	01 - 1940
Awagobibtal	1009 639	19° 39'	17° 52'	01 - 1940
Otjirukaku	1009 852	19° 42'	17° 59'	07 - 1926
Uitkomst	1009 850	19° 42'	17° 59'	03 - 1961
Gai Kaisa	1009 593	19° 53'	17° 50'	01 - 1940
Kombat	1009 343	19° 43'	17° 42'	01 - 1985
Una	1008 660	20° 00'	17° 22'	04 - 1954
Otavi	1008 578	19° 38'	17° 20'	09 - 1913
Goabpforte	1008 302	19° 32'	17° 11'	12 - 1949
Huettenhof	1054 329	19° 29'	17° 11'	12 - 1951
Soavis	1054 231	19° 21'	17° 08'	01 - 1940
Sissekab	1055 350	19° 20'	17° 12'	01 - 1940
Tsumeb	1055 374	19° 14'	17° 43'	07 - 1911
Gaub	1055 447	19° 27'	17° 45'	01 - 1940
Toggenburg	1056 809	19° 29'	17° 57'	03 - 1952
Gaikos	1056 717	19° 27'	18° 24'	07 - 1979
Klein Huis	1057 204	19° 24'	18° 37'	08 - 1950
Abendruhe	1057 465	19° 15'	18° 46'	10 - 1962
Maroelaboom	1057 616	19° 16'	18° 51'	08 - 1931
Sonop	1057 723	19° 03'	18° 55'	01 - 1964
Otjituuo	1011 130	19° 40'	18° 35'	01 - 1940

4.2.2 DATA COLLECTION AND PROCESSING

i) Background

The rainfall data obtained for each of the twenty-four stations were processed so as to obtain the statistics such as mean monthly, total annual, mean annual, median annual precipitation, calculated for the various number of years of data.

Where more localized rainfall data was required, but no rain gauges were present, a Multiquadric Surface Fitting programme (Plathe,1974) was used to calculate the mean monthly rainfall for these specific areas, using the existing Met. Office rainfall stations located near the respective sites. This programme fits a multiquadric surface to monthly rainfall data, whereby rainfall depths are intergrated over a predetermined grid system of rectangles. Two such sites were required during the study, one at Brandwag/Uitkomst and the other at Urupupa, for more detailed rainfall information near the soil moisture monitoring sites in these two areas.

ii) Point rainfall and areal rainfall

For the purpose of collecting baseline data, the rainfall years in which the baseline activities were being carried out, were closely examined. However, the years prior to and after the initial baseline, i.e. the first year of programmed monitoring, were also scrutinized in order to ascertain the general trend in rainfall over that decade.

All these rainfall stations' observed seasonal totals, as well as the converted values as percentage of the mean annual pricipitaion (MAP) were processed for the two seasons of the baseline study (1985/86 and 1986/87), and the first season of monitoring thereafter (1987/88).

The long-term medians were also calculated for each of the 24 stations for the same three year period. The median is a positional value in contrast with the arithmetic character of the mean, and is less affected by extreme values in the group than is the mean. This makes it a useful measure of the central tendency. The medians were included, since they have a more practical application in semi-arid climate areas as far as rainfall is concerned.

The seasonal rainfall totals in isolation did not convey much, but in relation to the MAPs, a tendency was noted throughout the various regions in the Karst area. The three seasons 1985/86, 1986/87 and 1987/88 were first analysed as a three year period, and then this period was compared with the general tendency in the years prior to the baseline period. The seasonal precipitaion totals are provided in Table 4.2.

TABLE 4.2 : TOTAL SEASONAL PRECIPITATION (mm) FOR SELECTED RAINFALL STATIONS

STATION NO.	1979/ 80	1980/ 81	1981/ 82	1982/ 83	1983/ 84	1984/ 85	1985/ 86	1986/ 87	1987/ 88	LONG TERM MAP	LONG TERM MEDIAN
1010 216	673.7	395.3	544.5	374.2	577.8	390.2	550.5	400.0	417.0	576.9	534.0
1010 422	578.5	448.7	**	**	**	439.6	493.4	400.0	523.5	527.3	468.4
1010 118	568.0	403.0	477.0	401.0	387.2	409.9	414.5	371.5	475.6	439.9	408.8
1009 467	**	**	**	**	**	**	601.5	469.6	692.0	570.5	504.3
1009 639	675.6	382.5	480.0	385.0	543.0	402.0	643.5	481.0	517.6	594.0	543.1
1009 852	939.4	404.0	470.4	447.2	533.0	427.5	550.5	445.0	498.0	564.1	509.3
1009 850	811.5	376.3	529.0	313.5	550.0	484.1	593.1	464.8	536.5	589.3	541.5
1009 593	656.0	409.0	477.0	503.0	550.0	389.0	412.3	**	**	550.2	503.0
1009 343	**	**	**	**	**	**	540.6	503.0	585.9	543.3	503.0
1008 660	475.8	358.9	555.1	315.3	426.9	341.0	350.5	244.5	285.5	471.0	465.2
1008 578	384.9	364.5	642.4	406.1	530.4	517.4	509.7	396.7	390.9	528.2	509.7
1008 302	535.0	431.3	543.4	465.4	566.3	387.4	512.6	423.4	505.3	588.8	556.1
1054 329	511.7	477.9	521.7	438.6	559.5	536.0	445.8	404.4	552.9	582.1	552.5
1054 231	444.3	324.1	460.3	450.3	513.2	413.0	471.0	371.9	412.6	509.2	470.7
1054 350	533.8	343.4	505.8	373.4	574.5	385.7	498.9	322.2	392.6	529.6	514.5
1055 374	727.0	360.9	521.0	370.3	456.2	466.0	694.0	**	373.2	527.3	502.8
1055 447	793.7	459.8	600.6	520.5	936.4	603.0	696.3	434.0	527.5	646.8	601.8
1056 809	627.0	330.0	469.0	358.0	521.0	626.0	820.0	555.5	661.0	592.4	555.5
1056 717	759.0	440.0	379.7	464.1	542.4	436.3	630.2	462.1	488.1	507.8	464.1
1057 204	483.9	409.3	329.0	370.4	551.4	423.0	442.5	306.8	271.4	491.4	446.4
1057 465	646.0	442.5	294.0	336.0	628.5	559.0	506.5	313.5	517.5	476.0	493.8
1057 616	600.5	401.9	338.8	291.5	533.4	630.3	404.5	332.0	466.6	434.1	420.6
1057 723	783.4	415.0	354.6	354.2	492.2	437.6	601.6	367.0	544.7	529.3	449.8
1011 130	523.5	354.0	286.0	245.3	323.7	357.5	268.0	178.5	482.0	430.1	373.0
Brandwag *				381.5	566.1	458.3	574.6	457.3	521.1		
Urupupa *				418.4	514.4	367.0	495.1	454.1	609.2		

** Stations temporarily closed.
* Rainfall values calculated using Multiquadric Surface Fitting programme.

In addition to these analyses, the relevant rainfall stations located closest to those transects where manual monitoring took place, ie. Transects 1, 2, 4, 6 and 8, were selected for incorporating into the ordination programme referred to in Section 6. These rainfall stations are all situated in Area I.

The rainfall data from these stations were defined as two separate environmental variables relating to each transect. The one environmental variable was made up of the current season's rainfall data, ie. the total precipitation for the first year of manual monitoring (1986), for the period October 1985 to April 1986. The other environmental variable was made up of the total rainfall of the two years prior to the current season, as well as the current season's rainfall, for the period October 1983 to April 1986. The four stations used to provide these data for use in the ordination programme were Brandwag (542.5mm, 1566.8mm), Uitkomst (554.5mm, 1588.6mm), Rietfontein (601.5mm, 1542.4mm) and Kombat (513.5mm, 1533.7mm)

4.3 RESULTS

4.3.1 RAINFALL TENDENCIES

The rainfall pattern over the Karstland has been analysed for the three hydrological seasons, in terms of percentage of the MAP. These are shown in Figure 4.2. This Figure shows the eight sections, or squares, within which the 24 stations occur. The 1985/86, 1986/87 and 1987/88 rainfall data are provided together with a rating for each station. Tendency ratings are specified next to each station number. The general rating for each square, for each of the hydrological years is also indicated above or below each section. The definition of the tendency rating is as follows :

very poor	=	<< median	< 75%
poor	=	< median	75 - 90%
fair	=	median	90 - 95%
good	=	mean	95 - 100%
very good	=	> mean	100 - 125%
exceptionally good	=	>> mean	>> 125%

It is hoped that these definitions can be correlated with plant vitality. Figure 4.2 is sufficient for a pure analysis of the rainfall, but the aim has been to arrive at some conclusions or definitions of how good or poor a rainy season has been in a particular area.

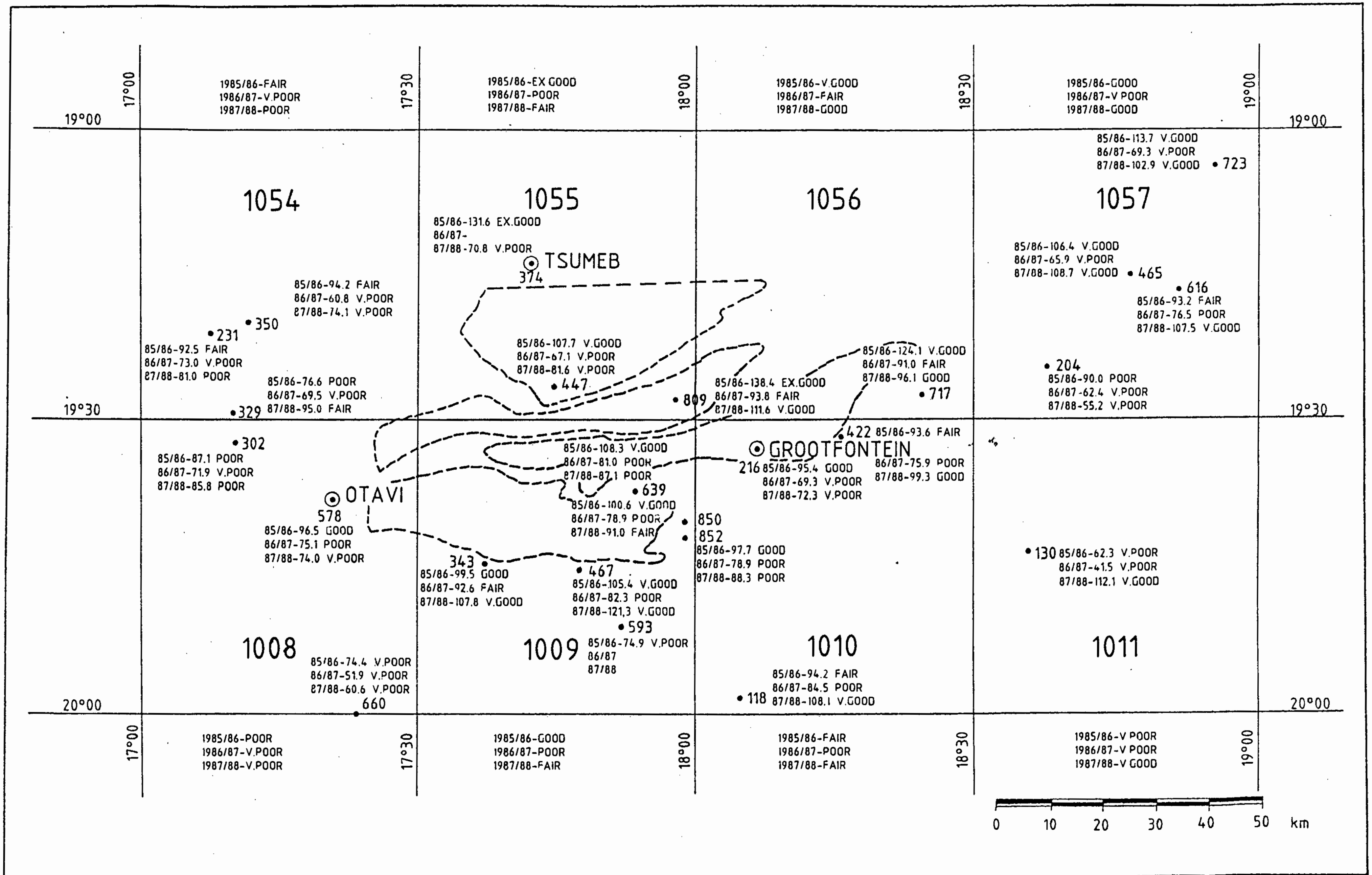


FIGURE 4.2 : RAINFALL TENDENCIES FOR THREE SEASONS

4.4 DISCUSSION

It was observed that during the baseline years 1986 and 1987, the rainfall pattern for the whole Karstland area was poor to fair relative to the MAP.

Examining the data for Area I and Area II, it was evident that during the three seasons 1985/86, 1986/87 and 1987/88, the rainfall in these two Areas followed a similar trend to that of the whole Karst area, ie. poor to fair relative to the MAP. It was also noted that in the five years prior to the baseline study (1979/80 onwards), the rainfall in these two Areas had been relatively poor as well. Table 4.3 shows these tendencies.

TABLE 4.3 : AREAS I AND II RAINFALL TENDENCIES RELATIVE TO MAP

SECTION NO	HYDROLOGICAL SEASONS								
	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
1010	very good	poor	good	poor	fair	poor	fair	poor	fair
1009	except. good	very poor	poor	poor	fair	very poor	good	poor	fair

5. SOIL STATUS

5.1 BACKGROUND

The difference in soil and vegetation between the lower lying areas and the hills in the Karst area is very noticeable. This phenomenon could be related to moisture, resulting from the normal downward drainage of water, as well as from groundwater.

The primary factor for the vegetation differences is the different soil types and thickness, and related to this are the different soil moisture regimes. The variations in soil moisture occur as a result of the difference in soil textures, the different water holding capacities of the soils, and perhaps the groundwater table being at different depths.

5.2 SOIL TYPES

The various soil types along the transect areas were briefly mentioned in Section 2, but the physical characteristics of each soil type were not included.

These physical details are provided in Table 5.1. Presented in this table are the soil types found in each transect, the description of the soils' horizons, water holding capacity, drainage, leaching, and depth in which the bulk of the roots occur.

The table is preceeded by a short introduction to each transect.

<u>Transect 1</u> (Brandwag/Uitkomst)

The whole transect line is located on a Mispah. Two soil profile pits were dug, at 50m and at 250 m along the length. Refer to Table 5.1 for the other details.

<u>Transect 2</u> (Urupupa)

This transect crosses over three soil types, a Mispah, Hutton and Glenrosa. Two soil profile pits were dug in the Mispah, at 50m and 300m, and one in each of the other soil types, at 700m and at 1000m respectively. Refer to Table 5.1 for the other details.

Transect 4 (Buschbrunnen)

This transect crosses over three soil types, a Hutton, Mispah and Rensburg. As the transect line starts on the fringe of the Hutton and Mispah, a soil profile pit was dug only in the Mispah. Two pits were dug in the Rensburg, but both have the same profile description. Refer to Table 5.1 for the other details.

Transect 5 (Kombat/Asis)

This transect crosses two soil types, an Avalon and a Hutton. A soil profile pit was dug in each of the soil types. Refer to Table 5.1 for the other details.

Transect 6 (Okambongora)

This transect crosses two soil types, a Mispah and a Milkwood. A soil profile pit was dug in each type. Refer to table 5.1 for the other details.

Transect 7 (Buschbrunnen)

This transect crosses three soil types, a Mispah, Glencoe and Clovelly. Soil profile pits were dug in each type. Refer to Table 5.1 for the other details.

Transect 8 (Buschbrunnen)

This transect crosses over three soil types, a Rensburg, Mispah and a Katspruit. A soil profile pit was dug in each of the types. Refer to Table 5.1 for the other details.

Transect 9 (Kombat Mine)

This transect crosses over three soil types, a Glencoe, Clovelly and a Mispah. Soil profile pits were dug in each type. Refer to Table 5.1 for the other details.

Transect 10 (Berg Aukas Mine

This transect crosses over two soil types, a Mispah and a Clovelly. A soil profile was dug in each soil type. Refer to table 5.1 for the other details.

The soil types occurring along Transects 1, 2, 4, 6 and 8, and their respective A-horizon depths were used in the ordination programme discussed in Section 6.

TABLE 5.1 : PHYSICAL DETAILS OF THE SOIL TYPES ALONG EACH TRANSECT

TRANSECT	VEGETATION COMMUNITY TYPES	SOIL CHARACTERISTICS					UNDERLYING ROCK FORMATIONS
		FORM : HORIZONS/DEPTH (cm)	WATER HOLDING CAPACITY	DRAINAGE	LEACHING	BULK ROOT DEPTH (cm)	
1	Mountain base/ contact fringe Contact community	**Mispah :** Orthic A horizon 0-20cm Hard rock calcrete horizon 20-N*	poor	poor	little/none	20cm	Dolomite/ Granite transition Granite, covered by calcrete and soil
	Slope community	**Mispah :** Orthic A horizon 0-10cm Hard rock calcrete horizon 10-N*	poor	poor	little/none	15cm	Granite, covered by calcrete and soil
2	Plain community	**Mispah :** Orthic A horizon 0-25cm Hard rock calcrete horizon 25-N*	poor	poor	little/none	25cm	Phylite, covered by calcrete and soil
	Contact community	**Mispah :** Orthic A horizon 0-30cm Hard rock calcrete horizon 30-N*	poor	poor	little/none	30cm	Phyllite, covered by calcrete and soil
	Plain community	**Hutton :** Orthic A horizon 0-15cm Red Apedal B horizon 15-N*	very good	good	moderate/good	60cm	Dolomite, outcrops in places
	Plain community	**Glenrosa :** Orthic A horizon 0-20cm Lithocutanic B horizon 20-N*	poor	fluctuating	little/none	30cm	Dolomite, outcrops in places
4	Plain community	**Hutton / Mispah** fringe					Dolomite
	Contact community	**Mispah :** Orthic A horizon 0-20cm Hard rock calcrete horizon 20-N*	poor	poor	little/none	20cm	Phyllite, covered by calcrete and soil
	Plain community	**Rensburg :** Vertic A horizon 0-25cm Gley B horizon 25-N*	very good	very poor	little (high clay content)	30cm	Phyllite, covered by calcrete and soil
5	Plain community Contact community Plain community	**Avalon :** Orthic A horizon 0-20cm Yellow brown Apedal B horizon 20-60cm Plinthic horizon 60-N*	good	good	little	60-120cm and deeper	Phyllite, covered by soil in places Phyllite, covered by soil in places Dolomite, partly covered by soil
	Plain community	**Hutton :** Orthic A horizon 0-25cm Red Apedal B horizon 25-N*	good/ moderate	good	a lot	120cm and deeper	Dolomite, partly covered by soil in places
6	Contact community	**Mispah :** Orthic A horizon 0-20cm Hard rock calcrete horizon 20-N*	poor	poor	little	20cm	Phyllite, covered by calcrete and loamy soil.
	Plain community						Dolomite
	Plain community	**Milkwood :** Melanic A horizon0-25cm Hard rock calcrete horizon25-N*	poor	poor	little	30cm	Dolomite
	Plain community	**Mispah :**	poor	poor	little	20cm	Dolomite

TRANSECT	VEGETATION COMMUNITY TYPES	SOIL CHARACTERISTICS					UNDERLYING ROCK FORMATIONS
		FORM : HORIZONS/DEPTH (cm)	WATER HOLDING CAPACITY	DRAINAGE	LEACHING	BULK ROOT DEPTH (cm)	
7	Slope community	**Clovelly** : Orthic A horizon 0-35cm Yellow-brown Apedal B horizon 35-120cm	good	moderate (high in clay)	little	120cm	Dolomite
	Slope community	**Glencoe** : Orthic A horizon 0-20cm Yellow brown Apedal B horizon 20-70cm Hard Plinthic horizon 70-N*	good	poor	little	70cm	Dolomite
	Slope community	**Mispah** : Orthic A horizon 0-30cm Hard rock calcrete horizon 30-N*	poor	poor	little	30cm	Dolomite
	Slope community	**Glencoe** :	good	poor	little	70cm	Dolomite
	Slope community	**Mispah** :	poor	poor	little	30cm	Limestone/Phyllite
	Mountain base comunity	**Mispah** :	poor	poor	little	30cm	Dolomite
8	Contact community	**Rensburg** : Vertic A horizon 0-30cm Gley B horizon 30-N*	good	poor	little	30cm	Phyllite, covered by loamy soil in places
	Slope community	**Mispah** : Orthic A horizon 0-25cm Hard rock calcrete horizon 25-N*	poor	poor	little	25cm	Dolomite
	Plain community	**Mispah** :	poor	poor	little	25cm	Dolomite
	Plain community	**Katspruit** : Orthic A horizon 0-30cm G-horizon 30-N*	moderate	poor	very little	30cm	Dolomite
	Slope community	**Mispah** :	poor	poor	little	25cm	Dolomite
	Slope community	**Mispah**:	poor	poor	little	25cm	Limestone/ Phyllite, covered by calcrete and soil
9	Plain community	**Glencoe** : Orthic A horizon 0-20cm Yellow brown Apedal horizon 20-70cm Hard Plinthic horizon 70-N*	good	poor	very little	whole profile	Phyllite, covered by soil
	Contact community	**Clovelly** : Orthic A horizon 0-50cm Yellow brown Apedal horizon 50-N*	good	good	moderately good	whole profile	Phyllite, covered by soil
	Mountain base community	**Clovelly** :	good	good	moderately good	whole profile	Dolomite, partly covered by soil
	Mountain community	**Mispah** : Orthic A horizon 0-30cm Hard rock calcrete horizon 30-N*	poor	poor	little	30cm	Dolomite, partly covered by soil in places

TRANSECT	VEGETATION COMMUNITY TYPES	SOIL CHARACTERISTICS					UNDERLYING ROCK FORMATIONS
		FORM : HORIZONS/DEPTH (cm)	WATER HOLDING CAPACITY	DRAINAGE	LEACHING	BULK ROOT DEPTH (cm)	
10	Plain community	**Mispah :** Orthic A horizon 0-20cm Hard rock calcrete horizon 20-N*	poor	poor	very little	20cm and deeper	Granite, covered by calcrete and soil
	Contact community	**Mispah :**	poor	poor	very little	20cm plus	Granite, covered by calcrete and soil
	Plain community	**Clovelly :** Orthic A horizon 0-30cm Yellow brown Apedal horizon 30-60cm	good	good	a lot	60cm and deeper	Dolomite
	Mountain community	**Mispah :**	poor	poor	very little	20cm plus	Dolomite
	Mountain community	**Mispah :**	poor	poor	very little	20cm	Dolomite
	Mountain community	**Mispah :**	poor	poor	very little	20cm plus	Dolomite

N* represents depth of next horizon deeper than soil profile pit.

5.3 SOIL MOISTURE

5.3.1 BACKGROUND

The top layers of soil were monitored in order to determine the soil moisture changes within a soil profile, and to ascertain if there really was a correlation between soil moisture and the groundwater table, especially in the areas where the groundwater table was initially shallow (less than 5m from the soil surface) at the beginning of the investigation. The assumption was made that if the top metre of soil remained quite moist as a result of precipitation, the trees would absorb enough water from this layer without being affected by a lowering of the groundwater level.

5.3.2 METHODS

i) Neutron Scattering

The method by which this was carried out, was neutron scattering, using a Troxler Neutron Probe. This is a depth probe which is lowered into the soil through an aluminium access tube, down to the desired depth at which the moisture content is to be read.

The neutron scattering method is an indirect way of determining soil moisture content. The moisture content of soil is estimated by measuring the thermal or slow neutron density. The radio-active source within the instrument emits neutrons with high energy into the soil, which are slowed down by elastic collisions with nuclei of atoms, and hence become thermalized. The average energy loss is much greater when neutrons collide with atoms of low atomic weight (mainly Hydrogen in soils), than from collisions with heavier atoms. Hydrogen can slow fast neutrons more effectively than any other elements in the soil. The density of the resultant cloud of slow neutrons is a function of the soil moisture content in the liquid, solid or vapour state. The number of slow neutrons returning to the detector per unit, are counted and the soil moisture derived from a previously determined calibration curve of counts versus volumetric water content (Troxler International, 1983).

ii) Site Selection and Description

This method was the most practical way to monitor soil moisture at various depths and on a regular basis. Soil moisture content was measured only in those transect areas where the groundwater table was closest to the soil surface, as contoured from the 1984 levels. Sites were chosen in and near to Transect 1 and Transect 2. The former's soil type was a Mispah throughout, while the latter had two soil types, a Mispah and a Hutton.

Depending on the accessibility of the soil and underlying rock, the aluminium tubes were installed to different depths in these two soil types. The details of the soil moisture sites are summarised in Table 5.2.

TABLE 5.2 : SOIL MOISTURE MONITORING SITES ALONG TRANSECTS 1 AND 2

SITE LOCATION	TRANSECT 1 / BRANDWAG			TRANSECT 2 / URUPUPA		
	At 50m marker pole	At 250m marker pole	Adjacent to 50m marker pole	At 100m marker pole	At 300m marker pole	Adjacent to 300m marker pole
DEPTH OF ACCESS TUBE	1.5m	2.0m	9.0	1.2m	2.0m	6.0m
SOIL TYPE AT SITE	Mispah	Mispah	Mispah	Mispah	Mispah/Hutton fringe	Mispah/Hutton fringe

iii) Data Collection and Processing

The first soil moisture measurements were taken in January 1986, and with the exception of a few months when the instrument required servicing, were continued regularly throughout the baseline period of 1986 and 1987, and two years into the monitoring programme period. Readings were taken towards the end of each month, and were read in percentage volumetric units. Calibration of the instrument for each soil type was carried out with the aid of a Gamma Ray Density Meter, as the bulk density of each soil type had to be incorporated into the calibration calculations. The cable of the density meter was only three metres long, and thus the calibration could be carried out for only the first three metres of soil.

The soil moisture data, from January 1986 to August 1989, was processed, analysed and then graphically represented for interpretation purposes. These graphs are included in the Departmental Report (Chivell, 1989).

5.3.3 RESULTS

In order to clarify the conclusions drawn from the soil moisture results, the graphs of the 2.0m deep sites for both Transect 1 (Brandwag) and Transect 2 (Urupupa) for the baseline period, are included here. Figures 5.1 and 5.2 refer to the Brandwag area for 1986 and 1987 respectively. Figures 5.3 and 5.4 refer to the Urupupa area for 1986 and 1987 respectively. These graphs are good examples of how soil moisture changes with depth during the year.

The general soil moisture trends as depicted in the graphs at both Brandwag and Urupupa, show very consistent behaviour over the two years. Within the first 30cm of each profile, the higher soil moisture values occurred during the rainy season months. The temporal variations in soil moisture are greatest near the surface of the soil and even down to one metre as seen in 1987. This is attributed to the bulk of the roots being present at this level. During the wetter months, the moisture content within the first metre of soil is very much a direct function of precipitation, whereas below one metre this does not appear to be the case.

At the Brandwag site, the soil moisture content below one metre appears to be lower than that above one metre, but between 1.5m and 2.0m, the moisture content is higher. This trend was evident during both years. This could possibly be attributed to the layer of soil at that depth having a better water holding capacity than the above layers, as well as there being fewer roots at that depth to utilize the available moisture.

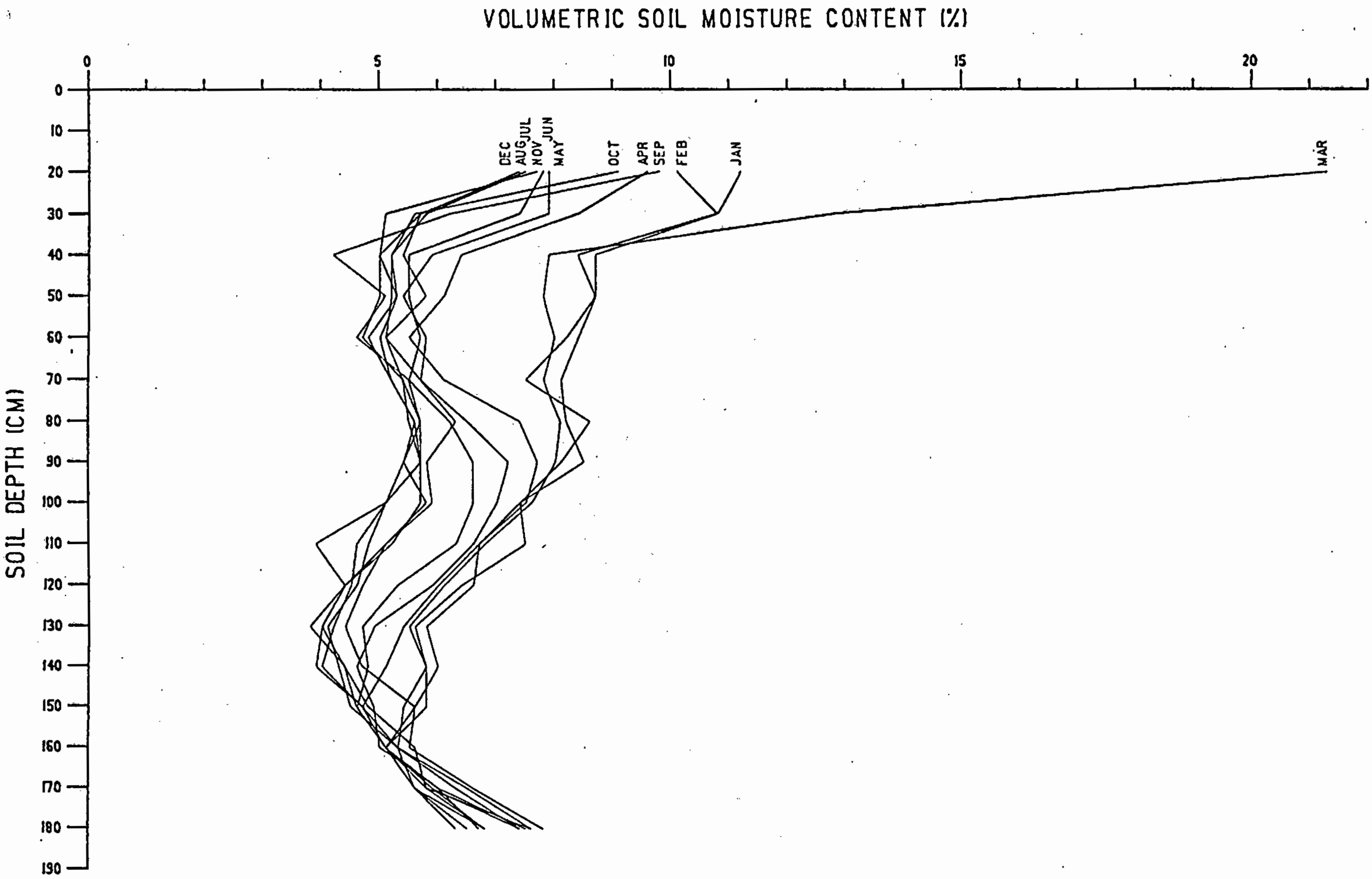


FIGURE 5.1: SOIL MOISTURE MEASUREMENTS - TRANSECT I (BRANDWAG), 2.0 M TUBE, 1986.

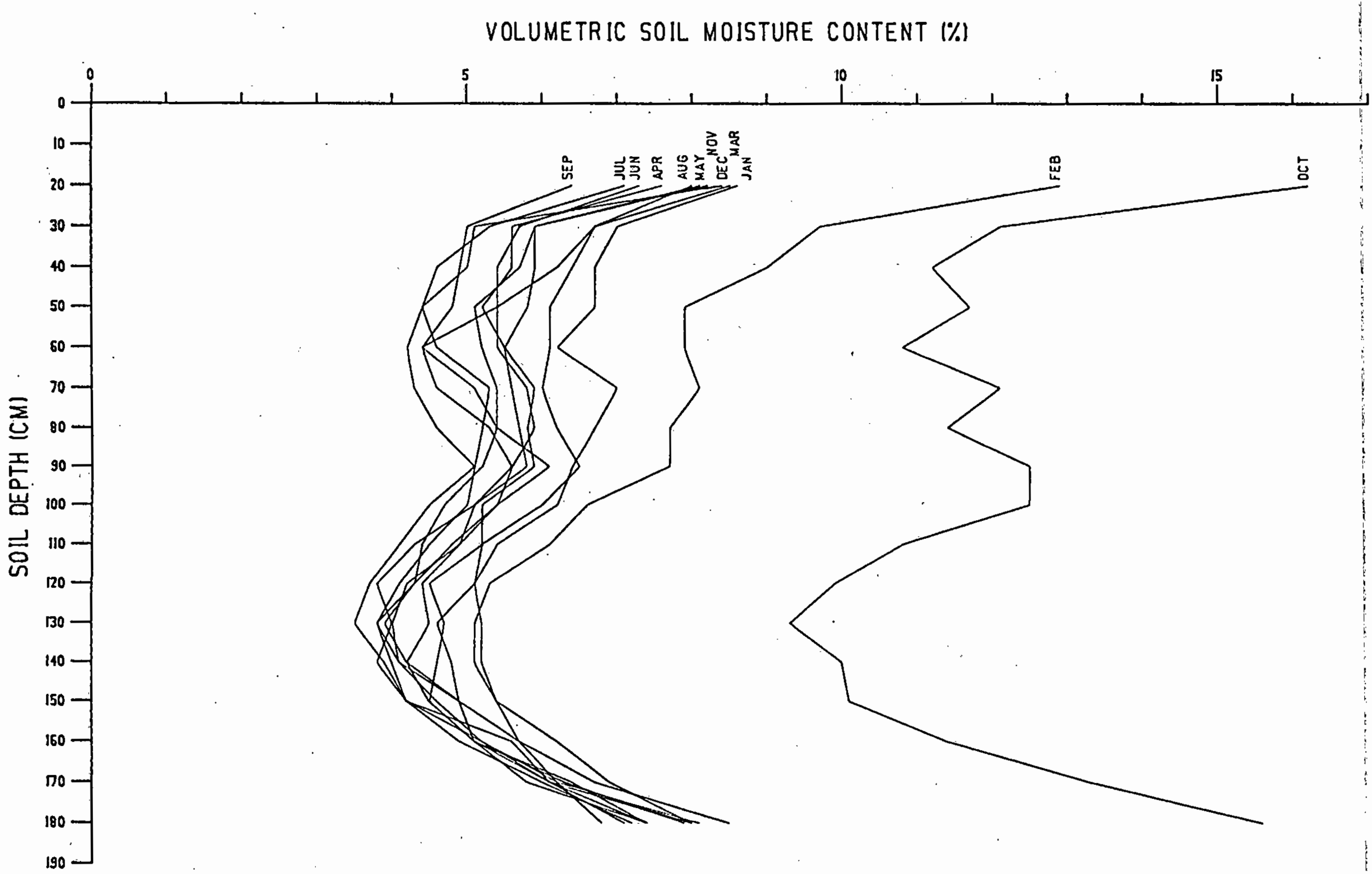


FIGURE 5.2: SOIL MOISTURE MEASUREMENTS - TRANSECT I (BRANDWAG), 2.0 M TUBE, 1987.

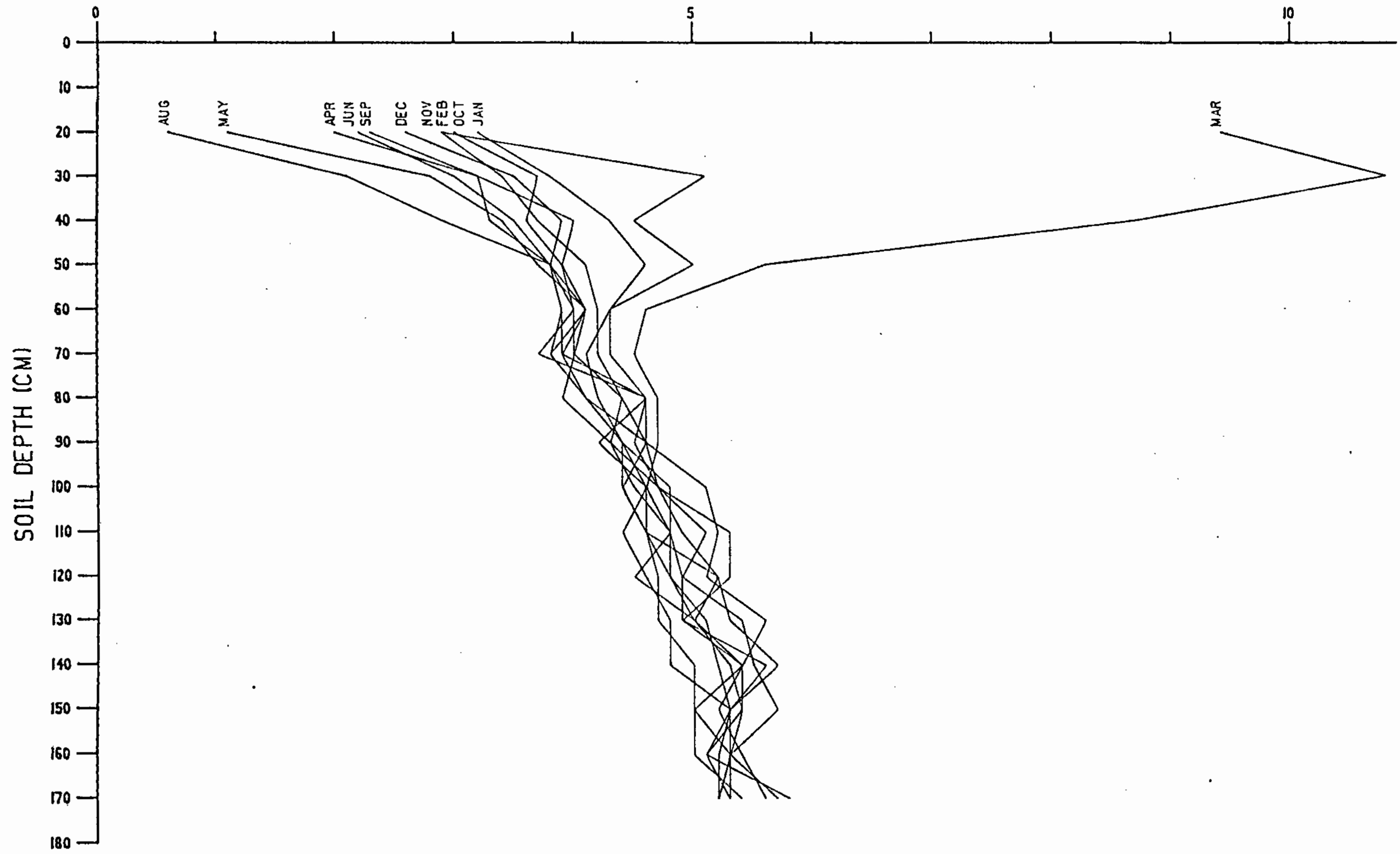


FIGURE 5.3: SOIL MOISTURE MEASUREMENTS - TRANSECT 2 (URUPUPA), 2.0 M TUBE, 1986.

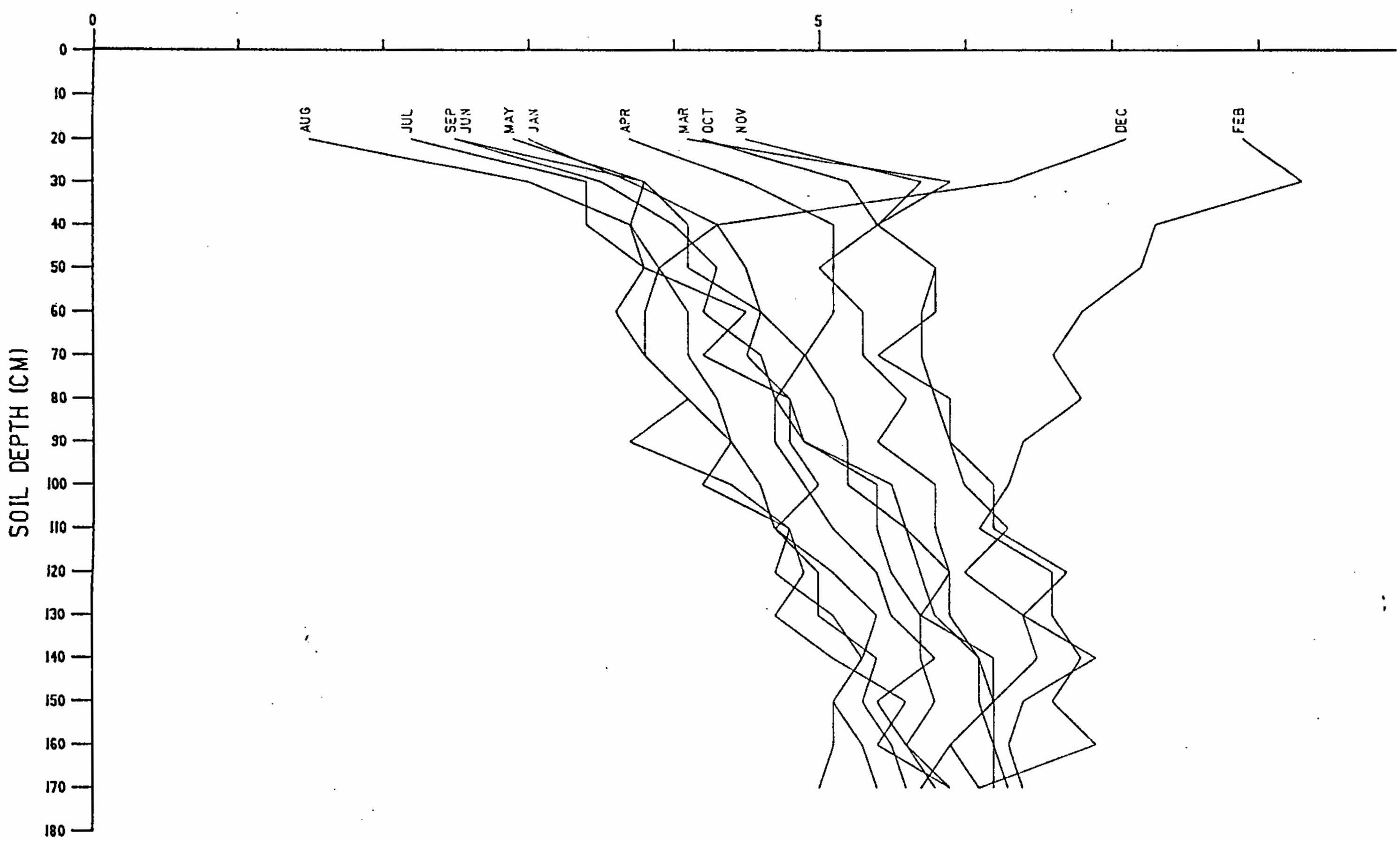


FIGURE 5.4: SOIL MOISTURE MEASUREMENTS - TRANSECT 2 (URUPUPA), 2.0 M TUBE, 1987.

In addition, the effect of precipitation seemed to be fairly short lived, as is illustrated by the fact that by the end of the rainy season, the higher moisture values have returned to similar values as those during the drier months, despite different rainfall patterns and amounts. This stabilization effect is important as it implies that the soil moisture status will always be the same at the beginning of the new rainy season, irrespective of how wet the previous rainy season was. It appears that below the top 30cm of soil, the moisture content rarely exceeds 10% or is less than 3%. This same trend was observed in all four years of monitoring, from 1986 to 1989. This could imply that there is rarely an excess of water in the root zone area.

At the Urupupa site, the majority of soil moisture values measured within the top 30cm of the profile were less than 5%. This could be attributed to the fact that this site is more exposed and dries out more rapidly after rain than the Brandwag site. The latter site is completely under the shady cover of the vegetation, and the top layer of soil is composed of a relatively large amount of organic matter as a result of leaf and woody litter.

Within the top 50cm, the soil moisture content value increases with increasing depth, and then stabilizes at approximately one metre. However, even at this depth where this effect is evident, the actual range of soil moisture is relatively low, mostly between 4% and 10%.

5.3.4 DISCUSSION

The following general observations were concluded from the soil moisture graphics :

- Below a soil surface depth of 1.5m - 2.0m, depending on the soil type, soil moisture content values show little variation.

- High levels of soil moisture in the upper 20cm dry out rapidly. (One of the disadvantages of using neutron scattering is that the moisture values in the top 20 - 30cm cannot be measured very accurately).

- Moisture content values in the main root zone down to one metre hardly ever exceed 10% indicating that there is rarely an oversupply of water.

- This also leads to what is referred to as a "stabilizing effect", since the removal of most available water in the main root zone results in a stabilized moisture content as the presence and density of roots diminish deeper down.

- The soil moisture content profile for each site returns to a very similar situation at the end of winter. "Antecedent" soil moisture conditions at the start of each rainy season therefore do not vary significantly.

5.3 ROOT DEPTH DETERMINATION

5.3.1 BACKGROUND

The main objective in the ecological investigation was to try to assess whether the vegetation is dependent on the availability of groundwater. This was particularly important along the contact zone regions, where permeability is more favourable.

5.3.2 METHODS

i) Site Selection and Description

A one-off investigation was carried out in order to ascertain whether the rooting systems of the plants growing along the contact zone penetrate to any great depths into the soil. Again the shallow groundwater table area was chosen as based on the 1984 contour levels. The selected site was very close to Transect 1. The soil type was a Mispah, with a 20cm deep Orthic A-horizon. The woody plant species were typically those of a contact type community, dominated by *Olea europeae*, *Acacia karroo*, and *Rhus lancea*.

A trench of eight metres in length and five metres in depth was dug by an excavator, and a grid of 1m x 1m squares marked on one of the lateral walls. The visible roots in each square of the B-horizon were then counted.

5.4.3 RESULTS

The highest number of roots occurred in the top 20cm, the A-horizon. These roots were not counted as it was apparent that the bulk of the rooting system was located here. It was evident that there was a decline in root numbers as the soil depth increases. However, there was no clear pattern of decline in the abundance of roots with increased soil depth, and roots were still found to occur at a depth of 5m and deeper, although they were very small and fine.

Table 5.3 summarises the findings of the root counts for the B-horizon.

TABLE 5.3 : ROOT COUNTS FOR B-HORIZON AT BRANDWAG, IN CONTACT VEGETATION

SOIL HORIZON	CHAINAGE ALONG TRENCH LENGTH (m)							
	1.	2.	3.	4.	5.	6.	7.	8.
A-HORIZON (20cm)	Bulk of roots							
B-HORIZON (depth in m)								
1.	28	32	23	21	19	17	18	57
2.		16	10	29	23	22	21	30
3.			5	10	6	9	9	11
4.				5	10	23	21	3
5.				2	3	3	2	

5.4.4 DISCUSSION

The root counts show that the contact vegetation roots can and do penetrate down to depths of 5m and more, but it is evident that the bulk of the roots occur in the top layer of soil, the A-horizon.

It appears that during the wet season when the plants are actively growing and surface water is plentiful, the surface roots in the top layer of soil are responsible for the bulk of the water taken up by the vegetation. During the dry period, this top soil dries out and the plants probably rely on the roots deeper down for moisture uptake. It was clear that some woody species like *O. europeae* and *A. karroo* do have fairly deep rooting systems.

This suggests that the plants of the contact type community in the vicinity of Transect 1, may have made use of the groundwater table prior to the water level having dropped to more than 5m below soil surface. This decline in water table is probably attributable to the small-scale abstraction of water for the construction of the canal phase of the ENWC, as well as inadequate recharge during the years of below average rainfall.

PART 4

6. VEGETATION MONITORING BY MANUAL SAMPLING

6.1 METHODS

6.1.1 SITE SELECTION AND PREPARATION

Five of the nine transects were chosen specifically for the purpose of carrying out manual ground surveys during the baseline period. These five were Transects 1, 2, 4, 6 and 8. Refer to Figure 2.2 for orientation.

The manual monitoring survey was carried out at the end of the growing season, April/May in 1986 and 1987. The preparatory work involved sub-dividing the entire length of each of these five transects into 5m x 5m subplots. This was done by roping off 100 metres at a time down the length of the transect using the permanent poles as markers. The other side of the transect line was roped off five metres away from the original rope. Sub-divisions of five metre intervals were roped off within this five metre wide corridor of vegetation. These same strips of vegetation were examined for two consecutive years, using the same method for delineating the strips.

6.1.2 DATA COLLECTION

Each of the five transects was treated in the same way. Within each subplot, the usual growth measurements of density, cover and frequency, were recorded. The following parameters were noted for each individual tree species above one metre in height :

- Listing of woody tree species
- Height of tree
- Widest growth point, parallel to transect length
- Height of growth at this widest growth point
- Height of the lowest growth point
- Estimation of percentage dead material on the tree

In addition, the following detailed observations were recorded for each 5m x 5m subplot as a whole :

- A listing and count of woody species under one metre in height.

- A listing and count of woody species' seedlings, since the presence or absence of seedlings is a reflection of the regeneration potential of the vegetation communities.

- An estimation of frequency and cover of dead material below one metre in height and lying on the ground, converted to percentage cover. This estimation was done by mentally sub-dividing the whole subplot into ten blocks. The blocks in which dead material occurred were counted and this total converted to a percentage.

- A listing of shrub-stratum species.

- An estimation of frequency and percentage cover of shrub-stratum species. This estimation was carried out in the same way as that of the dead material.

- A count of standing dead woody species (any dead species still above one metre in height)

- An estimation of percentage dead material below one metre in height and on the ground. This estimation was done by mentally re-arranging the dead material side by side within the subplot and allocating a percentage value to the area it occupied.

6.1.3 INITIAL DATA PROCESSING

The data collected during the baseline surveys were analysed in different ways to achieve two objectives. The first of these was for classification of the current vegetation, based on an analysis of the relationships between the vegetation and the various environmental factors. The second analysis involved the comparison of elements of the 1986 and 1987 baseline data, in order to ascertain the extent and possibly explain the various changes in the vegetation status over this two year period.

These two approaches, including information on the general background and the preparation of data, are discussed in Sections 6.2 and 6.3 respectively.

6.2 CLASSIFICATION OF VEGETATION DATA

6.2.1 INTRODUCTION

Certain plant communities occur in certain types of environment. The physical, chemical and biotic features of the environment have a strong effect on the distribution of plant communities. As vegetation is heterogeneous, and the approaches to its classification numerous, so are there different avenues to an orderly arrangement of the vegetational mosaic.

It is important to understand the intimate relationships between the vegetation and the site on which it grows. The innumerable features of the environment are so intricately interwoven, and in most ecological studies only a few of the more obvious features are singled out for investigation.

It should be borne in mind that the environment is dynamic, and every change produces chain reactions which may be of great consequence.

Vegetation classification or ordination should therefore not only be based on the features of the vegetation alone, but also on the various factors in the environment, such as climate, groundwater, soil and biotic features. These are important and necessary to develop a proper understanding of ecosystems including their vegetation components.

With this concept in mind, a multi-featured method was used for the purpose of classifying the representative strips of Karst vegetation.

A common problem in community ecology has been to relate a multitude of species' responses to external environmental factors. Data are collected on species composition and the external variables at a number of points in time and space. Previous statistical methods utilized to analyse such data, either assumed linear relationships or were restricted to regression analysis of the response of each species separately to one environmental variable at a time.

In order to analyse the generally non-linear, non-monotone response of a community of species, it has been necessary to resort to the data-analytical methods of ordination or cluster-analysis. These are "indirect" methods, and are generally less powerful than the "direct" statistical method of regression analysis.

However, as plant species experience the conditions provided by many environmental variables, the joint effects should be analysed. Multiple regression can be used for this purpose, but there are disadvantages to using this method (Ter Braak, 1987). These are :

- Each species requires separate analysis, and thus regression analysis takes a lot of effort.

- Vegetation data are often qualitative, or when they are quantitative, the data may contain many zero values for the plots where the species is absent. These data then do not satisfy the assumption of a normal error distribution that is implicit in ordinary multiple regression.

- Relationships between species and environmental variables are generally non-linear. Species abundance is often a single-peaked function of the environmental variable.

- Environmental variables are often highly mutually correlated, and so it is impossible to separate their independent effects.

However more recently, a method has been introduced whereby regression and ordination have been integrated into techniques of multivariate direct gradient analysis, referred to as canonical (or constrained) ordination. These techniques escape the assumption of linearity and are able to detect unimodal relationships between species and external variables. The use of this method improves the power to detect the specific effects in which the user is interested. Canonical ordination is thus a class of techniques for relating the composition of species communities to the environment as defined by several environmental factors.

Data analysis by canonical ordination can be either exploratory or confirmatory. When used in the former way, it leads to an ordination diagram of samples, species and environmental variables, which optimally display how community composition varies with the environment. The latter way leads to statistical tests of the effects of particular environmental variables on community composition, taking into account the effects of other variables.

6.2.2 CANONICAL CORRESPONDENCE ANALYSIS

The canonical ordination technique selected for application with the manually collected vegetation data, was Canonical Correspondence Analysis (CCA).

CCA is designed as a simple method to analyse and visualize the relationships between many species and many environmental variables. Its use greatly improves the ability to detect specific relationships between species and environmental factors. CCA is an eigenvalue ordination technique that also produces a multivariate direct gradient analysis (Ter Braak, 1987). The eigenvalue is a measure of the importance of the ordination axes. CCA aims to visualize both a pattern of community variation, as in standard ordination, and also the main features of species distributions along the environmental variables.

Canonical correspondence analysis is the technique that selects the linear combination of environmental variables that maximises the dispersion of the species scores, ie. CCA chooses the optimal weights for the environmental variables. The data analysis leads to an ordination diagram (biplot) of samples (releves, plots or subplots), species and environmental variables. The biplot optimally shows how community composition varies with the environment.

Ordination diagrams thus summarize the multivariate data in a graphical format. The biplots consist of three components; a set of ordination axes constructed in such a way as to describe the maximum variance in the species optima, vectors (arrows) representing the direction and rate of change of the environmental variables, and points representing the species optima. The biplot displays approximate qualitative covariance between species and environmental variables. The ordination diagram should be interpreted by using the intra-set correlation coefficients, whereby an indication of the correlation between the environmental variables and the ordination axes can be determined.

The ordination diagram of CCA therefore displays sites, species and environmental variables. The species and site points represent the dominant pattern in community composition in that these can be explained by the environmrntal variables. The species points and the arrows of the environmental variables jointly reflect the species distribution along each of the environmental variables.

Canonical correspondence analysis (CCA) is performed by CANOCO, a FORTRAN programme for canonical ordination.

6.2.3 DATA PROCESSING

The raw data collected during the first manual monitoring exercise in 1986, were used as input in the CANOCO programme. The data input of CANOCO consists of species data and environmental data.

Preparation of species data

The raw data collected from within the subplots of the five selected transects, No's 1, 2, 4, 6 and 8 were manipulated and converted to fit within a certain range, in order to comply with the format requirements for CANOCO.

In the five transects ranging from 300m to 1000m in length, there were a total of 842 subplots (samples), of 5m x 5m each. The programme had a sample limitation of 400, so every odd numbered subplot within the transects was used. The transect subplots were then strung together starting at Transect 1 through to Transect 8, and the subplots in excess of 400 were eliminated on a random basis. The remaining subplots were then re-numbered from 1 to 400. The number allocations for the subplots or samples in each transect were :

Transect 1, samples 1 - 29 ; Transect 2, samples 30 - 122 ;
Transect 4, samples 123 -216 ; Transect 6, samples 217 - 307 ;
Transect 8, samples 308 - 400 .

The term "samples" will be used when referring to the subplots as related to the CANOCO programe and "subplots" when referring to them in the vegetational sense. The occurrence and abundance data of all species (not incluing seedlings) within these 400 samples, were then converted to values from 1 - 9, as is required for the programme. The original abundance values were as high as 107, and these then had to be converted to comply with thes 1 to 9 format range. This was done by mutiplying the original abundance value, (ie. the number of plants counted for a particular species) by two and then taking the square root of this value. The newly adjusted species and sample data were then tabulated as required for the computer programme's "species input file". A total of fifty woody species occurred within these subplots, but only forty-eight were used in the analysis. A full list of these species is presented below. Table 6.1 shows the conversion table used to convert the actual abundance values to a value from 1 to 9 as is required for input to the programme. The complete species input file is presented in Annexure 1.

1. *Acacia karroo*
2. *Acacia tortilis*
3. *Acacia mellifera*
4. *Acacia reficiens*
5. *Acacia hereroensis*
6. *Acacia hebeclada*
7. *Acacia erubescens*
8. *Acacia nilotica*
9. *Boscia albitrunca*
10. *Carissa edulis*
11. *Cassine transvaalensis*
12. *Catophractes alexandri*
13. *Cissus juttae*
14. *Combretum hereroense*
15. *Combretum imberbe*
16. *Combretum molle*
17. *Combretum apiculatum*
18. *Commiphora africana*
19. *Commiphora pyracanthoides*
20. *Commiphora glaucescens*
21. *Croton gratissimus*
22. *Dichrostachys cinerea*
23. *Diospyros lycioides*
24. *Dombeya rotundifolia*
25. *Ehretia rigida*
26. *Euclea undulata*
27. *Ficus thoningii*
28. *Grewia flava*
29. *Grewia flavescens*
30. *Grewia bicolor*
31. *Grewia retinervis*
32. *Grewia villosa*
33. *Maytenus heterophylla*
34. *Maytenus senegalensis*
35. *Mundulea sericea*
36. *Olea europaea*
37. *Ozoroa insignis*
38. *Ozoroa paniculosa*
39. *Pavetta zeyheri*
40. *Peltophorum africanum*
41. *Rhus lancea*
42. *Rhus marlothii*
43. *Rhus pyroides*
44. *Securinega virosa*
45. *Sclerocarya birrea*
46. *Tarchonanthus camphoratus*
47. *Terminalia prunioides*
48. *Ximenia caffra*
49. *Ximenia americana*
50. *Ziziphus mucronata*

TABLE 6.1 : CONVERSION TABLE FOR TRANSFORMING SPECIES ABUNDANCE VALUES (REFERRED TO AS ACTUAL VALUES), TO VALUES ON A SCALE OF 1 TO 9, AS REQUIRED FOR THE CANOCO INPUT FILE

ACTUAL VALUES	CONVERTED VALUES	ACTUAL VALUES	CONVERTED VALUES
1	1.0	20	6.0
2	2.0	21	6.0
3	2.0	22	7.0
4	3.0	23	7.0
5	3.0	24	7.0
6	3.0	25	7.0
7	4.0	26	7.0
8	4.0	27	7.0
9	4.0	28	7.0
10	4.0	29	8.0
11	5.0	30	8.0
12	5.0	31	8.0
13	5.0	32	8.0
14	5.0	33	8.0
15	5.0	34	8.0
16	6.0	35	8.0
17	6.0	36	8.0
18	6.0	37	9.0
19	6.0	>37	9.0

Preparation of environmental data

The choice of environmental variables was more problematic, because the environmental variables selected for the investigation at the outset, are very broadly defined in comparison with the size of the subplots (5m x 5m). For example, rainfall is measured at points kilometres apart but then applied to a 5m x 5m area. The size of the whole study area made it difficult to use rainfall as a subplot specific variable, since rainfall will be more varied from subplot to subplot than is the actual recorded observation at the nearest rainfall station.

The same problem applies, but to an even greater extent, to the environmental variable of soil moisture, as this environmental factor is not measured in every subplot. The areas chosen for these moisture measurements were those where the groundwater table was closest to the soil surface, ie. 0 - 5m, as recorded in 1984. Two of the five selected transects occur within this defined area, Transect 1 and Transect 2. However, soil moisture measurements are taken at only three sites along or near each of these two transects. The soil moisture content would however be subject to local variations specific to that particular soil type. As the soil moisture values could not be projected onto the other three transects, let alone the other subplots in the same transects, this environmental variable was not suitable for inclusion in the CANOCO programme.

Environmental factors such as climate, soil types, soil cover and topography should play more of a role with regard to species diversity and abundance.

The following environmental variables were selected as input data :

- Total rainfall for the current growing season of the first manual survey in 1986 (October - April 1985/86). This season's rainfall would account for the most recent growth of the plants.

- Total rainfall for three growing seasons, the current one and the two antecedent seasons (October - April, 1983/84 to 1985/86). These three seasons' rainfall would account for the longer-term growth, and for the plants under one metre.

- Depth of the A-horizon soil

- Soil types

- Topographical classification of the vegetation units (nomenclature as used in classifying the vegetation for mapping purposes).

The first three environmenatl variables are quantätative (ie. having scalar quantity), and the latter two are nominal, with six and three classes respectively. The complete environmental input file is presented in Annexure 2. A list of the numbered environmental variables and their nominal or ordinal details are tabulated in Table 6.2.

TABLE 6.2 : ENVIRONMENTAL VARIABLES USED IN CANOCO

ENVIRONMENTAL VARIABLES	TRANSECT 1 (samples 1-29)	TRANSECT 2 (samples 30-122)	TRANSECT 4 (samples 123-216)	TRANSECT 6 (samples 217-307)	TRANSECT 8 (samples 308-400)
1. Rainfall (mm) Oct 85 - Apr 86 (R1)	542.5	601.5	601.5	554.5	513.5
2. Rainfall (mm) Oct 83 - Apr 86 (R3)	1566.8	1542.4	1542.4	1588.6	1533.7
3. Soil (cm) A-horizon depth (A1)	10 20	15 20 25 30	15 20 25	20 25	25 30
Soil Types (six classes)	4. Mispah	4. Mispah 5. Hutton 6. Glenrosa	4. Mispah 5. Hutton 7. Rensburg	4. Mispah 8. Milkwood	4. Mispah 7. Rensburg 9. Katspruit
Topography Types (three classes)	10. contact 12. slope	10. contact 11. plain	10. contact 11. plain	10. contact 11. plain	10. contact 11. plain 12. slope

6.2.4 DISCUSSION OF RESULTS

Canonical correspondence analysis was run using the CANOCO programme and the solution converged after the omission of two environmental variables, numbers 9 and 12, Katspruit and slope type topography respectively, which showed collinearity. The Katspruit soil was rare but occurred under the same conditions as another soil. The same applies to the slope factor. The full output is provided in Annexure 3. Some of the more important tables are repeated here in the text for convenience.

i) Eigenvalues

The eigenvalues for the four axes are given in Table 6.3.

TABLE 6.3 : EIGENVALUES AS CALCULATED BY CANOCO

```
ITERATION REPORT AXIS   1
RESIDUAL    .028066      AT ITERATION  0
RESIDUAL    .008048      AT ITERATION  1
RESIDUAL    .000950      AT ITERATION  2
RESIDUAL    .000168      AT ITERATION  3
RESIDUAL    .000031      AT ITERATION  4
EIGENVALUE    .17673

ITERATION REPORT AXIS   2
RESIDUAL    .010049      AT ITERATION  0
RESIDUAL    .000216      AT ITERATION  1
RESIDUAL    .000009      AT ITERATION  2
EIGENVALUE    .15712

ITERATION REPORT AXIS   3
RESIDUAL    .005208      AT ITERATION  0
RESIDUAL    .000016      AT ITERATION  1
EIGENVALUE    .11549

ITERATION REPORT AXIS   4
RESIDUAL    .002081      AT ITERATION  0
RESIDUAL    .000007      AT ITERATION  1
EIGENVALUE    .09163
```

Ordination axis 1 is the most important axis, and has an eigenvalue of 0.18, which is relatively low. The eigenvalue is always between 0 and 1, and the higher the value, the more important or significant the ordination axis. Eigenvalues of 0.30 and greater are quite common in ecological applications. However, in considering the significance of the eigenvalue obtained, it is necessary to look at the definition of eigenvalue, and the number of samples used in the analysis.

The eigenvalue is a measure of separation of the species' distribution along the specific ordination axis. The less separated the various species are along the axis, the lower the eigenvalue for that axis and the less significant the classification. From a statistical point of view, it is self-evident that with a small number of samples (subplots), it is possible to get good separation and hence a high eigenvalue quite by chance. Statistically therefore, it is important that the degree of separation is examined for significance in terms of the number of samples. What may appear to be good separation of species, and hence apparently well-defined relationships between the different species and the environmental factors, has to be critically assessed before being accepted.

In the situation where a large number of samples has been used, the separation of species along the relevant axis may not be readily apparent. This outcome would be due to the large number of samples and the amount of "noise" or clutter created by the inevitable anomalies and the fact that certain species are less sensitive to the environmental factors represented by the axes, than others. These species will probably not show good separation and may cloud the dispersion of other more well-separated species.

In this application, a large number of sample were used, 400 subplots, this being the maximum that the CANOCO programme will accept. In other ecological studies covered in the literature, sample numbers are generally between 15 and 80. In these cases, high eigenvalues were required for significant conclusions to be drawn. In this situation, the 400 samples were analysed in conjunction with 48 species.

ii) Significance of Eigenvalues

In order to examine the significance of the eigenvalues obtained, a Monte Carlo permutation test was performed. This standard statistical test randomises the samples in that the species data of a particular sample will be randomly linked to the environmental data of another sample. The species and environmental data for all 400 subplots are randomly permutated and the CCA analysis performed for each permutated data set. The eigenvalues are re-calculated for each analysis.

Essentially, the Monte Carlo permutation tests the hypothesis that the relationships between the environmental variables and the species are more significant than those that would be obtained from the analysis of random data.

In order to look at the significance as exhaustively as possible, 99 permutations were analysed and the eigenvalue for axis one calculated in each case. These are listed at the end of Annexure 3. None of the eigenvalues obtained was larger than the observed eigenvalue of 0.18. The largest was 0.050 (obtained twice), showing that the separation of species along axis 1 is significantly greater than that given by any one of the random analyses. The Monte Carlo significance value can be calculated as

$$\frac{0 + 1}{99 + 1} = 0.01$$

This implies that the result of the Karstland CCA is significantly different and better than that obtained from an analysis of random data at the 99 % level.

iii) Correlation Matrix

Table 6.4 provides the full correlation matrix. The intra-set correlation coefficients between the environmental variables and the ordination axes are linear combinations of the environmental variables. The relative importance of each environmental variable for predicting the community composition can be established by looking at the signs and relative magnitude of the intra-set correlations.

Axes 1 and 2, are the most relevant. The highest correlations are between R1 and axis 1 (-0.8987), and between R3 and axis 2 (0.7193). The thickness of the A horizon, A1, also shows significant negative correlation with axis 2. Thus axis 2 is associated with increasing three year rainfall and decreasing soil thickness. The relatively high negative correlation between R1 and axis 1 indicates that the most recent year's rainfall decreases with positive movement along axis 1.

As far as the soils are concerned, the Mispah also shows relatively high correlation (0.7221) with axis 1, while the Rensburg soil shows similar negative correlation (-0.606) with axis 1.

A more detailed discussion follows under the section on the ordination diagram.

TABLE 6.4 : INTRA-SET CORRELATIONS AS CALCULATED BY CANOCO

**** WEIGHTED CORRELATION MATRIX (WEIGHT = SAMPLE TOTAL) ****

	SPEC AX1	SPEC AX2	SPEC AX3	SPEC AX4	ENVI AX1	ENVI AX2	ENVI AX3	ENVI AX4
SPEC AX1	1.0000							
SPEC AX2	-.0564	1.0000						
SPEC AX3	.0476	-.0439	1.0000					
SPEC AX4	-.0019	-.1099	-.0011	1.0000				
ENVI AX1	.7777	.0000	-.0001	.0000	1.0000			
ENVI AX2	.0000	.7464	.0000	.0000	.0000	1.0000		
ENVI AX3	.0000	.0000	.6956	.0000	.0000	.0000	1.0000	
ENVI AX4	.0000	.0000	.0000	.6607	.0000	.0000	.0000	1.0000
RAI1SEA	-.6989	.0798	-.1812	-.0942	-.8987	.1070	-.2606	-.1425
RAI3SEA	.2364	.5369	.1602	-.3291	.3039	.7193	.2303	-.4981
A1	-.0706	-.3745	.4181	-.0355	-.0908	-.5017	.6011	-.0537
MISP	.5616	.1396	-.0495	-.1694	.7221	.1870	-.0711	-.2564
HUTT	-.2721	-.1844	-.3058	-.0362	-.3498	-.2470	-.4397	-.0548
GLEN	-.0862	-.0858	-.2441	.0020	-.1109	-.1150	-.3509	.0030
RENS	-.4715	.0450	.3641	.2652	-.6063	.0603	.5234	.4013
MILK	.0928	.0470	.0422	-.2479	.1194	.0629	.0607	-.3752
CONTA	.0981	-.0024	.1188	.0764	.1262	-.0033	.1709	.1156
PLAIN	-.3619	-.1158	.0613	-.2470	-.4653	-.1551	.0881	-.3738

	RAI1SEA	RAI3SEA	A1	MISP	HUTT	GLEN	RENS	MILK
RAI1SEA	1.0000							
RAI3SEA	-.2114	1.0000						
A1	-.0674	-.3348	1.0000					
MISP	-.6221	.4129	-.0481	1.0000				
HUTT	.3731	-.2245	-.5509	-.4603	1.0000			
GLEN	.1498	-.0901	-.0483	-.1848	-.0718	1.0000		
RENS	.4126	-.3196	.4571	-.6237	-.2423	-.0973	1.0000	
MILK	-.0722	.2551	.1080	-.1602	-.0623	-.0250	-.0844	1.0000
CONTA	-.3538	.0988	.1489	.4076	-.1778	-.0974	-.2447	-.0844
PLAIN	.5872	-.0833	.0932	-.5728	.2548	.1257	.3486	.1090

	CONTA	PLAIN
CONTA	1.0000	
PLAIN	-.7744	1.0000

iv) Variance Inflation Factors

The variances of estimated regression coefficients are proportional to their Variance Inflation Factors (VIF). If the Variance Inflation Factor is large (eg. >20), the variable is almost perfectly correlated with other variables and therefore has no contribution to the regression equation. As a result, its canonical coefficient is unstable and does not merit interpretation. The environmental variables with high Variance Inflation Factors are the Hutton (20.4954), Mispah (29.554) and Rensburg (22.9365) soils.

v) Percentage of Variance Accounted For

The percentage of variance accounted for refers to the amount of variance in the weighted average of the species accounted for with respect to each of the ordination axes. The programme calculates this percentage for each axis on a cumulative basis. The results are provided in Table 6.5.

TABLE 6.5 : PERCENTAGE OF VARIANCE ACCOUNTED FOR AS CALCULATED BY CANOCO

PERCENTAGE VARIANCE ACCOUNTED FOR BY FIRST S AXES OF SPECIES-ENVIRONMENT BIPLOT

S	PERC
1	23.6
2	44.5
3	59.9
4	72.1

As can be expected from the eigenvalues, axis 1 accounts for more of the variance than any of the other axes, although only 23.6% and axis 2 accounts for 20.9% (44.5-23.6). The total for the two axes is relatively low. However, as with the interpretation of the eigenvalues it is important to consider other factors such as the number of samples.

It is not the aim that the 4 axes should explain all 100% of the variance, because much of the total variance is due to noise in the data. Noise is inevitable since the environmental variables chosen in any study do not represent the total environmental influence. In this application, the environmental variables are very broad and include many assumptions. There are also many environmental variables which were not measured and therefore not included, but which may have been important. Their non-inclusion may be one of the causes of the noise. This is acceptable only because the high number of subplots make it statistically permissable, but it will lead to a considerable amount of noise, resulting from the cases where species have apparently not conformed to the environmental factors measured for the particular subplot.

The values in Table 6.5 indicate that trends and clusters will not be highly evident in the ordination diagram.

vi) Species Scores

The species scores are calculated by the programme and are the values used for plotting on the ordination diagram. They are presented in Table 6.6. The species are plotted on the ordination diagram in accordance with their axis 1 (AX 1) and axis 2 (AX 2) values. These scores are discussed in detail under the section on the ordination diagram. The species in Table 6.6 are arranged in alphabetical order down the left hand side. A high absolute value under the axis 1 column means that the species is strongly associated with either high or low values of axis 1. The species are also ranked relative to each of the 4 axes. Under the column of "ranked 1", it is evident that *Acacia hebeclada* has the strongest positive association (478) with axis 1, and *Carissa edulis* has the strongest negative association (-231). Under the next column of "ranked 2", *Pavetta zeyheri* and *Terminalia prunioides* have the strongest postive association (614) with axis 2, and *Acacia nilotica* has the strongest negative association (-407).

Since axis 2 has a strong association with R3, this implies that *Pavetta zeyheri* also has a strong association with higher R3 values. The same implication can be made of the strong association of R1 with axis 1 and *Acacia hebeclada* with axis 1. However, it is important to be cautious when drawing conclusions of this type due to the fact that a small number of observations in one particular area will lead to a strong correlation with the environmental variable for that area. It is therefore important to pay less attention to the less common species with narrow distributions, and rather concentrate on the more abundant species, even though their ranking may not be quite as high. More detailed analyses are discussed under the section on the ordination diagram.

TABLE 6.6 : SPECIES SCORES AS CALCULATED BY CANOCO

. SPECIES SCORES

N	NAME	AX1	AX2	AX3	AX4	RANKED 1			RANKED 2			RANKED 3			RANKED 4		
								EIG= .177			EIG= .157			EIG= .115			EIG= .092
1	ACA KAR	-62	80	165	136	6	ACA HEB	478	39	PAV ZEY	614	44	SEC VIR	256	6	ACA HEB	689
2	ACA TOR	-121	-46	-248	-47	12	CAT ALE	458	47	TER PRU	614	13	CIS JUT	244	39	PAV ZEY	583
3	ACA MEL	133	2	89	53	8	ACA NIL	396	35	MUN SER	550	27	FIC THO	214	47	TER PRU	583
4	ACA REF	96	-143	0	-63	15	COM IMB	394	36	OLE EUR	314	41	RHU LAN	195	35	MUN SER	492
5	ACA HER	43	-79	115	-75	39	PAV ZEY	380	6	ACA HEB	312	19	COM PYR	182	8	ACA NIL	412
6	ACA HEB	478	312	-234	689	47	TER PRU	380	13	CIS JUT	197	8	ACA NIL	181	34	MAY SEN	250
7	ACA ERU	-208	-170	-325	-69	35	MUN SER	339	27	FIC THO	190	1	ACA KAR	165	44	SEC VIR	237
8	ACA NIL	396	-407	181	412	37	OZO INS	320	41	RHU LAN	172	15	COM IMB	145	12	CAT ALE	197
9	BOS ALB	-101	-232	-56	-96	17	COM API	241	19	COM PYR	140	45	SCL BIR	129	10	CAR EDU	193
10	CAR EDU	-231	117	-44	193	45	SCL BIR	213	18	COM AFR	130	18	COM AFR	128	48	XIM CAF	183
11	CAS TRA	-177	5	-31	19	13	CIS JUT	192	10	CAR EDU	117	40	PEL AFR	117	37	OZO INS	170
12	CAT ALE	458	-370	-135	197	27	FIC THO	179	45	SCL BIR	117	17	COM API	116	32	GRE VIL	169

TABLE 6.6 : SPECIES SCORES AS CALCULATED BY CANOCO (CONTINUED)

13 CIS JUT	192	197	244	-495 !	24 DOM ROT	174 !	23 DIO LYS	96 !	5 ACA HER	115 !	15 COM IMB	157 !
14 COM HER	23	-52	6	-43 !	19 COM PYR	166 !	26 EUC UND	84 !	28 GRE GLA	107 !	1 ACA KAR	136 !
15 COM IMB	394	-390	145	157 !	44 SEC VIR	161 !	1 ACA KAR	80 !	3 ACA MEL	89 !	24 DOM ROT	114 !
16 COM MOL	150	26	42	-399 !	36 OLE EUR	152 !	24 DOM ROT	63 !	32 GRE VIL	63 !	43 RHU PYR	73 !
17 COM API	241	-65	116	-106 !	16 COM MOL	150 !	40 PEL AFR	60 !	50 ZIZ MUC	61 !	22 DIC CIN	68 !
18 COM AFR	130	130	128	-411 !	3 ACA MEL	133 !	48 XIM CAF	57 !	31 GRE RET	59 !	31 GRE RET	58 !
19 COM PYR	166	140	182	-395 !	18 COM AFR	130 !	28 GRE GLA	55 !	46 TAR CAM	54 !	36 OLE EUR	55 !
21 CRO GRA	76	-32	-155	-117 !	23 DIO LYS	129 !	29 GRE FLS	42 !	23 DIO LYS	51 !	3 ACA MEL	53 !
22 DIC CIN	-67	-74	-37	68 !	30 GRE BIC	110 !	33 MAY HET	37 !	33 MAY HET	45 !	46 TAR CAM	53 !
23 DIO LYS	129	96	51	-146 !	50 ZIZ MUC	107 !	16 COM MOL	26 !	16 COM MOL	42 !	11 CAS TRA	19 !
24 DOM ROT	174	63	-210	114 !	31 GRE RET	97 !	46 TAR CAM	10 !	14 COM HER	6 !	50 ZIZ MUC	12 !
25 EHR RIG	-79	-134	-124	-120 !	4 ACA REF	96 !	11 CAS TRA	5 !	42 RHU MAR	2 !	26 EUC UND	5 !
26 EUC UND	-6	84	-27	5 !	41 RHU LAN	88 !	3 ACA MEL	2 !	4 ACA REF	0 !	49 XIM AME	-5 !
27 FIC THO	179	190	214	-376 !	21 CRO GRA	76 !	21 CRO GRA	-32 !	26 EUC UND	-27 !	42 RHU MAR	-15 !
28 GRE GLA	-101	55	107	-30 !	34 MAY SEN	60 !	42 RHU MAR	-42 !	11 CAS TRA	-31 !	28 GRE GLA	-30 !
29 GRE FLS	19	42	-71	-98 !	5 ACA HER	43 !	2 ACA TOR	-46 !	34 MAY SEN	-35 !	33 MAY HET	-32 !
30 GRE BIC	110	-254	-120	-68 !	14 COM HER	23 !	14 COM HER	-52 !	22 DIC CIN	-37 !	40 PEL AFR	-32 !
31 GRE RET	97	-88	59	58 !	42 RHU MAR	21 !	17 COM API	-65 !	10 CAR EDU	-44 !	14 COM HER	-43 !
32 GRE VIL	-149	-239	63	169 !	48 XIM CAF	20 !	22 DIC CIN	-74 !	9 BOS ALB	-56 !	2 ACA TOR	-47 !
33 MAY HET	-128	37	45	-32 !	29 GRE FLS	19 !	43 RHU PYR	-74 !	36 OLE EUR	-68 !	41 RHU LAN	-49 !
34 MAY SEN	60	-254	-35	250 !	26 EUC UND	-6 !	49 XIM AME	-76 !	29 GRE FLS	-71 !	4 ACA REF	-63 !
35 MUN SER	339	550	-444	492 !	1 ACA KAR	-62 !	5 ACA HER	-79 !	48 XIM CAF	-111 !	30 GRE BIC	-68 !
36 OLE EUR	152	314	-68	55 !	22 DIC CIN	-67 !	31 GRE RET	-88 !	30 GRE BIC	-120 !	7 ACA ERU	-69 !
37 OZO INS	320	-338	-179	170 !	40 PEL AFR	-71 !	50 ZIZ MUC	-130 !	25 EHR RIG	-124 !	5 ACA HER	-75 !
39 PAV ZEY	380	614	-491	583 !	25 EHR RIG	-79 !	25 EHR RIG	-134 !	12 CAT ALE	-135 !	9 BOS ALB	-96 !
40 PEL AFR	-71	60	117	-32 !	9 BOS ALB	-101 !	4 ACA REF	-143 !	21 CRO GRA	-155 !	29 GRE FLS	-98 !
41 RHU LAN	88	172	195	-49 !	28 GRE GLA	-101 !	7 ACA ERU	-170 !	43 RHU PYR	-166 !	17 COM API	-106 !
42 RHU MAR	21	-42	2	-15 !	43 RHU PYR	-109 !	9 BOS ALB	-232 !	37 OZO INS	-179 !	21 CRO GRA	-117 !
43 RHU PYR	-109	-74	-166	73 !	2 ACA TOR	-121 !	32 GRE VIL	-239 !	49 XIM AME	-179 !	25 EHR RIG	-120 !
44 SEC VIR	161	-285	256	237 !	33 MAY HET	-128 !	30 GRE BIC	-254 !	24 DOM ROT	-210 !	23 DIO LYS	-146 !
45 SCL BIR	213	117	129	-883 !	32 GRE VIL	-149 !	34 MAY SEN	-254 !	6 ACA HEB	-234 !	27 FIC THO	-376 !
46 TAR CAM	-151	10	54	53 !	46 TAR CAM	-151 !	44 SEC VIR	-285 !	2 ACA TOR	-248 !	19 COM PYR	-395 !
47 TER PRU	380	614	-491	583 !	11 CAS TRA	-177 !	37 OZO INS	-338 !	7 ACA ERU	-325 !	16 COM MOL	-399 !
48 XIM CAF	20	57	-111	183 !	7 ACA ERU	-208 !	12 CAT ALE	-370 !	35 MUN SER	-444 !	18 COM AFR	-411 !
49 XIM AME	-218	-76	-179	-5 !	49 XIM AME	-218 !	15 COM IMB	-390 !	39 PAV ZEY	-491 !	13 CIS JUT	-495 !
50 ZIZ MUC	107	-130	61	12 !	10 CAR EDU	-231 !	8 ACA NIL	-407 !	47 TER PRU	-491 !	45 SCL BIR	-883 !

```
1
SPECIES - KARSTLAND DATA - APRIL/MAY 1986
CANOCO -- ANALYSIS  5 CANONICAL AXES 4 COVARIABLES  0 SCALING  1 CENT./STAND. BY SAMPLES: 0/0 BY SPECIES: 0/0 MULTIPLIER   100.
        DETRENDING 0 DOWNWEIGHTING 0 RESCALING 0 SEGMENTS  0 THRESHOLD  .00 RANKING BY SAMPLES/SPECIES: 0/0
TRANSFORMATION        -1.00     .00
```

vii) Sample Scores

The 400 samples are also scored on each of the ordination axes. These are included in Annexure 3. Only the top and bottom parts of the table are included here in Table 6.7 for discussion, as these include the most positively and most negatively associated samples. The relevance of the sample scores is considered in conjunction with ordination axes 1 and 2, and is used to assess the effectiveness of the CCA method.

TABLE 6.7 : SAMPLE SCORES AS CALCULATED BY CANOCO

SAMPLE SCORES

N	NAME	AX1	AX2	AX3	AX4	RANKED 1		EIG= .177	RANKED 2		EIG= .157	RANKED 3		EIG= .115	RANKED 4		EIG= .092
1	1	-33	5	-44	14	358	358	394	25	25	156	334	334	173	356	356	238
2	2	8	12	-49	-87	341	341	279	14	14	149	311	311	168	358	358	157
3	3	21	43	-73	-40	354	354	264	11	11	147	218	218	145	19	19	151
4	4	23	122	1	12	357	357	249	24	24	147	358	358	145	341	341	134
5	5	66	135	47	31	348	348	238	13	13	144	224	224	130	319	319	130
6	6	-22	66	18	15	334	334	223	16	16	142	304	304	128	313	313	119
7	7	6	80	12	24	349	349	213	19	19	141	299	299	127	17	17	108
8	8	-60	-20	-11	17	338	338	208	5	5	135	257	257	124	354	354	105
9	9	14	74	-31	23	356	356	174	304	304	130	357	357	121	16	16	103
10	10	3	35	-45	9	17	17	169	15	15	128	348	348	120	236	236	102
11	11	81	147	-26	3	368	368	157	28	28	127	354	354	117	318	318	98
12	12	-41	38	24	47	367	367	149	17	17	126	307	307	116	325	325	90
13	13	41	144	-29	12	273	273	133	18	18	126	319	319	116	320	320	89
14	14	107	149	-66	36	300	300	133	4	4	122	313	313	115	15	15	84
15	15	80	128	-11	84	303	303	133	235	235	120	296	296	107	357	357	84
16	16	105	142	-82	103	366	366	133	271	271	118	361	361	102	18	18	83
17	17	169	126	-177	108	267	267	132	250	250	111	349	349	101	24	24	82
18	18	99	126	-166	83	374	374	132	299	299	99	341	341	99	224	224	81
19	19	104	141	-149	151	304	304	130	247	247	93	232	232	98	331	331	80
20	20	42	65	-127	55	363	363	128	242	242	92	244	244	90	248	248	78
380	380	70	-27	-35	-36	110	110	-82	367	367	-117	117	117	-90	2	2	-87
381	381	46	-81	-65	0	60	60	-84	331	331	-125	32	32	-92	384	384	-90
382	382	31	-24	11	-1	86	86	-84	324	324	-126	113	113	-94	307	307	-91
383	383	-3	-51	0	-3	142	142	-85	345	345	-129	114	114	-94	227	227	-97
384	384	72	-54	-28	-90	321	321	-85	400	400	-129	116	116	-95	289	289	-104
385	385	5	-86	-21	10	51	51	-92	352	352	-130	47	47	-97	250	250	-107
386	386	16	-34	-4	-1	75	75	-92	325	325	-131	86	86	-100	278	278	-110
387	387	43	-83	14	28	211	211	-94	326	326	-137	100	100	-100	292	292	-110
388	388	40	-60	19	32	165	165	-95	347	347	-144	121	121	-100	253	253	-113
389	389	29	-37	-7	0	314	314	-98	339	339	-146	165	165	-106	279	279	-113
390	390	37	-50	-3	-18	66	66	-101	335	335	-147	104	104	-107	295	295	-114
391	391	46	-58	-25	-25	296	296	-101	368	368	-153	321	321	-107	286	286	-120
392	392	37	-72	-8	34	76	76	-102	329	329	-162	377	377	-107	293	293	-131
393	393	43	-59	-20	-1	83	83	-102	350	350	-168	103	103	-112	31	31	-133
394	394	18	-46	11	-10	82	82	-105	354	354	-194	84	84	-119	285	285	-152
395	395	67	-38	37	6	122	122	-105	357	357	-207	20	20	-127	276	276	-162
396	396	57	-61	41	11	207	207	-110	338	338	-216	67	67	-134	269	269	-183
397	397	28	-47	22	61	159	159	-111	349	349	-225	19	19	-149	288	288	-206
398	398	7	-72	4	46	73	73	-117	348	348	-231	110	110	-151	299	299	-250
399	399	54	-47	33	30	163	163	-120	341	341	-311	18	18	-166	334	334	-257
400	400	100	-129	14	27	67	67	-140	358	358	-390	17	17	-177	304	304	-411

It would be expected that a sample which is highly ranked, ie. positively associated, with respect to axis 1 should include species which are also highly ranked on this axis, and very few which are poorly ranked. The species data input file provided in Annexure 1 should be referred to to establish which species are present in these samples.

On examining sample No. 358, this does appear to be the case.

Sample 358, positively associated with axis 1.

Species No.	Name	Abundance	Ranking of Species on AX1
15	*Combretum imberbe*	4	3

Only species No. 15 (*Combretum imberbe*) occurs on subplot 358. For the same reasons stated under the species scores section, the samples with a few less common species will often tend to occur at the top or bottom of the rankings.

Samples No. 348 and No. 356 are the two highest ranked samples that have more than three species present. If these two highly ranked samples are examined, the following is apparent.

Sample No. 348, positively associated with axis 1

Species No.	Name	Abundance	Ranking of Species on AX1
3	*Acacia mellifera*	1	18
5	*Acacia hereroensis*	2	28
15	*Combretum imberbe*	4	4
50	*Ziziphus mucronata*	1	22

Sample No. 356, positively associated with axis 1

Species No.	Name	Abundance	Ranking of Species on AX1
1	*Acacia karroo*	1	34
6	*Acacia hebeclada*	1	1
24	*Dombeya rotundifolia*	1	13
50	*Ziziphus mucronata*	1	22

In the case of sample No. 348, three of the four species occur in the top half (first 24) of the species as ranked with axis 1. Even species No. 5 (*Acacia hereroensis*), ranked 28th has a positive score on axis 1. However, the associations are not as clear as might have been expected, confirming the fact that there is a good deal of noise, with a large number of species distributed throughout much of the area. These are the species which are found near the origin of the ordination diagram, and have low absolute scores on both axes 1 and 2.

In sample No. 348, it is the relatively high abundance of species No. 15 (*Combretum imberbe*), which is ranked 4th, that explains the high ranking of the sample.

Similarly, sample No. 356 includes only one species, No. 1 (*Acacia karroo*), which has a low ranking. *Acacia karroo* has low absolute scores on both axis 1 (-62), and axis 2 (11), placing it near the origin of the ordination diagram.

The fourth ranked species, No. 15 (*Combretum imberbe*), which occurred in both samples No. 348 and No. 358 with relatively high abundance, is strongly associated with Axis 1. The lowest ranked samples on axis 1, ie. those with the strongest negative association, are No's 67, 163, 73, 159, 207, 122, 82, 83, 76 and 296. As can be expected, *Combretum imberbe* is not present in any of these samples. The same is true for the No.1 ranked species in sample No. 356, *Acacia hebeclada*, which is also not found to occur in these ten samples.

If axis 2 is examined in the same way, sample No. 25 has the highest positive ranking, ie. positive association.

Sample No. 25, positively associated with axis 2.

Species No.	Name	Abundance	Ranking of Species on AX2
2	*Acacia tortilis*	1	28
3	*Acacia mellifera*	1	25
21	*Croton gratissimus*	1	26
22	*Dichrostachys cinerea*	2	31
23	*Diospyros lycioides*	2	13
24	*Dombeya rotundifolia*	1	16
26	*Euclea undulata*	3	14
36	*Olea europaea*	9	4

Half the species present in this sample fall into the lower half of the axis 2 rankings, although all of these occur within the central noise area. They all have low absolute scores on both axes 2 and 1. The ranking of sample No. 25 in first position, resulted largely from the very high abundance of *Olea europaea* which is ranked 4th on axis 2.

It is therefore evident that the presence of only one highly ranked species or even high abundance of one species with a relatively high ranking, is sufficient to allocate a high ranking to a sample. This implies that the majority of species do not have very strong links or associations with the ordination axes, and hence with any specific combination of environmental variables. It is apparent from the ordination diagram that there is a large "noise" zone which includes the majority of the species.

vii) Ordination Diagram

The Ordination Diagram (biplot) is shown in Figure 6.1. The ordination diagram essentially displays the solution of the CCA. Samples and species may be represented by points, and the environmental variables represented by either arrows or points depending on whether they are quantitative or nominal. The species and sample points jointly represent the dominant patterns in community patterns insofar as these can be explained by the environmental variables. The positions of the species relative to the arrows as well as to the axes provide an indication of their relation to the particular environmental variable or ordination axis respectively.

The plotting positions of the 48 species used in the analysis were derived from Table 6.6. It should be noted that in Table 6.6 the true values have been multiplied by a factor of 100. The plotted positions on the biplot correspond to the values before multiplication by the factor.

It was found impractical to plot the 400 sub-plots on the ordination daigram since this would have made analysis of the vegetation-environment relationship very difficult.

The quantitative environmental variables, that is those which have magnitude as well as position relative to the axes, are plotted as arrows. They have been plotted on a different scale from that of the species and samples, but they are on the same scale relative to each other. The distance from the origin to the tip of each arrow represents its magnitude, although the arrows have been extended as lines beyond the tips, for ease of interpretation.

The nominal environmental variables, which include the soil types and the topographical types are plotted as centroids. Their plotting positions, which are provided in Annexure 3 are calculated as the centroid of the sample scores belonging to the class. These centroids are plotted to the same scale as the species and samples.

On analysing and interpreting the ordination diagram, it is necessary to examine the relationships between the species and the ordination axes, as well as the intra-set correlations between the axes and the environmental variables, both quantitative and nominal.

Only axes 1 and 2 are considered. The biplot shows that the six species most closely associated with axis 1 are as follows:

Rank	Species No.	Name
1	6	*Acacia hebeclada*
2	12	*Catophractes alexandri*
3	8	*Acacia nilotica*
4	15	*Combretum imberbe*
5	39	*Pavetta zeyheri*
6	47	*Terminalia prunioides*

The six species most closely associated with the negative end of axis 1 are:

Rank	Species No.	Name
48	10	*Carissa edulis*
47	49	*Cassine transvaalensis*
46	7	*Acacia erubescens*
45	46	*Tarchonanthus camphoratus*
44	32	*Grewia villosa*
43	33	*Maytenus heterophylla*

In order to evaluate the significance of this it is necessary to re-examine the intra-set correlations (Table 6.4). With regard to the quantitative environmental variables, it is evident that only R1 has significant correlation (-0,8987) with the axis. This means that high R1 is closely associated with the negative end of the axis, and low R1 values associated with the positive end. Other environmental variables which show significant correlation with the axis are Rensburg and Hutton soils, plain topographical type (all negative) and Mispah soil (positive). The relatively central positions of the centroids representing the nominal environmental variables indicates, that their influences are mixed. It should also be noted that the high Variance Inflation Factors of the Mispah, Hutton and Rensburg soils make them unsuitable for analysis.

The main implication therefore, for the negative end of axis 1, is that the presence or abundance of the species with strong negative association with axis 1, may be mainly related to the R1 environmental variable. The significance of environmental variable R1 is, however, questionnable, as it is considered to be unlikely to influence species composition in only one season (although it may have an effect on abundances). The longer term rainfall measurement of R3 will probably have a greater influence.

With the exception of *Maytenus heterophylla*, the other five species are relatively uncommon, which may explain their positions at the extreme end of the axis. For example, the most extreme of these, relative both to the negative end of axis 1 and to the R1 variable if

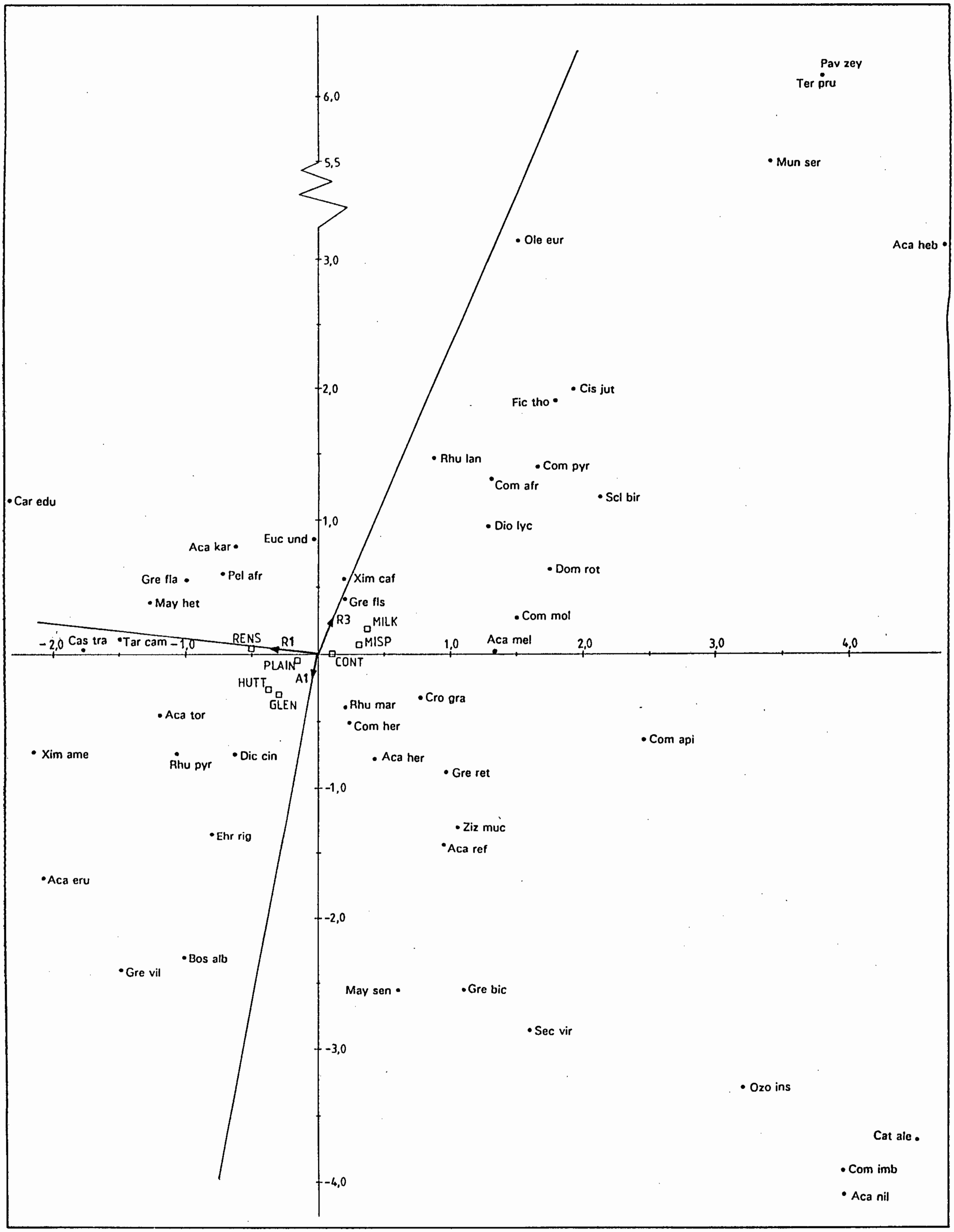


FIGURE 6.1 : CCA ORDINATION DIAGRAM

With Plant Species (●) and Environmental Variables (Arrow or □)

considered on its own, *Carissa edulis*, is found on two subplots in the same transect. The R1 figure for these two subplots is 601,5 mm, and is the highest of the R1 figures. The soil type, topographical type, and A1 thickness are different for the two subplots, and hence it is the high R1 figure which is the common factor for *Carissa edulis*. In this way the less common species often occur at the extreme end of the axes.

At the positive end of axis 1, the extreme species also tend to be quite rare, or concentrated on one transect, with the exception of *Combretum imberbe*. This species is however, also highly associated with the negative end of axis 2. Hence, its presence can not be solely explained in terms of environmental variables closely associated with axis 1.

On examination of axis 2, it is evident that there is significant positive correlation with R3 (+0,7193) and negative correlation with A1 (-0,5017).

The six species most positively associated with axis 2 are:

Rank	Species No.	Name
1	39	*Pavetta zeyheri*
2	47	*Terminalia prunioides*
3	35	*Mundulea sericea*
4	6	*Acacia hebeclada*
5	36	*Olea europaea*
6	13	*Cissus juttae*

It can be expected that these species are associated with high R3 and low A1 values. *Terminalia prunioides, Acacia hebeclada and Olea europaea* tend to survive well on shallow soils. Both *Pavetta zeyheri* and *Terminalia prunioides*, which are the highest ranked species, are relatively rare, both only occurrring in Transect 1. It is significant that they only appear in subplots with very shallow (10mm) A1 values, thus explaining their positions on axis 2.

On examination of the negative end of axis 2:

Rank	Species No.	Name
48	8	*Acacia nilotica*
47	15	*Combretum imberbe*
46	12	*Catophractus alexandri*
45	37	*Ozoroa insignis*
44	44	*Securinega virosa*
43	34	*Maytenus senegalensis*

Of these, *Combretum imberbe* is known as a hardy plant with a widespread distribution. It has been observed to survive well in difficult conditions such as in areas subject to occasional flooding, although growth appears to be stunted compared to the well-drained areas. Hence, it is not unexpected that *Combretum imberbe* has a poor association with high R3. Of the other six lowest ranked species, *Catophractus alexandri* and *Maytenus senegalensis* are also hardy species which cope relatively better than most other species under dry conditions.

6.2.5 CONCLUSIONS

Canonical Correspondence Analysis (CCA) as performed by CANOCO has a useful function in the classification of plant species in terms of dependence upon environmental variables. Despite low eigenvalues, it has been shown that CCA is able to carry out the classification of large numbers of species using relatively vague and broadly defined environmental variables, provided that the sample size is large enough. This is significant since it makes it possible to use CCA in applications where a lot of data, but of a general nature only, are available. This is often the case where data were not collected with classification or any particular analysis in mind.

In the case of the Karst area investigation, the large number of relatively neutral species is evident from the fact that many species have low absolute scores on both of the main axes. Species occurring at or near to the extremes of the axes are usually either rare or show a fairly strong affinity for the environmental variables associated with the axis in question.

6.3 STATISTICAL COMPARISON OF 1986 AND 1987 DATA

6.3.1 INTRODUCTION

The 1986 and 1987 sets of manual ground survey data for Transects 1, 2, 4, 6 and 8, were utilized for quantitative comparative purposes. As the contact communities were considered to be more critical than the other community types, the data from only these areas were processed for analysis. It was felt that any detrimental effects might be detectable in these communities before the other community types, and it was thus important to have an understanding of the current vegetation status.

6.3.2 DATA PROCESSING

Each transect strip was dealt with separately. The raw data corresponding to the subplots occurring only in the contact zone community, were extracted from the full data set. These raw data were considered both at species and at subplot level.

The following was calculated for each woody species :

- The mean frequency of trees above one metre in height per subplot
- The number of subplots in which these species occurred
- The mean frequency of seedlings and plants less than one metre in height, and number of subplots in which they occurred

The following was calculated per community of plant species :

- The total number of living individuals of each species
- The mean height
- The mean widest growth point
- The mean height at the widest growth point
- The mean percentage dead material

The following was calculated relative to the whole contact strip :

- The mean frequency of standing dead relative to the actual number of subplots in which they occurred
- The actual number of subplots in which they occurred

- The actual number of standing dead
- The mean frequency of standing dead relative to the whole contact community
- The percentage number of subplots over the whole contact community in which standing dead occurred
- The percentage mean dead per subplot, and the number of subplots in which they occurred
- The percentage frequency cover of dead material per subplot

The full results of these field counts are included in the Departmental Report (Chivell, 1989).

6.2.3 DATA MANIPULATION

After careful consideration of the various parameters measured during the manual ground surveys in 1986 and 1987, only a few of these, which were considered to include sufficient data, were selected for evaluation purposes. The following parameters were chosen and a mean value calculated for each of the five transects surveyed in 1986 and 1987.

- Mean percentage dead material per subplot
- Mean percentage frequency cover of dead material per subplot
- Mean frequency of standing dead per subplot
- Percentage of the total number of subplots with standing dead

These parameters are not direct measurements of vitality of the woody vegetation, but are rather indirect indices, as they can be considered to be the end result of the deterioration in vitality due to natural or unnatural mortality. A paired sample analysis was carried out using the five pairs of data for each of the above parameters, in order to assess the changes which may have occurred in the period between surveys.

The other parameters such as mean tree height, mean frequency of woody species above one metre in height etc, were not considered for analysis at this stage, since the changes in these features are generally thought to be too small to be detected on an annual basis, or over only a two year period. These parameters will have a more interpretable value when the manual monitoring method is repeated after a number of years.

6.3.4 DISCUSSION OF RESULTS

The 1986 and 1987 sample pairs of data for each of the contact communities of the transects are presented in Figures 6.2, 6.3, 6.4 and 6.5. A paired sample analysis was carried out to determine whether there was a significant trend with respect to each of the chosen parameters for all the transects over the period between surveys.

The correlation values obtained from the paired sample analysis, as well as the t-statistic which provides a measure of significance, are presented in Table 6.8. As the number of sample pairs is small in this case, the concept of correlation should be treated with caution.

TABLE 6.8 : PAIRED SAMPLE ANALYSIS FOR THE 1986 AND 1987 MANUAL SURVEYS

PARAMETER	FIGURE NO. REFERENCE	CORRELATION COEFFICIENT (r)	t-STATISTIC
1. Mean % dead material per subplot	6.2	0,735	2,169 (95%)
2. Mean % frequency cover of dead material per subplot	6.3	0,821	2,883 (95%)
3. Mean frequency standing dead per subplot	6.4	0,951	6,165 (99%)
4. % Total number of subplots with standing dead	6.5	0,899	4,109 (95%)

Referring to Table 6.8, it is evident that parameters 3 and 4 (see Figures 6.4 and 6.5) give the best correlation, and yet a visual examination of the graphs tend to indicate that a deteriorating trend is not nearly so obvious as for parameters 1 and 2 (see Figures 6.2 and 6.3). The reason for this is that the counts made in both 1986 and 1987 are relatively similar, even if two of the transects show an improvement (Transects 2 and 4). This similarly can lead to a high correlation coefficient.

With reference to Figures 6.2 and 6.3, the parameters "Mean percentage dead material per subplot" and "Mean frequency cover dead material per subplot" seem to be more sensitive to deterioration in vitality, and are perhaps better indicators of gradual changes.

The statistical analysis points to a deterioration in vitality of vegetation in the period from 1986 to 1987.

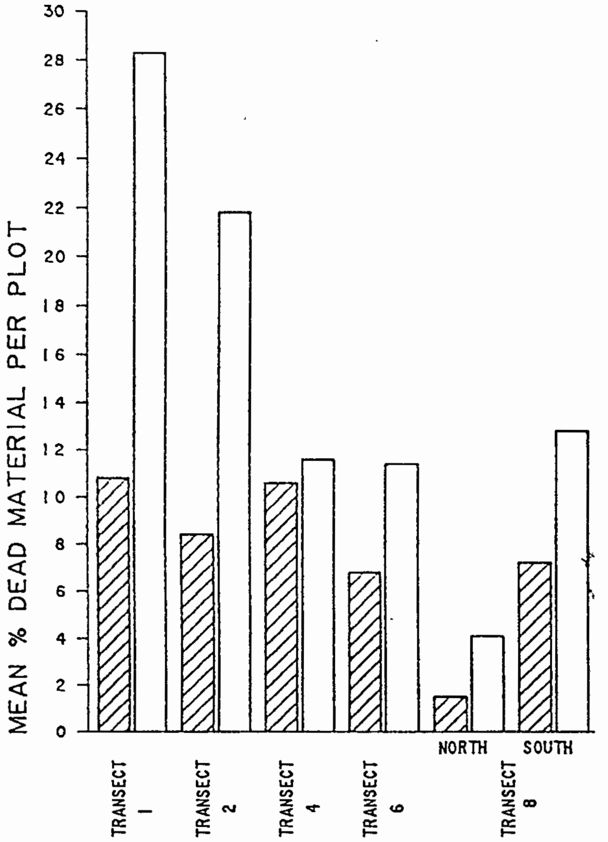


FIGURE 6.2
COMPARISON OF MEAN % DEAD MATERIAL PER PLOT IN CONTACT COMMUNITY OF TRANSECTS FOR 1986 AND 1987 MANUAL SURVEYS

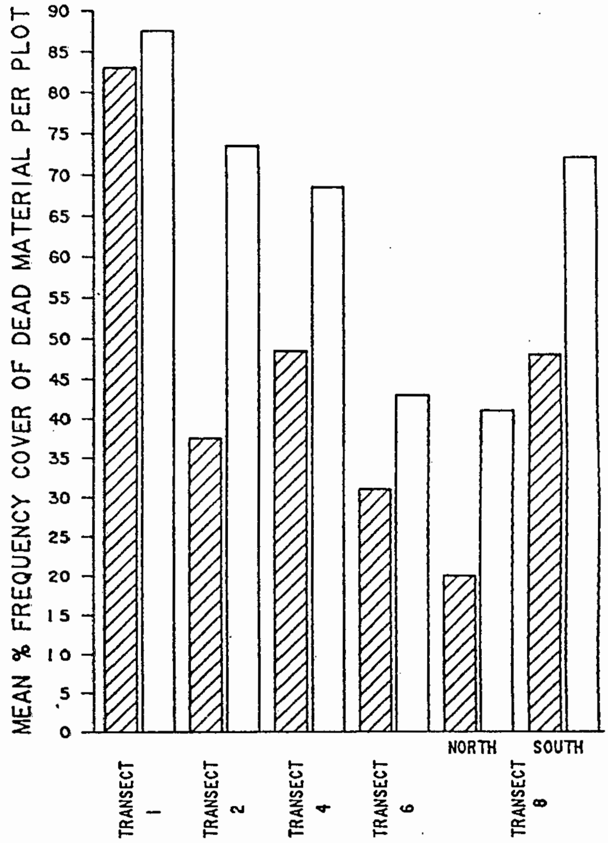


FIGURE 6.3
COMPARISON OF MEAN % FREQUENCY COVER OF DEAD MATERIAL PER PLOT IN CONTACT COMMUNITY OF TRANSECTS FOR 1986 AND 1987 MANUAL SURVEYS

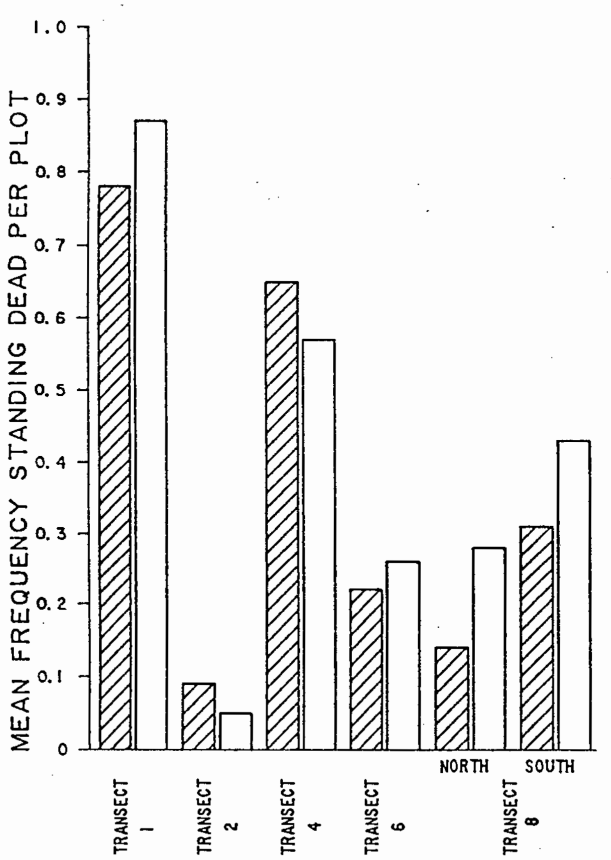


FIGURE 6.4
COMPARISON OF MEAN FREQUENCY OF STANDING DEAD PER PLOT IN CONTACT COMMUNITY OF TRANSECTS FOR 1986 AND 1987 MANUAL SURVEYS

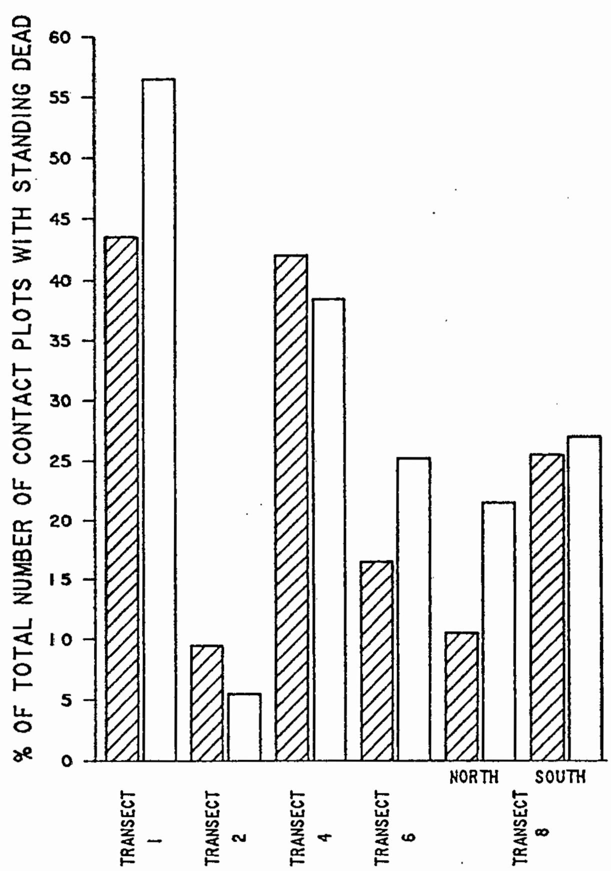


FIGURE 6.5
COMPARISON OF % OF TOTAL NUMBER OF PLOTS WITH STANDING DEAD IN CONTACT COMMUNITY OF TRANSECTS FOR 1986 AND 1987 MANUAL SURVEYS

LEGEND 1986 [hatched] 1987 [open]

6.3.5 CONCLUSIONS

In Figure 6.2, there appears to be a general tendency towards an increase in dead material per subplot along the contact zone vegetation of all the transects from 1986 to 1987. The contact vegetation in Transect 1 and Transect 2 especially, show a marked increase, almost threefold, in mean percentage dead material per subplot. These two transects are situated in what was originally described as sensitive areas, ie. with shallow water tables.

In Figure 6.3, there again appears to be a general tendency towards an increase in percentage frequency cover of dead material per subplot. Transect 1 shows the smallest increase (<5%) while the other transects show much larger increases (40% - 108%). The contact area of Transect 1 is a densely wooded and shady area with very little greenery or foliage in the lower stratum. As the mean percentage frequency cover of dead material in 1986 was already high (>80%), the increase observed in 1987 is not significant when compared to that at the other transects.

In Figure 6.4, there also appears to be a tendency towards an increase in frequency of standing dead per subplot, with the exception of Transect 2 and Transect 4. The latter two transects show the opposite trend.

In Figure 6.5, the same tendencies are seen as above, where Transect 2 and Transect 4 show "positive" trends while the other transects show an increase in number of subplots with standing dead.

The observation made with respect to both the mean percentage dead material per subplot and the mean percentage frequency cover of dead material per subplot, is a general tendency towards a decline in vitality.

With regard to the mean frequency of standing dead per subplot, and the percentage of total subplots where standing dead occurred, the general tendency was again towards an increase, in three out of five transects. Transect 2 and Transect 4 showed an increase in standing dead, and a decrease in the percentage number of subplots in which they occurred. The reason for this positive effect is probably that some of those standing dead recorded in 1986 could have fallen over. As they were no longer standing, they would have been recorded as dead material less than one metre in the 1987 survey.

At this stage, it can be said that the changes observed in the vegetation from 1986 to 1987, ie. during the baseline period, should be noted as natural anomalies, occurring under normal no-abstraction conditions.

PART 7

7. VEGETATION MONITORING BY AERIAL PHOTOGRAPHY

7.1 BACKGROUND

The use of colour infra-red (IR) aerial photography for monitoring growth and vitality of the Karst vegetation was seen as a long-term procedure. This method would be used in conjunction with the initial ground surveys which could then fall away. The remote sensing method is suitable for detecting medium and long-term changes in vegetation vitality.

The advantages of infra-red aerial photography over other methods for monitoring vegetation are the follows :

- The method is an objective one, and thus less biased than manual ground monitoring.

- IR photography makes it possible to detect the degree of decline in vitality, ie. trees under stress are distinguishable from those that are not.

- It provides a permanent record of a situation at a particular time, and differences can be detected over a number of years.

- Twice the detail can be retrieved on this type of film than on panchromatic or colour film.

- Haze penetration is improved, and photo images have sharper boundaries because of its longer wavelengths. The resolution is thus improved.

- Although there are additional costs attached to IR photography, the saving in time and effort usually spent on field work makes it the most cost effective method especially in the case of a long-term project.

Colour infra-red photographs referred to as "false" colour photographs, record the same wavelengths as black and white infra-red, ie. infra-red wavelengths and visible wavelengths, but different dyes in the film are sensitive to different wavelengths which create different hues on processing (Jarman *et al*, 1983). Hues in this medium represent the following hue features on the ground:

Red colours on the photographs represent objects on the ground with high infra-red reflectivity, for example healthy, active and growing vegetation.

Ground features with red and green hues are represented by green and blue photographic hues respectively, eg. green vegetation under stress photographs in shades of blue.

Objects with blue hues are excluded from the image by using a blue filter.

False colour film can therefore be used to emphasize differences between objects that are visually quite similar, and is a good tool for distinguishing small variations in shades of green not detectable by eye. Colour infra-red film emphasizes differences in infra-red reflectance. However, in any given vegetation, the season, the water and mineral content, the age and health of the vegetation may cause its reflectance to vary. The first sign of stress in a tree or plant is often indicated by a decrease in the infra-red reflectance, which will be evident in colour infra-red photography.

7.2 METHODS

7.2.1 DATA COLLECTION

The first two aerial surveys undertaken at the ends of the growing season in 1986 and 1987, formed part of the baseline monitoring activities, in conjunction with the ground surveys carried out over the same period. The 1988 and 1989 aerial surveys formed part of the long-term monitoring programme, and will not be discussed in this document.

The nine transects were photographed in all the aerial surveys. Prior to flying, the terminal and mid-points of each transect were marked by white, plastic half or full crosses, placed five metres apart on previously bush-cleared strips of ground. These were necessary for alignment when flying, and for facilitating the exact scaling of the photographs. This precision was also necessary for the printing of subsequent photographs at the same scale, for ease of comparison. The photographed transect strips were approximately 500m in width.

7.2.2 DATA PROCESSING

The end result of both baseline aerial surveys was in the form of sets of stereoscopic infra-red and matching colour prints for each of the nine transect strips. The scale of both years' prints was 1 : 1667.

In addition to a qualitative description of the transects, a quantitative data processing method was also undertaken. This was in the form of stressed tree counts along each transect strip, using the infra-red prints. This counting exercise was carried out only on the 1986 and 1987 aerial survey photographs.

i) Qualitative Approach

The descriptive data of the first survey in 1986 will be used as the initial record and basis for future comparisons between temporal photographs.

The aerial photographs made it possible to note the variations between the vegetation in the various transects. The variations within the transects between species composition, density, vitality and height, were ascribed mainly to changes in soil types with their various accompanying properties. The contact zone was clearly visible as a result of the dense vegetation along its length. The vitality of the vegetation varied considerably between and within transects, and along most of the transects, the height, density and vitality of the vegetation decreased from north to south.

ii) Quantitative Approach

A grid system was used for counting stressed trees on the 1986 and 1987 infra-red photographs. Grid lines of 20mm x 20mm (ie. 33.3m x 33.3m on the ground) were drawn onto plastic overlays, for use on all the transect strips for both years. The outlines of the area to be quantified under the grids, were then marked onto the prints for future referencing and checking purposes. Stressed trees on the corresponding strips of vegetation for 1986 and 1987 were counted per square and then totalled for that transect area. A scale of 1 - 3 was used to rate these stressed trees.

The scores on the rating scale were defined as follows :

- "1" was rated as "slightly stressed", and was detectable as a slight tinge of blue colouring in healthy red or pink individuals (depending on the species), or within clumps of trees.

- "2" was rated as "severely stressed", and was detectable as a darker and more definite blue colouring of almost the entire individual, or within clumps of trees, with only small amounts of pink or red still visible.

- "3" was rated as "dead", and was detectable as definite blue colouring in individuals on their own, or within clumps of trees, with no visible signs of healthy foliage. A thorough check was carried out to make sure that the individuals rated as "3" were definitely dead, and these individuals were then circled on the photographs for future referencing.

A few factors had to be taken into account at the outset, such as the slight variations in colour of the photographs from year to year, as well as the colour differences between batches of photographic paper. Each transect strip had to be scrutinized beforehand, and some general decisions and allocations made with respect to which variations of pink or blue would fall within each category or rating.

7.3 RESULTS

7.3.1 OUTCOME OF QUANTITATIVE METHOD

This rating method was applied to the baseline aerial photographs for evaluation of the data. For this purpose, the ratings were used in two groups. Total stress counts which included all the stress ratings, ie. "1", "2" and "3", and the dead counts, which included only the counts of dead trees, rated as "3".

The counts for those trees rated as "1" and "2" on their own, were not included in the statistical analysis, as it was felt that the vitality rating might fluctuate too much between only two growing seasons. These ratings should prove to be more useful over a longer term, when more than two seasons' ratings can be compared.

The results of the total stress ("1", "2", and "3") and the dead tree counts, were calculated for both the entire transect strip, and for the contact vegetation on its own for both the 1986 and 1987 surveys. A mean value for these chosen parameters, as indicated in Table 7.1, was calculated for all nine transects for both seasons, and these nine pairs of values were then used in the paired sample analyses. Using the results of these analyses, it was possible to examine any trends over the whole area, and to ascertain which parameters best show the trends.

The correlation values together with the t-statistic, which provided a measure of significance, are presented in Table 7.1.

TABLE 7.1 : PAIRED SAMPLE ANALYSIS FOR THE 1986 AND 1987 AERIAL SURVEYS

PARAMETER	FIGURE NO. REFERENCE	CORRELATION COEFFICIENT (r)	t-STATISTIC
1. Total number of stressed trees over whole transect	7.1	0,954	8,459 (99%)
2. Total number of dead trees over whole transect	7.2	0,866	4,589 (99%)
3. Total number of stressed trees in contact community	7.3	0,988	15,625 (99%)
4. Total number of dead trees in contact community	7.4	0,986	14,369 (99%)

With reference to Table 7.1 it appears that the correlation values are relatively high, with the counts of total stressed and dead in the contact communities providing the best correlation coefficients.

If all four scenarios are considered, the total number of stressed trees and total number of dead trees over the whole transect strips, show the biggest changes from one year to the next, although the magnitude of change is relatively inconsistent, hence the poor correlation coefficients.

In Figure 7.1, there appears to be a tendency towards an increase in total stressed tree counts in all the transects from 1986 to 1987, with the exception of Transect 2 (Urupupa), where the situation seems to have improved slightly.

In Figure 7.2, the tendency again shows an increase along all the transect strips. Although this increase is not consistent in all the transects, in many areas the increase is almost two-fold.

In Figure 7.3, the transects show an increase in deterioration of vitality in seven out of eight cases where contact community was present. Transect 2 and Transect 8 show a positive effect from one season to the next, ie. a slight improvement in vitality. Although the general tendency is that of decline in vitality from 1986 to 1987, the order of magnitude of the decline along the contact strips is not as great as that along the transect strips as a whole.

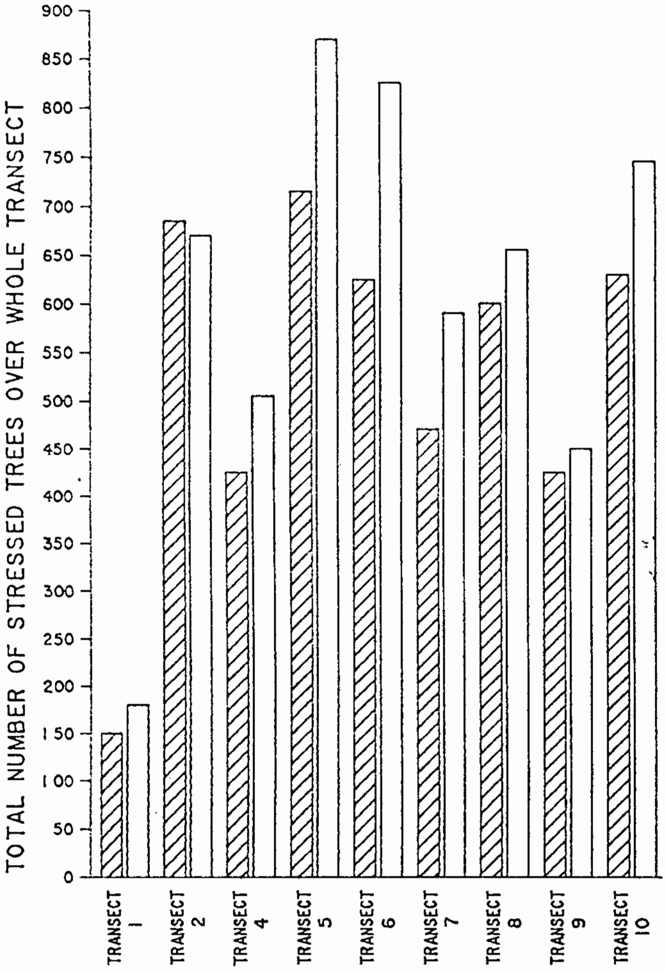


FIGURE 7.1
COMPARISON OF TOTAL NUMBER OF STRESSED TREES OVER WHOLE TRANSECT FOR 1986 AND 1987 AERIAL SURVEYS

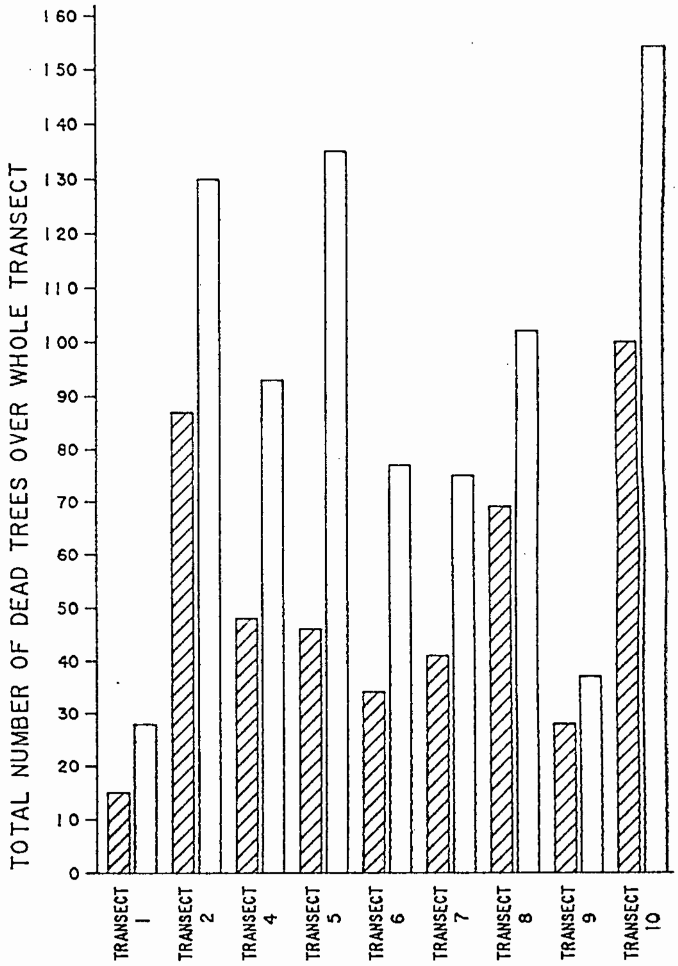


FIGURE 7.2
COMPARISON OF TOTAL NUMBER OF DEAD TREES OVER WHOLE TRANSECT FOR 1986 AND 1987 AERIAL SURVEYS

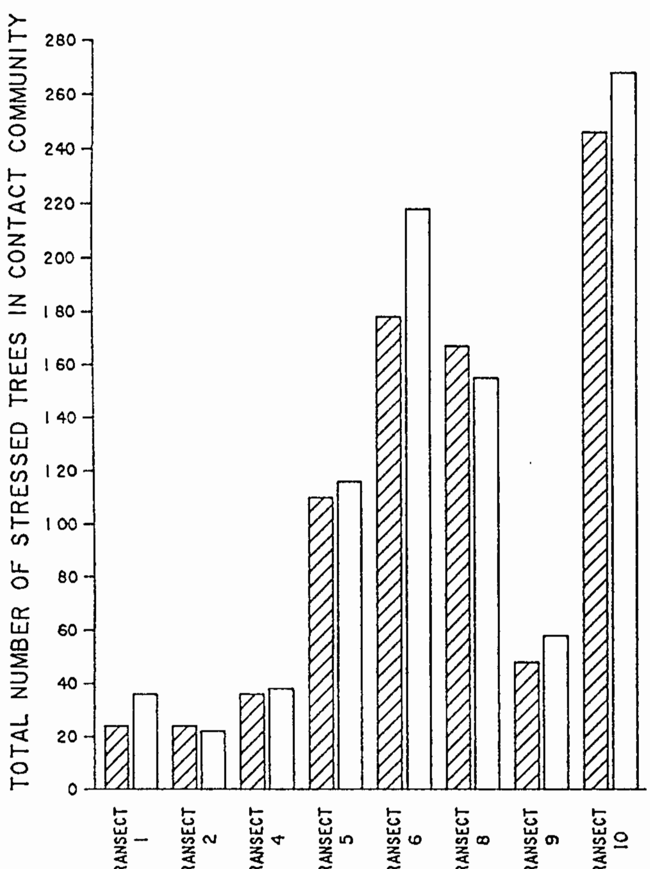


FIGURE 7.3
COMPARISON OF TOTAL NUMBER OF STRESSED TREES IN CONTACT COMMUNITY OF TRANSECTS FOR 1986 AND 1987 AERIAL SURVEYS

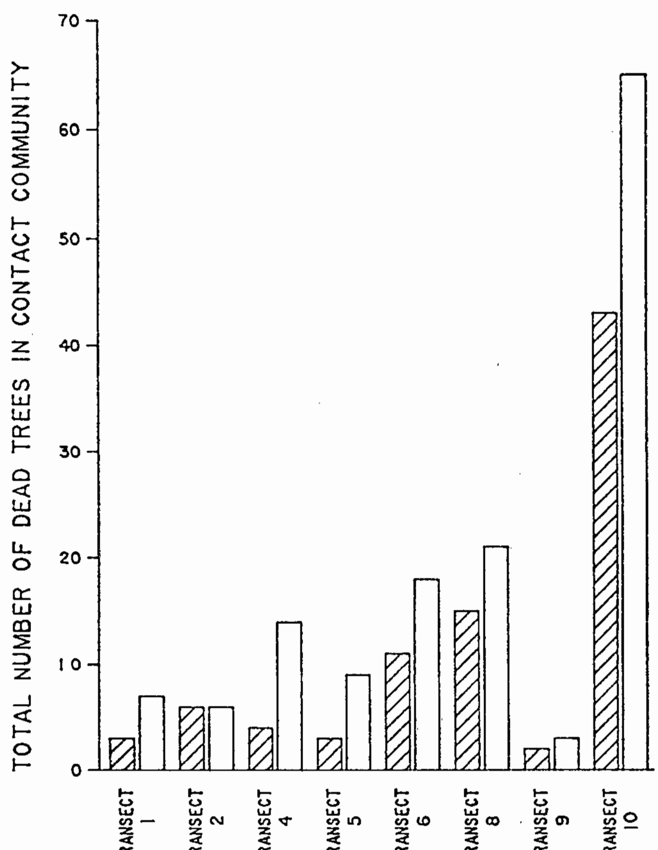


FIGURE 7.4
COMPARISON OF TOTAL NUMBER OF DEAD TREES IN CONTACT COMMUNITY OF TRANSECTS FOR 1986 AND 1987 AERIAL SURVEYS

LEGEND 1986 [hatched] 1987 [open]

In Figure 7.4, the tendency is towards an increase, with the exception of Transect 2 (Urupupa), where the situation appears to have remained stable. The order of magnitude of decline appears to be similar to that of the transects as a whole.

7.4 DISCUSSION

In conclusion, the observation made with respect to the total number of stressed trees in all the transects as a whole, is a general tendency towards an increase in stress, with only Transect 2 showing a slight improvement. The same tendency is evident with respect to the contact vegetation on its own, but the magnitude of change is more consistent throughout the transects. The counts of dead trees along all the transects as a whole, as well as along only the contact vegetation, show a tendency towards an increase.

As the baseline years are considered to be the pre-implementation or pre-abstraction stage, the vegetational changes that are evident in the transect areas, should be interpreted as "normal" seasonal conditions and changes. Any deterioration or loss of vitality can probably be ascribed to the natural variations of especially the climatic environmental variables.

8. VEGETATION MONITORING BY FIXED POINT PHOTOGRAPHY

8.1 BACKGROUND

Another vegetation monitoring method which was carried out, was that of fixed point photography. This is an excellent way of obtaining visual effects of any changes taking place in the vegetation using colour film and photographing specifically selected sites from fixed spots, on a regular basis. This method offers a means by which a comparative record can be kept of particular sites on a seasonal basis, over the long term.

8.2 METHODS

8.2.1 BACKGROUND AND SITE SELECTION

The photographic sites along the transect areas were selected according to certain criteria. The sections of vegetation or individual large trees had to be situated at or near water level recorders or production boreholes. The photographic records are in the form of friezes for each site.

All the transects originally selected, including No. 3, are used for these photographic surveys. The fixed point surveys are carried out on a biannual basis, towards the "end of the wet season", ie. April/May, and towards the "end of the dry season", ie. August/September.

Fifteen fixed point photographic sites (F) were selected from within Area I and Area II. Eleven of the sites are situated along or near transect lines, while the remaining four are of individual trees. The fixed point photographic sites are indicated in Figures 2.2 and 2.3 under the Study Area section.

8.2.2 DATA COLLECTION

The first fixed point photographic survey took place in August 1985, and the biannual surveys have been continued ever since. As the baseline period (1986 and 1987) is a very short period to detect any obvious and blatant vegetational changes, the data gathered during this period should serve only as a photographic record of the current vegetation status before abstraction. However, over the long term, this method should provide some valuable visual evidence as to whether or not changes are taking place. The period from 1988 to 1989 formed part of the long-term monitoring programme activities, and will not be discussed in this document.

8.3 RESULTS

8.3.1 DATA EVALUATION

The results of this photographic method are in the form of a set of colour prints for each of the fifteen sites. Descriptive evaluations, carried out for each site, are based on the visual examination of the each season's set of photographs. This document includes only a brief description of the setting of each site, any relevant aspects, and a listing of the species present in the photographic sequence.

Transect 1 (Brandwag farm) - F4

This stand of vegetation is situated at the beginning of the transect on the contact zone in the vicinity of a water level recorder. It is characteristic of contact community vegetation. The following woody species are present in this photographic sequence :

Euclea undulata, Olea europaea, Rhus lancea, Ficus thoningii, Acacia karroo, A. hereroensis, Croton gratissimus, Dichrostachys cinerea, Mundulea sericea, Grewia spp.

Transect 2 (Urupupa farm) - F10

This stand of vegetation is situated on the edge of the contact zone, next to a plain community, in the vicinity of a water level recorder, adjacent to the 300m area down the transect length. The woody species composition is typical of both contact and plain type communities. The following woody species are present in this photographic sequence :

Euclea undulata, Olea europaea, Rhus lancea, Acacia reficiens, Croton gratissimus, Dichrostachys cinerea, Combretum apiculatum, Peltophorum africanum, Lonchocarpus nelsii.

Transect 3 (Urupupa farm) - F11

This stand of vegetation is situated near a borehole on the contact zone, approximately halfway down the length of the transect. This particular transect was rejected as a representative sample of the area due to there being a drainage channel and sinkholes within the area. However, the transect was retained as a fixed point photographic site at the contact zone. The following woody species are visible in the photographic sequence :
Euclea undulata, Olea europaea, Acacia karroo, A. reficiens, A. hereoensis, Dichrostachys cinerea, Ziziphus mucronata.

Transect 4 (Buschbrunnen farm) - F1

This stand of vegetation is situated on the contact zone near a water level recorder, within the first 100m of the transect length. The woody species composition is typical of a contact community, and the following species are present in the photographic sequence :

Euclea undulata, Olea europaea, Acacia karroo, A. reficiens, Dichrostachys cinerea, Peltophorum africanum, Maytenus heterophylla.

Transect 5 (Kombat/Asis farm) - F12

This stand of vegetation is situated approximately halfway down the length of the transect, at a water level recorder on the contact zone. The following woody species are present in this photographic sequence :

Acacia karroo, A. reficiens, A. tortilis, Croton gratissimus, Dichrostachys cinerea, Combretum imberbe, Grewia spp., *Peltophorum africanum, Lonchocarpus nelsii, Tarchonanthus camphoratus.*

Transect 6 (Okambongoro farm) - F9

This stand of vegetation is situated at the beginning of the transect along the contact zone, and the species composition is characteristic of a contact community. This photographic sequence includes the following woody species :

Euclea undulata, Olea europaea, Acacia karroo, A. reficiens, A. mellifera, Dichrostachys cinerea, Combretum imberbe, Maytenus heterophylla, Rhus marlothii.

Transect 7 (Buschbrunnen farm) - F2

This stand of vegetation is situated along a flat area at the base of a mountain, and is adjacent to the last 100m of the transect. A production borehole is also situated in the vicinity. This photographic sequence includes the following woody species :

Ficus thoningii, Acacia karroo, A. tortilis, Dichrostachys cinerea, Combretum imberbe, Peltophorum africanun, Ziziphus mucronata.

Transect 8 (Buschbrunnen farm) - F3

This stand of vegetation is situated along the contact zone in close proximity to a water level recorder, and is approximately 300m down the length of the transect. In this particular area, the topography is very flat with a slight upward sloping gradient at each end of the transect. The soil underlain by calcrete, is very shallow, and the poor drainage characteristics result in frequent flooding and drowning. The following woody species are present in the photographic sequence :

Rhus lancea, Acacia karroo, Dichrostachys cinerea, Combretum imberbe, Ziziphus mucronata, Grewia retinervis.

Transect 9 (Kombat Mine) - F13

This stand of vegetation, dominated by *Acacia* spp., is situated on the contact zone, halfway down the length of the transect. The following woody species are present in the photographic sequence :

Acacia karroo, A. hereroensis, A. reficiens, A. tortilis, A. hebeclada, A. mellifera, A. fleckii, Dichrostachys cinerea, Grewia spp.

Transect 9 (Kombat Mine) - F14

This stand of vegetation is situated near the top of the mountain, within approximately the last 100m of the transect. The vegetation is characteristic of a mountain type community, the soil is shallow, and the area is strewn with rocky dolomite outcrops. The following woody species are present in the photographic sequence :

Ficus thoningii, Acacia hereroensis, Dichrostachys cinerea, Croton gratissimus, Combretum apiculatum, Peltophorum africanum, Lonchocarpus nelsii, Grewia flavescens, Grewia retinervis, Commiphora pyracanthoides, Kirkia acuminata, Dombeya rotundifolia.

Transect 10 (Berg Aukas farm) - F8

This stand of vegetation is situated approximately halfway up the length of the transect, and is characteristic of a mountain base/mountain community. The area is extremely rocky, has a shallow soil cover with calcrete interspersions. This photographic sequence includes the following woody species :

Euclea undulata, Croton gratissimus, Dichrostachys cinerea, Combretum apiculatum, Commmiphora africana, Terminalia prunioides.

Individuals (Brandwag farm) - F5

This photographic sequence includes a stand of individual large trees along the contact zone. One of the major production boreholes for Area I is located close to this stand. The vegetation type in this area is that of a contact community, and the photographic sequence includes the following species :

Olea europaea, Acacia karroo, Rhus lancea, and *Ficus* spp. individuals.

Individuals (Brandwag farm) - F6

This photographic record shows a *Ficus thoningii* and a *Ficus cordata* individual. Both trees are large and old, and are situated close to one of the production boreholes. The vegetation type in this area was previously that of a mountain base community, but the area was cleared for the installation of the boreholes. These two individuals are some of the few remaining large trees in the area.

Individuals (Brandwag farm) - F7

This photographic sequence shows three large,old trees situated near a production borehole, within what used to be a mountain type community. The individuals are a *Ficus sycomorus*, *Acacia karroo* and a *Combretum imberbe* tree.

Individual (Berg Aukas Mine area) - F15

This individual was included in the survey from the second season onwards. The photographic record shows an extremely large, old Maroela tree, *Sclerocarya birrea*. It is situated adjacent to the area approximately 600m down the length of the Transect 10. This is one of the many large Maroela trees in the Berg Aukas area.

8.4 DISCUSSION

At the end of the baseline study, it was difficult to draw any concrete conclusions. Whether the vegetation was under continuous and increasing stress, or whether the stress pattern was just the normal seasonal variation, or whether the vegetation in a particular soil type or topographical location was slower or faster to react to seasonal climatic variations, were all possible explanations for any change noted during the baseline period. Any long-term trends will thus be visible only after a number of years.

PART 5

9. CONCLUSIONS

The intention and purpose of a baseline study is not primarily in the drawing of conclusions, but rather to provide a data base against which future medium or long-term changes can be measured.

As expected, the relatively poor rainfall during the five years prior to the study, as well as the below average rainfall during the baseline period, generally resulted in poor recharge to the groundwater and a deterioration in the vegetation status, although the latter could not be considered statistically significant. The general, continuing decline of the water table in most parts of the Karst Area from 1983/84 to the end of 1989, was therefore a result of insufficient recharge to the aquifer system. This is despite the fact that existing abstraction by farmers is relatively small compared to any foreseeable large-scale abstraction. Since the former has been a constant factor for many years, any possible resultant changes in the vegetation will already have taken place prior to the commencement of the baseline study.

The nature of the study made it necessary to choose sampling techniques in which all possible variations in plant communities in the area where abstraction would take place, could be monitored, both over the short and long term. The area of interest, only 13% of the whole karst area, was characterized by a groundwater table of less than 20m from the soil surface at the outset of the study.

The exact location of the sampling sites within this area, was dictated by certain groundwater criteria. Belt transects were used as the basic sampling units on which the various monitoring methods were applied.

Only the woody plants were examined, as the sub-woody and other plants (grasses etc.) were considered to have too shallow a rooting system to either rely on groundwater, or be affected by a lowering of the groundwater table. The root depth examination confirmed that the woody species, especially along the contact zones, do penetrate to depths greater than 5 metres, although the bulk of the roots are concentrated in the first metre of soil.

The direct use of the belt transects was for very detailed and comprehensive data collection. Certain aspects of these data which indirectly related to the vitality of the vegetation, showed that there was a general tendency towards a decline in vitality of the vegetation. However, these changes should be noted as natural anomalies during the baseline period, under no-abstraction and poor rainfall conditions.

Similarly, the infra-red aerial photography detected this general deterioration in the vegetation status during the baseline period. This is important, since infra-red aerial photography was found to be a more convenient and practical method of evaluation than the manual approach. The fact that it detected the same trends as the manual monitoring survey, confirms the usefulness of the method as a convenient tool for detecting and quantifying change in vegetation vitality.

Both these analyses were very useful in providing an indication of natural seasonal variations in the vegetation status. This indicates that changes of this order are a natural phenomenon, and should be taken into account when assessing any deterioration after large-scale abstraction.

The fixed point photographic surveys also showed certain stress patterns over the two baseline years, although these were accepted as the normal seasonal variations/changes under the current climatic conditions. If these seasonal changes were to continue to show a decline, they would be detectable as a long-term trend only after a number of years.

The vegetation-environment classification, as carried out using the Canonical Correspondence Analysis ordination method, produced statistically significant results, but interpretation was complicated by a large degree of "noise". This noise resulted from several factors, including the broad nature of the environmental variables, and the fact that the total environmental influence could not be represented. The decision to use CANOCO as an analytical tool, was made at a late stage, only after the collection of environmental data had been completed. The selection of environmental variables was therefore not made with CANOCO in mind. The presence of a large number of widely distributed species which showed neutral associations with most of the environmental variables, also contributed to this noise. It is clear that in most applications involving large numbers of samples and species, a high degree of noise can be expected.

The interpretation of these data by conventional means, in order to achieve a classification, is difficult, and conclusions are often impossible to establish. The statistical significance of these conclusions is even more dubious. The Canonical Correspondence Analysis method was successful in producing a statistically significant classification of the vegetation in relation to various very broadly defined environmental variables.

The species with strong associations (both positive and negative) with the ordination axes, were often those less common species. A number of these species can perhaps be considered as "indicator species", which grow and flourish under precisely defined environmental conditions. The decrease or increase in the abundance of any indicator species should be closely linked with the environmental variables associated with the relevant axis.

Table 9.1 shows possible indicator species as selected by CANOCO, together with their specific environmental conditions.

TABLE 9.1 : INDICATOR SPECIES AND RELATED ENVIRONMENTAL CONDITIONS AS DEFINED BY CANOCO

SPECIES NO.	SPECIES NAME	R1 RAINFALL (Current season) (High rainfall)	R3 RAINFALL (Current plus previous two seasons) (High rainfall)	A1 SOIL (Thick A-horizon)	SOIL TYPES	TOPOGRAPHY
6	*Acacia hebeclada*	0	+	0	Mispah	not Plain
7	*A. erubescens*	0	-	0	0	Plain
8	*A. nilotica*	0	-	++	0	Plain
10	*Carissa edulis*	0	-	0	Rensburg	Plain
11	*Cassine transvaalensis*	0	-	0	Rensburg	Plain
12	*Catophractes alexandri*	0	+	0	Mispah	not Plain
13	*Cissus juttae*	0	++	-	Mispah	0
15	*Combretum imberbe*	0	-	++	Hutton	(Plain)
32	*Grewia villosa*	0	-	0	0	Plain
33	*Maytenus heterophylla*	0	-	0	Rensburg	Plain
34	*M. senegalensis*	0	-	++	Hutton	(Plain)
35	*Mundulea sericea*	0	++	-	Mispah	0
36	*Olea europaea*	0	++	-	Mispah	0
37	*Ozoroa insignis*	0	-	++	0	(Plain)
39	*Pavetta zeyheri*	0	++	-	Mispah	0
44	*Securinega virosa*	0	-	++	0	(Plain)
46	*Tarchonanthus camphoratus*	0	-	0	Rensburg	Plain
47	*Terminalia prunioides*	0	++	-	Mispah	0

+, ++ indicates slight, strong positive relationship
- , -- indicates slight, strong negative relationship
0 indicates no clear (insignificant) relationship
( ) indicates weak relationship

Although the CANOCO analysis did indicate a relationship between certain of the above listed species and the environmental variable R1, it was decided to classify this as insignificant (0) in view of the questionable usefulness of the single rainfall season variable, which is considered unlikely to have an immediate influence on species composition.

The increased or decreased presence of one or more of these indicator species, can in the future first be investigated in terms of the environmental variables which have been defined as important, and thereafter in terms of any other introduced factors which could be suspected of having an influence on the vegetation.

Indicator species are useful, especially in a study such as this, since they may provide an advanced warning of environmental changes (either natural or man-induced), which if continuing for a prolonged period, may affect even the less environmentally sensitive species. It is the possible deteriorating status of this broader group of species, which would be of greatest concern in the Karst area.

The monitoring techniques used in the baseline study have been evaluated against certain criteria, in order to assess their usefulness and cost-effectiveness, and the findings are summarized in Table 9.2. The summary also fulfills the function of highlighting the methods which would be most appropriate for future long-term monitoring during abstraction.

TABLE 9.2 : EVALUATION AND ASSESSMENT OF MONITORING TECHNIQUES WITH RESPECT TO THE BASELINE STUDY AND FUTURE MONITORING

CRITERIA	MONITORING TECHNIQUES		
	MANUAL SURVEYS	INFRA-RED AERIAL PHOTOGRAPHIC SURVEYS	FIXED POINT PHOTOGRAPHIC SURVEYS
ACCURACY :	Data collection - good Data evaluation - good	Data collection - good Data evaluation accuracy affected by subjective interpretation of colour hues	Data collection - good Data evaluation - good
REPEATABILITY :	Data collection (measurements) - good; potential problems with precise repeatable demarcation of plots Data evaluation - good	Data collection - good Data evaluation - fair; potential problems associated with hues of different batches of photographic paper	Data collection - good Data evaluation - good
COST : TIME	Data collection - very time consuming (slow and laborious) Data evaluation - very time consuming	Data collection - quick, but requires advanced planning Data evaluation - relatively slow	Data collection - quick Data evaluation - relatively quick
COST : EQUIPMENT	Data collection - relatively low Data evaluation - relatively low	Data collection - high Data evaluation - relatively low	Data collection - low Data evaluation - low
USEFULNESS :	Provides comprehensive vegetation inventory and identification of indicator species relative to environmental variables	Provides readily accessible static and quantifiable overview of vitality of vegetation	Provides easily accessible qualitative description of selected vegetation sections
REPRESENTATIVENESS OF SAMPLE RELATIVE TO ENTIRE STUDY AREA :	Total sampling area (5m wide strips) - limited/small	Total sampling area (approx. 500m wide bands of vegetation including transect strips) - relatively large	Total sampling area (selected sections of vegetation) - very small

It is therefore evident that all three techniques served useful functions as part of the baseline study. With respect to future monitoring during large-scale abstraction, infra-red aerial photography provides the most easily accessible general overview of the vegetation status, but its cost may preclude its regular use. Fixed point photography however, is cheap and easily carried out. Although only selected sections of vegetation are monitored, regular fixed point surveys combined with occasional infra-red aerial photographic surveys, would provide early warning of possible deterioration. More intensive monitoring could then be carried out in the form of more regular aerial surveys in addition to a manual survey, in order to re-examine the vegetation-habitat relationships.

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ANNEXURE 1

Species Data Input File

for Canoco CCA Programme

```
SPECIES - KARSTLAND DATA - APRIL/MAY 1986
(I10,X,5(I4,F5.0))
5
         1  22  2.0  24  1.0  29  1.0  33  2.0
         2  21  2.0  22  1.0  27  1.0  29  2.0  33  1.0
         2  43  1.0
         3  21  2.0  22  1.0  29  1.0  33  1.0  36  1.0
         4   1  2.0  21  2.0  26  2.0  33  3.0  36  5.0
         4  41  3.0  43  2.0
         5   1  2.0  22  1.0  26  2.0  31  2.0  36  5.0
         5  41  4.0  42  1.0
         6   1  1.0   3  1.0  26  6.0  33  2.0
         7   1  1.0  26  4.0  33  1.0  36  1.0  50  1.0
         8  22  2.0  28  3.0  29  1.0  31  1.0  43  2.0
         9  22  3.0  23  1.0  26  5.0  31  1.0  33  1.0
         9  36  3.0  43  1.0
        10  22  2.0  26  4.0  29  2.0  36  1.0  43  1.0
        10  50  1.0
        11  23  2.0  31  1.0  33  1.0  36  4.0  43  1.0
        12   1  2.0  26  2.0  31  1.0  33  4.0  42  1.0
        12  48  2.0
        13   1  1.0  26  4.0  29  2.0  36  3.0
        14   1  1.0   3  3.0  21  4.0  29  1.0  33  1.0
        14  36  6.0  47  1.0
        15   1  3.0   2  1.0   3  5.0  24  1.0  31  1.0
        15  33  2.0  36  5.0  47  1.0
        16   1  2.0   3  2.0  21  2.0  22  2.0  24  2.0
        16  26  3.0  31  2.0  35  2.0  36  5.0  39  1.0
        16  42  1.0
        17   3  2.0  21  3.0  24  2.0  35  2.0
        18   2  2.0   3  2.0  21  5.0  28  2.0  35  4.0
        18  42  1.0
        19   2  1.0   6  2.0  21  4.0  22  2.0  26  2.0
        19  28  1.0  33  2.0  35  4.0  36  1.0  48  2.0
        19  50  1.0
        20   2  2.0   3  2.0  21  3.0  22  2.0  33  2.0
        20  35  2.0
        21  21  4.0  22  4.0  26  7.0  33  2.0  36  1.0
        21  48  1.0
        22  11  1.0  21  3.0  22  1.0  26  3.0  28  1.0
        22  29  2.0  36  3.0  42  2.0
        23   1  3.0   2  2.0   6  1.0  21  3.0  22  5.0
        23  26  3.0  28  2.0  29  2.0  36  4.0  39  1.0
        23  42  1.0  50  1.0
        24   1  3.0  21  3.0  22  2.0  26  4.0  35  2.0
        24  36  6.0  42  1.0  48  2.0
        25   2  1.0   3  1.0  21  1.0  22  2.0  23  2.0
        25  24  1.0  26  3.0  36  9.0
        26   1  3.0   3  1.0  21  3.0  22  2.0  24  3.0
        26  26  5.0  36  3.0  41  1.0  42  1.0
        27   1  3.0   2  2.0   3  2.0  21  3.0  22  2.0
        27  24  2.0  26  4.0  29  3.0  33  1.0  36  3.0
        27  42  2.0
        28   1  2.0   3  2.0  22  1.0  26  3.0  35  1.0
        28  36  2.0  41  1.0  42  1.0
        29   1  2.0  21  2.0  22  2.0  26  1.0  42  1.0
        30   2  2.0  21  2.0  22  1.0  25  1.0  28  2.0
        30  29  3.0  42  1.0
        31  18  1.0  21  2.0  25  1.0  29  1.0  33  2.0
        32   2  1.0  21  5.0  22  4.0  24  1.0  29  2.0
```

32	31	2.0	36	1.0						
33	2	2.0	14	2.0	19	1.0	21	4.0	22	1.0
33	28	2.0	42	1.0	46	1.0				
34	2	2.0	3	3.0	14	3.0	16	1.0	18	1.0
34	21	3.0	22	3.0	25	2.0	26	2.0	29	1.0
34	30	2.0	42	2.0						
35	2	3.0	4	1.0	14	1.0	21	2.0	22	4.0
35	28	2.0	29	1.0	42	1.0				
36	2	1.0	21	4.0	22	1.0	25	4.0	26	1.0
36	28	3.0	29	1.0	30	4.0	31	1.0	33	4.0
36	42	1.0	50	2.0						
37	2	4.0	19	1.0	21	3.0	22	2.0	29	1.0
37	33	1.0	42	4.0	50	1.0				
38	2	1.0	3	2.0	21	2.0	22	3.0	33	7.0
39	4	2.0	5	1.0	14	1.0	18	1.0	21	2.0
39	22	2.0	25	1.0	26	2.0	28	1.0	29	2.0
40	2	1.0	4	1.0	22	5.0	29	1.0	33	5.0
41	2	2.0	4	1.0	14	1.0	21	2.0	22	3.0
41	29	1.0	30	1.0	33	6.0	43	1.0		
42	2	4.0	4	1.0	21	2.0	22	3.0	33	5.0
43	3	1.0	4	2.0	9	1.0	18	1.0	21	7.0
43	22	1.0	26	2.0	28	1.0	33	2.0	42	3.0
43	49	1.0								
44	4	2.0	14	2.0	21	5.0	22	2.0	26	5.0
44	29	3.0	33	3.0	42	3.0	46	1.0		
45	2	2.0	21	3.0	22	2.0	26	4.0	36	1.0
45	46	2.0								
46	2	2.0	3	1.0	9	2.0	22	2.0	26	9.0
46	28	2.0	30	1.0	33	3.0	42	3.0		
47	2	5.0	3	1.0	4	1.0	14	1.0	21	5.0
47	29	2.0	42	3.0	46	2.0				
48	2	2.0	5	1.0	21	3.0	22	1.0	25	2.0
48	28	1.0	33	6.0						
49	2	2.0	21	2.0	25	1.0	26	9.0	33	6.0
49	36	1.0	42	2.0	46	1.0				
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50	33	4.0								
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53	30	1.0	48	1.0						
54	1	1.0	9	1.0	21	6.0	22	4.0	26	2.0
54	33	1.0	36	1.0						
55	9	1.0	22	3.0	28	1.0	29	4.0		
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57	22	4.0								
58	5	1.0	15	1.0	22	2.0	29	1.0	33	2.0
58	42	1.0	46	1.0						
59	1	2.0	2	1.0	22	2.0	26	3.0	28	1.0
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60	1	3.0	2	1.0	14	1.0	22	3.0	28	1.0
60	33	4.0								
61	3	1.0	22	3.0	50	1.0				
62	1	2.0	5	1.0	22	4.0	28	1.0	29	1.0
62	33	8.0	42	2.0	46	2.0	50	2.0		
63	1	2.0	2	1.0	3	1.0	5	2.0	22	4.0
63	25	1.0	28	2.0	31	1.0	33	2.0	42	1.0
63	46	2.0	50	1.0						
64	3	2.0	5	1.0	22	4.0	42	1.0	46	1.0
65	22	3.0	29	1.0	30	1.0	42	2.0	46	1.0

65	50	1.0								
66	11	4.0	22	3.0	31	1.0				
67	7	2.0	22	2.0	46	1.0				
68	21	3.0	22	2.0	29	1.0	33	7.0		
69	1	1.0	5	2.0	21	2.0	25	2.0	32	2.0
69	33	2.0	42	2.0	46	3.0	48	3.0		
70	3	2.0	11	3.0	14	2.0	21	4.0	22	2.0
70	24	1.0	26	1.0	33	6.0	42	1.0		
71	11	2.0	21	5.0	22	3.0	23	1.0	24	2.0
71	25	5.0	26	1.0	29	1.0	33	4.0	46	1.0
71	50	1.0								
72	18	1.0	21	2.0	22	4.0	28	1.0		
73	11	4.0	22	2.0	42	1.0				
74	5	2.0	11	3.0	22	4.0	25	2.0	42	2.0
74	46	2.0								
75	4	1.0	11	4.0	22	4.0	29	1.0	46	1.0
76	1	1.0	11	2.0	22	4.0	25	1.0	46	1.0
77	9	1.0	14	1.0	15	1.0	19	1.0	22	4.0
77	31	1.0	42	2.0						
78	5	1.0	21	2.0	22	5.0	26	2.0	28	1.0
78	42	1.0	50	1.0						
79	5	1.0	21	2.0	22	2.0	33	3.0	46	2.0
80	21	3.0	22	2.0	26	1.0	33	3.0	46	3.0
81	1	2.0	21	4.0	22	4.0	24	1.0	25	1.0
81	26	1.0	46	1.0						
82	2	2.0	22	4.0	33	3.0	46	1.0		
83	2	2.0	22	4.0	33	2.0	46	1.0		
84	2	3.0	22	3.0	28	1.0	35	1.0	40	1.0
85	2	4.0	22	1.0	23	1.0	26	2.0	33	4.0
86	2	3.0	22	7.0						
87	2	2.0	21	3.0	22	2.0	25	3.0	26	3.0
87	33	3.0								
88	1	2.0	14	1.0	21	4.0	22	1.0	25	1.0
88	28	2.0	31	1.0	42	1.0	49	1.0		
89	5	1.0	14	1.0	16	1.0	21	1.0	22	5.0
90	2	2.0	22	3.0	24	1.0	33	3.0	42	1.0
91	21	1.0	22	5.0	33	1.0	46	1.0		
92	5	1.0	21	3.0	22	3.0	24	1.0	25	1.0
92	28	1.0	31	2.0	46	1.0				
93	2	2.0	4	1.0	5	1.0	21	2.0	22	3.0
93	30	1.0	46	1.0						
94	21	4.0	22	2.0	42	1.0	46	1.0	48	1.0
95	1	1.0	14	1.0	21	4.0	22	2.0	26	7.0
95	42	3.0	46	2.0						
96	1	1.0	2	2.0	3	1.0	22	2.0	26	1.0
96	36	1.0	42	1.0						
97	1	1.0	2	4.0	3	1.0	21	1.0	22	4.0
97	26	1.0	31	3.0	42	1.0				
98	2	1.0	21	4.0	22	2.0	25	1.0	26	5.0
98	42	1.0								
99	2	3.0	22	3.0	23	1.0	25	1.0	26	5.0
99	31	2.0	42	4.0	46	3.0	50	1.0		
100	2	5.0	21	1.0	22	3.0	31	1.0	33	1.0
100	42	3.0								
101	2	2.0	3	1.0	21	3.0	22	4.0	26	3.0
101	33	2.0	42	2.0	50	1.0				
102	2	2.0	3	1.0	21	3.0	26	5.0	28	1.0
102	33	3.0	42	2.0						
103	2	4.0	14	2.0	19	1.0	21	5.0	22	3.0
104	2	2.0	3	1.0	21	4.0	22	4.0		

105	2	1.0	21	4.0	22	5.0	28	1.0	42	2.0
105	46	2.0								
106	2	2.0	3	1.0	21	4.0	22	2.0	26	4.0
106	31	2.0	42	1.0						
107	2	3.0	4	2.0	14	1.0	21	2.0	22	4.0
107	25	1.0	28	1.0	46	2.0				
108	2	1.0	14	1.0	21	3.0	22	1.0	25	1.0
108	28	2.0	33	2.0	42	2.0				
109	21	4.0	22	2.0	28	1.0				
110	2	3.0	21	1.0	22	3.0	43	3.0		
111	21	1.0	22	4.0	26	2.0	28	1.0	33	3.0
111	46	2.0								
112	2	1.0	4	1.0	21	4.0	22	3.0	33	4.0
113	2	1.0	21	3.0	22	3.0	24	2.0	26	2.0
113	33	1.0	42	2.0	43	3.0	46	1.0		
114	2	2.0	14	1.0	18	1.0	21	2.0	22	3.0
114	24	1.0	42	2.0	43	4.0	50	1.0		
115	2	1.0	3	1.0	21	3.0	22	2.0	33	8.0
115	42	1.0	43	3.0						
116	2	2.0	14	2.0	21	3.0	22	3.0	37	1.0
116	42	2.0								
117	2	3.0	9	1.0	14	1.0	21	3.0	22	3.0
117	24	2.0	26	4.0	28	1.0	42	1.0	43	1.0
117	50	1.0								
118	2	2.0	14	1.0	21	2.0	22	4.0	24	1.0
118	26	3.0	28	1.0	42	1.0	46	1.0		
119	22	5.0								
120	2	3.0	14	2.0	21	1.0	22	1.0	26	5.0
120	31	1.0	42	1.0						
121	2	1.0	22	3.0	43	3.0	50	1.0		
122	5	1.0	33	4.0	43	3.0	46	1.0		
123	22	3.0	29	1.0						
124	3	1.0	22	2.0	28	2.0				
125	1	1.0	2	1.0	3	1.0	22	3.0	29	2.0
125	42	2.0								
126	3	1.0	5	2.0	29	1.0	33	7.0	42	1.0
127	1	2.0	2	2.0	3	1.0	22	3.0	33	2.0
127	34	2.0	42	2.0	49	1.0				
128	5	1.0	10	2.0	22	3.0	29	2.0	36	1.0
128	40	1.0	42	3.0	46	1.0				
129	21	2.0	22	1.0	26	2.0	36	3.0	42	1.0
129	46	2.0								
130	26	8.0	42	3.0	46	4.0	48	1.0		
131	2	2.0	22	3.0	26	2.0	36	1.0	40	1.0
131	42	5.0	50	1.0						
132	2	2.0	3	2.0	5	1.0	14	2.0	22	3.0
132	25	1.0	26	2.0	28	1.0	29	1.0	33	3.0
132	48	1.0								
133	2	3.0	3	1.0	14	2.0	21	2.0	22	3.0
133	25	1.0	29	1.0	36	2.0	40	2.0	42	2.0
133	48	1.0	50	1.0						
134	26	1.0	31	2.0	33	2.0	36	2.0	42	2.0
135	3	1.0	5	2.0	26	3.0	36	1.0	42	3.0
135	50	1.0								
136	3	1.0	22	2.0						
137	1	1.0	3	1.0	5	1.0	14	1.0	22	1.0
137	26	3.0	31	1.0	33	1.0	36	1.0	42	2.0
137	48	1.0								
138	5	1.0	22	5.0	42	1.0	48	1.0		
139	22	4.0	26	5.0	33	2.0	36	1.0	42	2.0

140	1	1.0	2	3.0	3	1.0	22	3.0	33	2.0
141	1	3.0	2	2.0	3	2.0	11	2.0	22	3.0
141	28	1.0	42	4.0	48	1.0	50	1.0		
142	1	1.0	2	1.0	22	4.0	28	1.0	33	6.0
142	42	2.0								
143	1	1.0	3	1.0	22	1.0	26	2.0	30	1.0
143	31	1.0	33	6.0	42	1.0	48	2.0		
144	1	1.0	10	2.0	22	2.0	23	1.0	26	6.0
144	29	3.0	33	4.0	36	2.0	42	1.0	46	1.0
144	48	1.0								
145	1	1.0	22	1.0	26	6.0	33	4.0	36	2.0
145	41	1.0	42	1.0	43	1.0	49	1.0		
146	1	1.0	4	1.0	22	1.0	26	7.0	28	2.0
146	33	5.0	42	4.0	46	2.0				
147	1	2.0	2	1.0	22	1.0	26	3.0	28	1.0
147	33	7.0	36	1.0	42	1.0	46	3.0		
148	1	2.0	11	2.0	22	3.0	26	5.0	28	1.0
148	33	6.0	50	1.0						
149	1	2.0	22	3.0	26	5.0	28	1.0	33	5.0
149	36	1.0	42	3.0	46	1.0				
150	1	2.0	22	1.0	26	6.0	31	1.0	33	7.0
150	44	1.0	50	1.0						
151	1	2.0	22	1.0	26	3.0	33	5.0	36	2.0
151	42	2.0	43	2.0	46	1.0				
152	3	1.0	22	4.0	25	1.0	31	2.0	42	3.0
152	50	1.0								
153	3	1.0	22	4.0	25	1.0	26	3.0	28	1.0
153	31	1.0	33	3.0	36	1.0	40	1.0	42	4.0
153	46	3.0								
154	5	1.0	22	2.0	28	1.0	33	6.0	36	2.0
154	42	2.0	46	4.0						
155	1	1.0	22	1.0	25	1.0	28	1.0	33	2.0
155	41	2.0	42	1.0	46	3.0				
156	1	2.0	14	3.0	22	1.0	26	1.0	31	1.0
156	42	1.0	46	1.0						
157	3	3.0	22	1.0	28	1.0	31	1.0	33	4.0
157	36	1.0	42	1.0	46	4.0				
158	1	2.0	11	1.0	22	4.0	26	3.0	28	3.0
158	33	9.0	40	1.0	42	3.0				
159	1	2.0	2	2.0	22	3.0	28	2.0	33	9.0
159	46	2.0								
160	3	2.0	14	3.0	22	3.0	25	1.0	28	1.0
160	33	3.0	46	1.0						
161	1	1.0	3	2.0	22	2.0	26	3.0	33	5.0
161	46	3.0								
162	1	1.0	3	2.0	14	2.0	22	3.0	28	2.0
162	33	2.0	42	1.0	46	2.0				
163	1	1.0	11	2.0	22	2.0	28	2.0	33	4.0
163	46	2.0								
164	1	2.0	2	1.0	14	3.0	22	4.0	28	1.0
164	33	3.0	36	1.0	46	3.0				
165	2	3.0	22	4.0	33	1.0				
166	1	1.0	2	2.0	3	2.0	22	1.0	42	1.0
166	46	3.0	50	1.0						
167	1	3.0	11	3.0	14	1.0	22	2.0	31	2.0
167	33	9.0	40	2.0	42	1.0	50	1.0		
168	1	1.0	3	1.0	26	8.0	31	1.0	33	4.0
168	42	2.0	46	3.0						
169	22	1.0	25	1.0	26	3.0	28	2.0	31	2.0
169	43	2.0								

170	22	2.0	28	1.0	31	1.0	46	1.0	50	1.0
171	1	2.0	3	1.0	14	1.0	22	2.0	26	7.0
171	33	3.0	42	1.0	46	2.0				
172	1	2.0	3	1.0	14	2.0	22	3.0	28	2.0
172	31	1.0	43	1.0	46	2.0				
173	1	3.0	2	1.0	3	2.0	14	2.0	22	1.0
173	26	1.0	28	1.0	33	8.0	48	1.0	50	2.0
174	1	3.0	22	3.0	33	4.0	42	2.0		
175	1	1.0	3	1.0	15	1.0	28	2.0	41	1.0
175	42	3.0	46	1.0						
176	1	2.0	3	1.0	22	1.0	28	1.0	43	1.0
176	46	2.0								
177	1	4.0	22	4.0	26	4.0	28	3.0	33	5.0
177	40	1.0	42	2.0						
178	1	2.0	3	1.0	14	2.0	22	4.0	26	1.0
178	28	4.0	31	1.0	46	1.0				
179	1	2.0	2	1.0	3	1.0	22	1.0	28	2.0
179	31	2.0								
180	1	1.0	2	1.0	3	2.0	14	1.0	22	2.0
180	28	1.0	43	1.0	46	1.0				
181	1	1.0	22	1.0	31	1.0	46	3.0		
182	1	2.0	2	1.0	3	2.0	22	4.0	28	3.0
182	31	1.0	33	3.0	46	4.0				
183	1	2.0	3	2.0	22	3.0	28	2.0	43	1.0
184	1	2.0	11	3.0	14	4.0	22	4.0	28	2.0
184	29	1.0	31	1.0	33	1.0	42	3.0		
185	1	3.0	2	1.0	3	2.0	5	1.0	14	1.0
185	22	2.0	28	3.0	40	1.0	42	2.0	50	1.0
186	1	3.0	3	1.0	5	1.0	22	1.0	25	4.0
186	28	2.0	31	2.0	33	3.0	40	1.0	46	2.0
187	2	1.0	15	1.0	22	2.0	28	1.0	31	1.0
187	33	3.0	42	1.0	46	1.0				
188	1	2.0	2	1.0	3	2.0	5	2.0	22	4.0
188	26	1.0	28	1.0	33	3.0	42	1.0	46	2.0
188	50	1.0								
189	1	3.0	3	1.0	5	2.0	26	6.0	31	2.0
189	33	9.0	40	1.0	42	1.0	46	1.0		
190	1	2.0	2	1.0	3	2.0	5	2.0	11	3.0
190	26	1.0	28	3.0	31	1.0	33	8.0	46	1.0
191	2	1.0	3	2.0	22	2.0	28	2.0	33	5.0
191	40	3.0	46	1.0						
192	3	1.0	5	1.0	14	3.0	22	2.0	43	3.0
193	3	5.0	22	2.0	26	1.0	28	2.0	33	2.0
193	43	1.0	46	2.0	50	1.0				
194	1	1.0	3	2.0	22	1.0	46	1.0		
195	3	1.0	5	1.0	22	3.0	28	2.0	40	1.0
195	42	1.0	46	3.0						
196	1	1.0	3	1.0	5	1.0	22	2.0	28	3.0
196	46	3.0								
197	1	2.0	3	1.0	5	2.0	14	1.0	22	1.0
197	28	3.0	42	1.0	46	1.0				
198	1	3.0	3	1.0	22	3.0	28	3.0	33	3.0
198	42	1.0	46	1.0						
199	1	2.0	5	2.0	22	3.0	28	3.0	40	1.0
200	1	3.0	3	1.0	5	1.0	10	1.0	14	1.0
200	22	3.0	26	2.0	28	3.0	31	3.0	42	1.0
201	1	3.0	14	2.0	26	3.0	28	4.0	33	2.0
201	42	2.0	50	1.0						
202	2	1.0	3	1.0	22	3.0	28	1.0	42	2.0
203	1	2.0	14	1.0	22	2.0	28	1.0	33	2.0

203	42	1.0	50	1.0						
204	1	1.0	14	1.0	22	2.0	28	2.0	31	1.0
204	33	1.0	42	2.0						
205	5	2.0	22	4.0	33	4.0	50	1.0		
206	22	3.0	28	3.0	31	1.0	50	1.0		
207	22	2.0	28	2.0	33	6.0				
208	1	2.0	3	1.0	22	1.0	28	2.0	31	1.0
208	42	2.0								
209	5	2.0	22	3.0	28	1.0	31	2.0	42	1.0
209	50	1.0								
210	1	2.0	5	1.0	11	1.0	22	4.0	28	3.0
210	33	2.0	42	2.0						
211	14	1.0	22	4.0	33	5.0	46	1.0		
212	1	3.0	5	3.0	14	1.0	28	3.0	31	2
212	33	5.0								
213	1	2.0	22	2.0	28	3.0	31	2.0	46	2.0
214	1	1.0	3	2.0	22	2.0				
215	22	2.0	33	1.0	40	1.0	42	1.0	43	1.0
215	46	1.0	50	1.0						
216	1	1.0	3	2.0	22	3.0	26	1.0	31	1.0
216	33	4.0	42	1.0	46	1.0				
217	1	2.0	3	2.0	14	1.0	33	4.0		
218	1	2.0	41	1.0	46	1.0				
219	1	2.0	14	2.0	33	5.0	36	1.0	42	3.0
219	46	5.0								
220	1	2.0	3	2.0	14	1.0	19	2.0	33	2.0
220	36	1.0	46	3.0						
221	1	1.0	3	1.0	14	1.0	21	1.0	26	7.0
221	31	3.0	42	2.0						
222	3	4.0	4	1.0	14	1.0	19	1.0	22	2.0
222	28	2.0	31	1.0	33	2.0	42	3.0		
223	3	2.0	19	1.0	26	3.0	31	3.0	36	2.0
223	42	1.0								
224	1	3.0	3	2.0	28	1.0				
225	3	3.0	22	1.0	28	1.0	42	1.0		
226	3	4.0	22	2.0	41	1.0	42	1.0		
227	3	2.0	4	1.0	11	1.0	18	3.0	33	3.0
227	36	2.0								
228	3	6.0	4	1.0	22	3.0	46	5.0		
229	3	4.0	4	1.0	19	1.0	22	3.0	46	1.0
230	19	3.0	22	2.0	26	5.0	28	1.0	31	1.0
230	36	2.0	42	3.0						
231	1	2.0	3	3.0	4	2.0	22	1.0	31	1.0
232	1	1.0	3	3.0	31	1.0				
233	3	3.0	4	1.0	26	4.0	31	3.0	33	3.0
233	36	1.0	46	3.0						
234	3	3.0	14	2.0	19	1.0	22	1.0	33	2.0
235	3	2.0	19	1.0	26	1.0	33	4.0	36	3.0
236	1	2.0	22	2.0						
237	2	3.0	3	2.0	22	2.0	26	3.0	31	1.0
237	42	2.0								
238	2	1.0	3	4.0	14	1.0	33	1.0	41	1.0
238	46	1.0	50	1.0						
239	1	1.0	2	1.0	3	4.0	11	4.0	21	1.0
239	31	1.0	33	1.0	42	1.0	50	1.0		
240	1	3.0	3	3.0	5	1.0	22	2.0	31	2.0
240	33	3.0	42	1.0						
241	1	1.0	2	1.0	3	2.0	21	3.0	22	2.0
241	26	3.0	28	2.0	31	1.0	42	2.0		
242	1	3.0	4	2.0	19	3.0	21	4.0	26	3.0

242	28	1.0	36	4.0	41	2.0	42	1.0		
243	1	2.0	2	1.0	3	3.0	15	1.0	17	2.0
243	21	3.0	22	2.0	26	3.0	28	2.0	36	4.0
243	42	1.0	46	3.0	50	1.0				
244	1	3.0	14	1.0	15	1.0	19	2.0	22	2.0
244	28	3.0	33	4.0						
245	1	1.0	14	1.0	18	1.0	19	2.0	22	1.0
245	26	4.0	31	2.0	33	3.0	36	2.0	50	2.0
246	23	1.0	33	4.0						
247	26	2.0	33	4.0	41	3.0				
248	1	1.0	11	1.0	22	1.0	26	2.0	44	1.0
249	1	3.0	22	3.0	26	7.0	28	2.0	36	1.0
249	42	1.0								
250	19	3.0	21	2.0	28	2.0	33	2.0	36	3.0
250	42	1.0								
251	21	2.0	22	1.0	26	4.0	36	3.0	42	2.0
252	1	3.0	15	1.0	19	1.0	21	6.0	22	1.0
252	26	2.0	28	1.0	41	1.0	42	2.0		
253	3	5.0	14	1.0	19	1.0	21	3.0	26	1.0
253	27	4.0	28	2.0	33	2.0				
254	3	6.0	19	1.0	21	3.0	24	1.0	26	1.0
254	28	2.0	29	2.0	31	2.0	42	1.0		
255	3	3.0	4	1.0	18	1.0	22	1.0		
256	1	2.0	3	1.0	18	1.0	24	1.0	26	3.0
256	36	2.0	50	3.0						
257	1	3.0	19	2.0	22	1.0	33	1.0		
258	1	2.0	3	1.0	22	1.0	26	4.0	33	4.0
258	42	2.0	50	1.0						
259	1	3.0	3	1.0	5	1.0	14	1.0	21	4.0
259	26	2.0	29	2.0	36	4.0	41	1.0	42	4.0
259	50	1.0								
260	1	2.0	19	3.0	21	5.0	22	1.0	24	1.0
260	26	1.0	28	3.0	33	2.0	36	3.0	42	1.0
260	50	1.0								
261	1	2.0	3	1.0	19	2.0	21	6.0	24	2.0
261	25	3.0	26	1.0	28	3.0	29	2.0	31	2.0
261	36	4.0	42	3.0	46	2.0	50	2.0		
262	1	1.0	5	1.0	21	3.0	22	1.0	25	2.0
262	26	2.0	28	4.0	42	1.0				
263	1	2.0	3	1.0	5	1.0	19	1.0	21	3.0
263	22	2.0	28	5.0	29	3.0	31	1.0	36	2.0
263	42	3.0	46	1.0						
264	1	3.0	19	1.0	21	4.0	26	2.0	31	2.0
264	36	3.0								
265	3	1.0	5	1.0	14	1.0	18	2.0	19	2.0
265	21	2.0	22	1.0	28	2.0	36	3.0	42	2.0
265	46	3.0								
266	3	1.0	19	2.0	22	1.0	26	3.0	28	3.0
266	33	2.0	40	2.0	41	1.0	42	1.0	46	1.0
266	50	1.0								
267	14	1.0	15	1.0	17	1.0	29	2.0	31	1.0
268	3	2.0	5	1.0	23	3.0	40	2.0	50	2.0
269	5	1.0	18	1.0	19	3.0	23	4.0	33	4.0
270	5	2.0	18	1.0	22	1.0	24	2.0	26	3.0
270	42	3.0	50	1.0						
271	18	1.0	26	3.0	29	1.0	41	3.0		
272	3	2.0	14	1.0	19	1.0	31	1.0		
273	3	1.0								
274	3	2.0	31	1.0						
275	3	2.0	5	1.0	14	1.0	16	1.0	19	2.0

275	26	5.0	28	1.0	36	1.0	40	1.0	42	3.0
276	14	1.0	16	1.0	18	2.0	19	2.0	21	2.0
276	29	1.0	36	2.0	42	1.0	50	2.0		
277	18	2.0	19	1.0	21	4.0	26	4.0	29	1.0
277	33	4.0	36	3.0	42	1.0	50	1.0		
278	5	2.0	14	1.0	18	2.0	19	1.0	21	3.0
278	28	1.0	33	5.0	42	2.0	50	1.0		
279	5	2.0	14	1.0	18	2.0	19	2.0	21	3.0
279	28	1.0	33	3.0	36	3.0	42	2.0		
280	5	1.0	18	1.0	21	3.0	28	3.0	33	3.0
280	35	1.0	42	2.0	46	2.0				
281	3	1.0	21	3.0	22	1.0	28	1.0	33	2.0
281	42	2.0								
282	3	1.0	5	1.0	14	3.0	21	3.0	22	1.0
282	28	2.0	33	2.0	36	3.0	41	1.0	42	2.0
283	5	3.0	14	3.0	21	3.0	22	1.0	28	2.0
283	40	1.0								
284	3	2.0	5	1.0	18	1.0	21	4.0	31	2.0
284	36	2.0								
285	3	2.0	16	1.0	17	1.0	19	2.0	21	3.0
285	28	1.0	29	1.0						
286	19	2.0	21	3.0	33	4.0	40	1.0	42	1.0
287	5	2.0	21	3.0	33	4.0				
288	3	1.0	14	1.0	19	1.0	22	1.0	33	1.0
288	45	1.0								
289	3	1.0	5	2.0	19	3.0	22	1.0	23	2.0
289	26	3.0	40	1.0	42	2.0				
290	22	1.0								
291	11	2.0	14	1.0	26	1.0	42	1.0		
292	3	2.0	5	2.0	16	1.0	17	1.0	18	1.0
292	19	2.0	21	1.0	22	2.0	28	1.0	29	4.0
292	42	3.0								
293	13	1.0	18	2.0	19	1.0	21	1.0	26	2.0
293	31	1.0	33	6.0	42	1.0				
294	5	1.0	29	1.0	42	1.0				
295	2	1.0	5	1.0	16	1.0	40	1.0	42	1.0
296	28	1.0								
297	3	2.0	5	2.0	26	2.0	31	1.0	33	7.0
297	42	2.0								
298	3	2.0	5	1.0	24	1.0	31	1.0	33	6.0
299	19	3.0	33	2.0						
300	3	1.0								
301	3	1.0	18	1.0	31	1.0	33	3.0		
302	14	4.0	22	1.0						
303	3	2.0								
304	18	2.0								
305	1	2.0	5	3.0	26	6.0	41	1.0		
306	5	1.0	14	1.0	19	1.0	42	2.0	48	1.0
307	1	1.0	19	1.0	42	1.0				
308	4	1.0	22	4.0	50	1.0				
309	1	3.0	5	2.0	9	1.0	22	4.0		
310	1	6.0	9	1.0	22	3.0	29	1.0	42	1.0
311	1	4.0	5	2.0	41	1.0	44	1.0		
312	22	2.0								
313	1	3.0	22	1.0						
314	22	2.0	33	2.0						
315	1	2.0	29	2.0						
316	22	3.0	29	1.0	50	1.0				
317	1	1.0	5	3.0	22	2.0	26	1.0	29	1.0
317	33	1.0	41	1.0	42	1.0				

318	22	1.0	24	1.0	29	1.0	32	1.0	44	1.0
319	1	3.0	8	1.0	22	1.0	40	1.0	46	1.0
320	1	2.0	15	1.0	22	2.0	26	1.0	46	1.0
321	2	1.0	22	2.0						
322	1	1.0	5	2.0	14	2.0	21	4.0	24	3.0
322	26	1.0	31	2.0	40	2.0	42	1.0		
323	1	2.0	8	1.0	21	3.0	24	2.0	31	1.0
324	22	2.0	30	1.0	31	4.0	37	1.0	42	1.0
325	8	1.0	14	1.0	22	2.0	31	2.0	50	1.0
326	22	2.0	30	2.0	31	2.0	50	1.0		
327	14	1.0	31	3.0	50	1.0				
328	22	2.0	31	3.0						
329	14	1.0	22	3.0	30	1.0	31	1.0	37	2.0
330	16	1.0	22	3.0	31	1.0				
331	22	2.0	31	3.0	37	1.0				
332	19	1.0	25	1.0	31	2.0	42	1.0	50	1.0
333	22	2.0								
334	15	1.0	19	3.0						
335	14	2.0	15	2.0	19	1.0	43	2.0	44	1.0
336	22	2.0	31	1.0	41	1.0	42	1.0	50	1.0
337	3	1.0	22	1.0	42	1.0				
338	15	2.0	42	2.0						
339	15	2.0	22	1.0	42	4.0				
340	5	2.0	15	2.0	26	3.0	42	3.0		
341	15	3.0	22	1.0						
342	5	2.0	22	2.0						
343	5	3.0	22	3.0	42	1.0				
344	3	1.0	4	1.0	5	1.0	22	1.0	42	2.0
344	50	1.0								
345	5	1.0	15	1.0	22	1.0	25	2.0	31	2.0
345	42	1.0	50	2.0						
346	3	1.0	5	1.0	31	2.0	42	1.0	50	2.0
347	5	1.0	15	2.0	22	2.0	31	1.0	42	2.0
347	50	2.0								
348	3	1.0	5	2.0	15	4.0	50	1.0		
349	5	1.0	15	2.0	42	1.0				
350	5	1.0	15	1.0	22	1.0	50	1.0		
351	22	2.0								
352	50	2.0								
353	22	2.0								
354	3	1.0	15	1.0						
355	22	2.0								
356	1	1.0	6	1.0	24	1.0	50	1.0		
357	3	2.0	5	1.0	15	3.0				
358	15	4.0								
359	3	2.0	5	1.0	8	1.0	22	2.0	42	2.0
360	3	3.0	15	1.0	22	2.0				
361	1	1.0	3	5.0						
362	3	6.0	22	2.0						
363	3	4.0	50	1.0						
364	3	3.0	22	2.0	31	2.0	42	1.0	50	3.0
365	3	6.0	4	1.0	5	1.0	22	1.0		
366	3	7.0	15	2.0	21	4.0	22	1.0	24	1.0
366	42	1.0	50	1.0						
367	3	6.0	4	1.0	15	4.0	21	2.0	22	2.0
367	42	2.0								
368	3	2.0	4	1.0	15	3.0	22	1.0	31	1.0
368	42	2.0	50	1.0						
369	3	1.0	22	1.0	31	2.0	42	1.0		
370	3	2.0	8	1.0	14	2.0	21	2.0	26	1.0

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370   31  1.0  42  1.0
371    2  1.0   3  5.0   5  2.0  14  2.0  21  3.0
371   46  1.0
372    3  2.0  14  3.0  19  1.0  21  3.0  26  4.0
372   31  2.0  42  2.0
373    3  1.0  14  3.0  17  1.0  21  3.0  42  1.0
374    3  2.0  12  4.0  14  3.0  17  1.0  21  1.0
374   26  3.0  42  3.0  46  1.0
375    3  7.0  14  2.0  28  1.0  42  2.0
376    3  2.0  14  1.0  21  2.0  43  1.0  50  1.0
377   21  3.0  22  2.0
378    3  1.0   8  1.0  14  2.0  21  2.0  22  2.0
378   24  1.0  28  1.0
379    3  2.0  17  1.0  21  2.0  31  2.0  42  1.0
379   50  1.0
380    3  2.0  21  3.0  42  3.0
381   21  4.0  25  1.0  26  1.0  28  1.0  34  2.0
381   37  1.0  42  4.0
382    3  4.0   5  1.0  14  1.0  21  4.0  26  1.0
382   31  3.0  42  3.0  46  4.0
383   14  4.0  21  2.0  22  3.0  28  1.0  31  1.0
383   46  2.0  50  2.0
384    4  2.0  19  1.0  21  3.0  22  1.0  42  1.0
384   50  1.0
385    1  1.0   4  2.0  14  1.0  22  2.0  30  1.0
385   42  1.0  43  1.0
386    4  1.0  21  1.0  22  2.0  26  2.0  28  1.0
386   31  2.0  42  4.0
387    3  1.0   4  1.0  21  2.0  22  4.0  26  1.0
387   42  4.0  44  2.0  50  2.0
388    3  2.0   4  1.0  22  4.0  26  1.0  31  4.0
388   42  3.0  50  1.0
389    3  2.0   4  1.0  21  3.0  22  2.0  26  2.0
389   31  1.0  42  2.0  46  2.0  50  2.0
390    4  2.0  21  3.0  26  2.0  28  1.0  42  1.0
390   44  1.0  46  1.0  50  1.0
391    3  1.0   4  1.0   5  1.0  21  3.0  22  2.0
391   31  1.0  42  2.0
392    3  1.0   5  1.0  21  4.0  22  3.0  25  2.0
392   26  4.0  28  1.0  30  2.0  31  3.0  34  1.0
392   42  1.0  44  3.0  46  1.0  48  3.0  50  2.0
393   14  1.0  21  2.0  22  3.0  23  2.0  25  1.0
393   26  3.0  30  2.0  31  3.0  34  1.0  42  5.0
393   48  1.0  50  3.0
394    1  2.0   3  2.0   4  3.0   5  1.0  21  3.0
394   25  2.0  26  1.0  28  1.0  30  1.0  31  1.0
394   33  4.0  42  4.0  44  1.0  48  1.0  50  1.0
395    1  2.0   3  1.0  15  1.0  17  1.0  18  1.0
395   21  2.0  22  1.0  26  1.0  28  1.0  31  3.0
395   42  3.0  48  1.0  50  2.0
396    3  1.0   5  1.0  17  1.0  22  2.0  31  2.0
396   42  2.0
397    3  3.0  22  4.0  31  1.0
398   22  4.0  31  3.0  42  2.0
399    3  5.0  14  2.0  22  5.0  23  1.0  31  2.0
399   50  2.0
400   30  1.0  31  3.0
  0
ACA KAR ACA TOR ACA MEL ACA REF ACA HER ACA HEB ACA ERU ACA NIL BOS ALB CAR EDU
CAS TRA CAT ALE CIS JUT COM HER COM IMB COM MOL COM API COM AFR COM PYR COM GLA
```

CRO GRA DIC CIN DIO LYS DOM ROT EHR RIG EUC UND FIC THO GRE GLA GRE FLS GRE BIC

GRE RET GRE VIL MAY HET MAY SEN MUN SER OLE EUR OZO INS OZO PAN PAV ZEY PEL AFR

RHU LAN RHU MAR RHU PYR SEC VIR SCL BIR TAR CAM TER PRU XIM CAF XIM AME ZIZ MUC

......1	2	3	4	5	6	7	8	9	10
.....11	12	13	14	15	16	17	18	19	20
.....21	22	23	24	25	26	27	28	29	30
.....31	32	33	34	35	36	37	38	39	40
.....41	42	43	44	45	46	47	48	49	50
.....51	52	53	54	55	56	57	58	59	60
.....61	62	63	64	65	66	67	68	69	70
.....71	72	73	74	75	76	77	78	79	80
.....81	82	83	84	85	86	87	88	89	90
.....91	92	93	94	95	96	97	98	99	100
....101	102	103	104	105	106	107	108	109	110
....111	112	113	114	115	116	117	118	119	120
....121	122	123	124	125	126	127	128	129	130
....131	132	133	134	135	136	137	138	139	140
....141	142	143	144	145	146	147	148	149	150
....151	152	153	154	155	156	157	158	159	160
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....201	202	203	204	205	206	207	208	209	210
....211	212	213	214	215	216	217	218	219	220
....221	222	223	224	225	226	227	228	229	230
....231	232	233	234	235	236	237	238	239	240
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....251	252	253	254	255	256	257	258	259	260
....261	262	263	264	265	266	267	268	269	270
....271	272	273	274	275	276	277	278	279	280
....281	282	283	284	285	286	287	288	289	290
....291	292	293	294	295	296	297	298	299	300
....301	302	303	304	305	306	307	308	309	310
....311	312	313	314	315	316	317	318	319	320
....321	322	323	324	325	326	327	328	329	330
....331	332	333	334	335	336	337	338	339	340
....341	342	343	344	345	346	347	348	349	350
....351	352	353	354	355	356	357	358	359	360
....361	362	363	364	365	366	367	368	369	370
....371	372	373	374	375	376	377	378	379	380
....381	382	383	384	385	386	387	388	389	390
....391	392	393	394	395	396	397	398	399	400

ANNEXURE 2

Environmental Data Input File

for Canoco CCA Programme

ENVIRONMENTAL VARIABLES - KARSTLAND DATA

(I5,X,I1,F7.0,X,I2,F8.0,X,I2,F6.0,2(2X,I2,F2.0))

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3	1	542.5	2	1566.8	3	20.0	4	1	10	1
4	1	542.5	2	1566.8	3	20.0	4	1	10	1
5	1	542.5	2	1566.8	3	20.0	4	1	10	1
6	1	542.5	2	1566.8	3	20.0	4	1	10	1
7	1	542.5	2	1566.8	3	20.0	4	1	10	1
8	1	542.5	2	1566.8	3	20.0	4	1	10	1
9	1	542.5	2	1566.8	3	20.0	4	1	10	1
10	1	542.5	2	1566.8	3	20.0	4	1	10	1
11	1	542.5	2	1566.8	3	20.0	4	1	10	1
12	1	542.5	2	1566.8	3	20.0	4	1	10	1
13	1	542.5	2	1566.8	3	10.0	4	1	12	1
14	1	542.5	2	1566.8	3	10.0	4	1	12	1
15	1	542.5	2	1566.8	3	10.0	4	1	12	1
16	1	542.5	2	1566.8	3	10.0	4	1	12	1
17	1	542.5	2	1566.8	3	10.0	4	1	12	1
18	1	542.5	2	1566.8	3	10.0	4	1	12	1
19	1	542.5	2	1566.8	3	10.0	4	1	12	1
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21	1	542.5	2	1566.8	3	10.0	4	1	12	1
22	1	542.5	2	1566.8	3	10.0	4	1	12	1
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24	1	542.5	2	1566.8	3	10.0	4	1	12	1
25	1	542.5	2	1566.8	3	10.0	4	1	12	1
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27	1	542.5	2	1566.8	3	10.0	4	1	12	1
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30	1	601.5	2	1542.4	3	25.0	4	1	11	1
31	1	601.5	2	1542.4	3	25.0	4	1	11	1
32	1	601.5	2	1542.4	3	25.0	4	1	11	1
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34	1	601.5	2	1542.4	3	25.0	4	1	11	1
35	1	601.5	2	1542.4	3	25.0	4	1	11	1
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44	1	601.5	2	1542.4	3	25.0	4	1	11	1
45	1	601.5	2	1542.4	3	25.0	4	1	11	1
46	1	601.5	2	1542.4	3	25.0	4	1	11	1
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61	1	601.5	2	1542.4	3	15.0	5	1	11	1
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63	1	601.5	2	1542.4	3	15.0	5	1	11	1
64	1	601.5	2	1542.4	3	15.0	5	1	11	1
65	1	601.5	2	1542.4	3	15.0	5	1	11	1
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337	1	513.5	2	1533.7	3	25.0	4	1	11	1
338	1	513.5	2	1533.7	3	25.0	4	1	11	1
339	1	513.5	2	1533.7	3	25.0	4	1	11	1
340	1	513.5	2	1533.7	3	25.0	4	1	11	1
341	1	513.5	2	1533.7	3	25.0	4	1	11	1
342	1	513.5	2	1533.7	3	25.0	4	1	11	1
343	1	513.5	2	1533.7	3	25.0	4	1	11	1
344	1	513.5	2	1533.7	3	25.0	4	1	11	1
345	1	513.5	2	1533.7	3	25.0	4	1	11	1
346	1	513.5	2	1533.7	3	25.0	4	1	11	1
347	1	513.5	2	1533.7	3	25.0	4	1	11	1
348	1	513.5	2	1533.7	3	25.0	4	1	11	1
349	1	513.5	2	1533.7	3	25.0	4	1	11	1
350	1	513.5	2	1533.7	3	25.0	4	1	11	1
351	1	513.5	2	1533.7	3	25.0	4	1	11	1
352	1	513.5	2	1533.7	3	25.0	4	1	11	1
353	1	513.5	2	1533.7	3	30.0	9	1	11	1
354	1	513.5	2	1533.7	3	30.0	9	1	11	1
355	1	513.5	2	1533.7	3	30.0	9	1	11	1
356	1	513.5	2	1533.7	3	30.0	9	1	11	1
357	1	513.5	2	1533.7	3	30.0	9	1	11	1

358	1	513.5	2	1533.7	3	30.0	9 1	11 1
359	1	513.5	2	1533.7	3	30.0	9 1	11 1
360	1	513.5	2	1533.7	3	30.0	9 1	11 1
361	1	513.5	2	1533.7	3	30.0	9 1	11 1
362	1	513.5	2	1533.7	3	30.0	9 1	11 1
363	1	513.5	2	1533.7	3	25.0	4 1	11 1
364	1	513.5	2	1533.7	3	25.0	4 1	11 1
365	1	513.5	2	1533.7	3	25.0	4 1	11 1
366	1	513.5	2	1533.7	3	25.0	4 1	12 1
367	1	513.5	2	1533.7	3	25.0	4 1	12 1
368	1	513.5	2	1533.7	3	25.0	4 1	12 1
369	1	513.5	2	1533.7	3	25.0	4 1	12 1
370	1	513.5	2	1533.7	3	25.0	4 1	12 1
371	1	513.5	2	1533.7	3	25.0	4 1	12 1
372	1	513.5	2	1533.7	3	25.0	4 1	12 1
373	1	513.5	2	1533.7	3	25.0	4 1	12 1
374	1	513.5	2	1533.7	3	25.0	4 1	12 1
375	1	513.5	2	1533.7	3	25.0	4 1	12 1
376	1	513.5	2	1533.7	3	25.0	4 1	12 1
377	1	513.5	2	1533.7	3	25.0	4 1	12 1
378	1	513.5	2	1533.7	3	25.0	4 1	10 1
379	1	513.5	2	1533.7	3	25.0	4 1	10 1
380	1	513.5	2	1533.7	3	25.0	4 1	10 1
381	1	513.5	2	1533.7	3	25.0	4 1	10 1
382	1	513.5	2	1533.7	3	25.0	4 1	10 1
383	1	513.5	2	1533.7	3	25.0	4 1	10 1
384	1	513.5	2	1533.7	3	25.0	4 1	10 1
385	1	513.5	2	1533.7	3	25.0	4 1	10 1
386	1	513.5	2	1533.7	3	25.0	4 1	10 1
387	1	513.5	2	1533.7	3	25.0	4 1	10 1
388	1	513.5	2	1533.7	3	25.0	4 1	10 1
389	1	513.5	2	1533.7	3	25.0	4 1	10 1
390	1	513.5	2	1533.7	3	25.0	4 1	10 1
391	1	513.5	2	1533.7	3	25.0	4 1	10 1
392	1	513.5	2	1533.7	3	25.0	4 1	10 1
393	1	513.5	2	1533.7	3	25.0	4 1	10 1
394	1	513.5	2	1533.7	3	25.0	4 1	10 1
395	1	513.5	2	1533.7	3	25.0	4 1	10 1
396	1	513.5	2	1533.7	3	25.0	4 1	10 1
397	1	513.5	2	1533.7	3	25.0	4 1	10 1
398	1	513.5	2	1533.7	3	25.0	4 1	10 1
399	1	513.5	2	1533.7	3	25.0	4 1	10 1
400	1	513.5	2	1533.7	3	25.0	4 1	10 1

0

RAI1SEA PLAIN	RAI3SEA SLOPE	A1	MISP	HUTT	GLEN	RENS	MILK	KATS	CONTA
......1	2	3	4	5	6	7	8	9	10
.....11	12	13	14	15	16	17	18	19	20
.....21	22	23	24	25	26	27	28	29	30
.....31	32	33	34	35	36	37	38	39	40
.....41	42	43	44	45	46	47	48	49	50
.....51	52	53	54	55	56	57	58	59	60
.....61	62	63	64	65	66	67	68	69	70
.....71	72	73	74	75	76	77	78	79	80
.....81	82	83	84	85	86	87	88	89	90
.....91	92	93	94	95	96	97	98	99	100
....101	102	103	104	105	106	107	108	109	110
....111	112	113	114	115	116	117	118	119	120
....121	122	123	124	125	126	127	128	129	130
....131	132	133	134	135	136	137	138	139	140

....141	142	143	144	145	146	147	148	149	150
....151	152	153	154	155	156	157	158	159	160
....161	162	163	164	165	166	167	168	169	170
....171	172	173	174	175	176	177	178	179	180
....181	182	183	184	185	186	187	188	189	190
....191	192	193	194	195	196	197	198	199	200
....201	202	203	204	205	206	207	208	209	210
....211	212	213	214	215	216	217	218	219	220
....221	222	223	224	225	226	227	228	229	230
....231	232	233	234	235	236	237	238	239	240
....241	242	243	244	245	246	247	248	249	250
....251	252	253	254	255	256	257	258	259	260
....261	262	263	264	265	266	267	268	269	270
....271	272	273	274	275	276	277	278	279	280
....281	282	283	284	285	286	287	288	289	290
....291	292	293	294	295	296	297	298	299	300
....301	302	303	304	305	306	307	308	309	310
....311	312	313	314	315	316	317	318	319	320
....321	322	323	324	325	326	327	328	329	330
....331	332	333	334	335	336	337	338	339	340
....341	342	343	344	345	346	347	348	349	350
....351	352	353	354	355	356	357	358	359	360
....361	362	363	364	365	366	367	368	369	370
....371	372	373	374	375	376	377	378	379	380
....381	382	383	384	385	386	387	388	389	390
....391	392	393	394	395	396	397	398	399	400

ANNEXURE 3

Canoco CCA Programme

Output File

```
TYPE NAME OF OUTPUT FILE
a:newr3-01
1 **** CANOCO **** VERSION 2.1 **** MARCH 1987 ****

 PROGRAM CANOCO - WRITTEN BY CAJO J.F. TER BRAAK
 COPYRIGHT (C) 1987 TNO INSTITUTE OF APPLIED COMPUTER SCIENCE,
 BOX 100, 6700 AC WAGENINGEN, THE NETHERLANDS.
 CANOCO PERFORMS (PARTIAL) (DETRENDED) (CANONICAL) CORRESPONDENCE ANALYSIS,
 PRINCIPAL COMPONENTS ANALYSIS AND REDUNDANCY ANALYSIS.
 THE PROGRAM IS AN EXTENSION OF CORNELL ECOLOGY PROGRAM DECORANA (M.O. HILL,1979)

 FOR EXPLANATION OF THE INPUT/OUTPUT SEE THE MANUAL OR
 TER BRAAK, C.J.F. (1987) ORDINATION. CHAPTER 5 IN:
 DATA ANALYSIS IN COMMUNITY AND LANDSCAPE ECOLOGY
 (JONGMAN, R.H.G., TER BRAAK, C.J.F. AND VAN TONGEREN, O.F.R., EDS), PUDOC, WAGENINGEN.

 *** TYPE OF ANALYSIS ***
  MODEL              GRADIENT ANALYSIS
              INDIRECT     DIRECT     HYBRID
 LINEAR        1=PCA       2= RDA       3
 UNIMODAL      4= CA       5= CCA       6
    ,,         7=DCA       8=DCCA       9
              10=NON-STANDARD ANALYSIS
 TYPE ANALYSIS NUMBER
 ANSWER =  5

 TYPE NAME OF FILE WITH SPECIES DATA
 a:karst400.spe
 TYPE NAME OF FILE WITH ENVIRONMENTAL DATA
 a:karst400.env
 TYPE 1 IF YOU HAVE COVARIABLES, ELSE TYPE 0
 *EXPLANATION* COVARIABLES ARE:
              VARIABLES WITH KNOWN OR UNINTERESTING EFFECTS ON THE SPECIES.
              THEIR EFFECTS ARE ELIMINATED WHEN EXTRACTING ORDINATION AXES.
 ANSWER =  0

 *** SCALING OF ORDINATION SCORES ***
 1 = SAMPLE  SCORES ARE WEIGHTED MEAN SPECIES SCORES
 2 = SPECIES   ,,    ,, WEIGHTED MEAN SAMPLE     ,,
 3 = SYMMETRIC SCALING
 ANSWER =  1

 TYPE 1 FOR A MACHINE READABLE COPY OF THE SOLUTION
 ANSWER =  0


 FILE   : a:karst400.spe
 TITLE  : SPECIES - KARSTLAND DATA - APRIL/MAY 1986
 FORMAT :  (I10,X,5(I4,F5.0))
 NO. OF COUPLETS OF SPECIES NUMBER AND ABUNDANCE PER LINE :    5


 ENTER NUMBERS (NOT NAMES) OF SAMPLES TO BE OMITTED
 ONE AT A TIME, ENDING LIST WITH A ZERO
           0
 NUMBER OF SAMPLES           400
 NUMBER OF SPECIES            50
 NUMBER OF OCCURRENCES      2434


 FILE  : a:karst400.env
```

```
TITLE : ENVIRONMENTAL VARIABLES - KARSTLAND DATA
NO. OF ENVIRONMENTAL VARIABLES :    12
FORMAT :
(I5,X,I1,F7.0,X,I2,F8.0,X,I2,F6.0,2(2X,I2,F2.0))


ENTER NUMBERS (NOT NAMES) OF ENVIRONMENTAL VARIABLES TO BE OMITTED
ONE AT A TIME, ENDING LIST WITH A ZERO
                          0

*** INTERACTIONS OF ENVIRONMENTAL VARIABLES ***

ENTER PAIRS OF NUMBERS OF  ENVIRONMENTAL VARIABLES
IF YOU WISH TO DEFINE PRODUCT VARIABLES
ENTER -1 0 IF NO (FURTHER) PRODUCT VARIABLES ARE DESIRED

NO INTERACTION VARIABLES DEFINED


*** TRANSFORMATION OF SPECIES DATA ***
 TYPE -1 0 IF NO TRANSFORMATION IS REQUIRED
 TYPE -2 0 FOR THE SQUAREROOT-TRANSFORMATION
 TYPE -3 0 FOR LN(Y+C)-TRANSFORMATION
OR
 ENTER COUPLETS OF OLD AND NEW VALUES FOR
 PIECEWISE LINEAR TRANSFORMATION, ENDING WITH -1 0
(IF NO TRANSFORMATION DESIRED, MERELY PRESS RETURN)
   -1.00     .00
NO TRANSFORMATION OF DATA WILL BE MADE
TYPE NON-NEGATIVE WEIGHT TO BE GIVEN TO
* SAMPLES * THAT YOU WILL BE ASKED TO SPECIFY NEXT, OR
TYPE 0.01 TO GIVE ITEM NEGLIGIBLE WEIGHT
TYPE 0    TO DELETE ITEM
ANSWER =       1.00

TYPE NON-NEGATIVE WEIGHT TO BE GIVEN TO
* SPECIES * THAT YOU WILL BE ASKED TO SPECIFY NEXT, OR
TYPE 0.01 TO GIVE ITEM NEGLIGIBLE WEIGHT
TYPE 0    TO DELETE ITEM
ANSWER =       1.00

IS DOWNWEIGHTING OF RARE SPECIES REQUIRED?
TYPE 1 IF YES, TYPE 0 IF NO
ANSWER =  0


NO. OF ACTIVE  SAMPLES:    400
NO. OF PASSIVE SAMPLES:      0
NO. OF ACTIVE  SPECIES:     48

****** COLLINEARITY DETECTED WHEN FITTING VARIABLE    9 ******

VARIABLE      9 OMITTED

****** COLLINEARITY DETECTED WHEN FITTING VARIABLE   12 ******

VARIABLE     12 OMITTED

ITERATION REPORT AXIS   1
RESIDUAL   .028066      AT ITERATION  0
```

RESIDUAL .008048 AT ITERATION 1
RESIDUAL .000950 AT ITERATION 2
RESIDUAL .000168 AT ITERATION 3
RESIDUAL .000031 AT ITERATION 4
EIGENVALUE .17673

ITERATION REPORT AXIS 2
RESIDUAL .022713 AT ITERATION 0
RESIDUAL .000771 AT ITERATION 1
RESIDUAL .000007 AT ITERATION 2
EIGENVALUE .15712

ITERATION REPORT AXIS 3
RESIDUAL .010316 AT ITERATION 0
RESIDUAL .000150 AT ITERATION 1
RESIDUAL .000004 AT ITERATION 2
EIGENVALUE .11549

ITERATION REPORT AXIS 4
RESIDUAL .024675 AT ITERATION 0
RESIDUAL .000223 AT ITERATION 1
RESIDUAL .000001 AT ITERATION 2
EIGENVALUE .09163

1

**** WEIGHTED CORRELATION MATRIX (WEIGHT = SAMPLE TOTAL) ****

	SPEC AX1	SPEC AX2	SPEC AX3	SPEC AX4	ENVI AX1	ENVI AX2	ENVI AX3	ENVI AX4
SPEC AX1	1.0000							
SPEC AX2	-.0564	1.0000						
SPEC AX3	.0476	-.0439	1.0000					
SPEC AX4	-.0019	-.1099	-.0011	1.0000				
ENVI AX1	.7777	.0000	-.0001	.0000	1.0000			
ENVI AX2	.0000	.7464	.0000	.0000	.0000	1.0000		
ENVI AX3	.0000	.0000	.6956	.0000	.0000	.0000	1.0000	
ENVI AX4	.0000	.0000	.0000	.6607	.0000	.0000	.0000	1.0000
RAI1SEA	-.6989	.0798	-.1812	-.0942	-.8987	.1070	-.2606	-.1425
RAI3SEA	.2364	.5369	.1602	-.3291	.3039	.7193	.2303	-.4981
A1	-.0706	-.3745	.4181	-.0355	-.0908	-.5017	.6011	-.0537
MISP	.5616	.1396	-.0495	-.1694	.7221	.1870	-.0711	-.2564
HUTT	-.2721	-.1844	-.3058	-.0362	-.3498	-.2470	-.4397	-.0548
GLEN	-.0862	-.0858	-.2441	.0020	-.1109	-.1150	-.3509	.0030
RENS	-.4715	.0450	.3641	.2652	-.6063	.0603	.5234	.4013
MILK	.0928	.0470	.0422	-.2479	.1194	.0629	.0607	-.3752
CONTA	.0981	-.0024	.1188	.0764	.1262	-.0033	.1709	.1156
PLAIN	-.3619	-.1158	.0613	-.2470	-.4653	-.1551	.0881	-.3738

	RAI1SEA	RAI3SEA	A1	MISP	HUTT	GLEN	RENS	MILK
RAI1SEA	1.0000							
RAI3SEA	-.2114	1.0000						
A1	-.0674	-.3348	1.0000					
MISP	-.6221	.4129	-.0481	1.0000				
HUTT	.3731	-.2245	-.5509	-.4603	1.0000			
GLEN	.1498	-.0901	-.0483	-.1848	-.0718	1.0000		
RENS	.4126	-.3196	.4571	-.6237	-.2423	-.0973	1.0000	
MILK	-.0722	.2551	.1080	-.1602	-.0623	-.0250	-.0844	1.0000
CONTA	-.3538	.0988	.1489	.4076	-.1778	-.0974	-.2447	-.0844
PLAIN	.5872	-.0833	.0932	-.5728	.2548	.1257	.3486	.1090

CONTA	1.0000	
PLAIN	-.7744	1.0000
	CONTA	PLAIN

VAR	(WEIGHTED) MEAN	STAND. DEV.	INFLATION FACTOR
SPEC AX1	.0000	.5958	
SPEC AX2	.0000	.5784	
SPEC AX3	.0000	.5195	
SPEC AX4	.0000	.4807	
ENVI AX1	.0000	.4633	
ENVI AX2	.0000	.4318	
ENVI AX3	.0000	.3613	
ENVI AX4	.0000	.3176	
RAI1SEA	571.2864	34.2447	2.4813
RAI3SEA	1553.2370	20.4136	3.0696
A1	21.3981	4.9113	5.2428
MISP	.5422	.4982	29.5545
HUTT	.1517	.3588	20.4054
GLEN	.0280	.1650	4.5342
RENS	.2472	.4314	22.9365
MILK	.0212	.1441	3.4625
CONTA	.2474	.4315	4.9543
PLAIN	.6459	.4782	7.2241

PERCENTAGE VARIANCE ACCOUNTED FOR BY FIRST S AXES OF SPECIES-ENVIRONMENT BIPLOT

S	PERC
1	23.6
2	44.5
3	59.9
4	72.1

SUM OF ALL CANONICAL EIGENVALUES: TRACE = .75031

1

SPECIES - KARSTLAND DATA - APRIL/MAY 1986

CANOCO -- ANALYSIS 5 CANONICAL AXES 4 COVARIABLES 0 SCALING 1 CENT./STAND. BY SAMPLES: 0/0 BY SPECIES: 0/0 MULTIPLIER 100.
DETRENDING 0 DOWNWEIGHTING 0 RESCALING 0 SEGMENTS 0 THRESHOLD .00 RANKING BY SAMPLES/SPECIES: 0/0

TRANSFORMATION -1.00 .00

SPECIES SCORES

N	NAME	AX1	AX2	AX3	AX4	RANKED 1	EIG= .177	RANKED 2	EIG= .157	RANKED 3	EIG= .115	RANKED 4	EIG= .092
1	ACA KAR	-62	80	165	136	6 ACA HEB	478	39 PAV ZEY	614	44 SEC VIR	256	6 ACA HEB	689
2	ACA TOR	-121	-46	-248	-47	12 CAT ALE	458	47 TER PRU	614	13 CIS JUT	244	39 PAV ZEY	583
3	ACA MEL	133	2	89	53	8 ACA NIL	396	35 MUN SER	550	27 FIC THO	214	47 TER PRU	583
4	ACA REF	96	-143	0	-63	15 COM IMB	394	36 OLE EUR	314	41 RHU LAN	195	35 MUN SER	492
5	ACA HER	43	-79	115	-75	39 PAV ZEY	380	6 ACA HEB	312	19 COM PYR	182	8 ACA NIL	412
6	ACA HEB	478	312	-234	689	47 TER PRU	380	13 CIS JUT	197	8 ACA NIL	181	34 MAY SEN	250
7	ACA ERU	-208	-170	-325	-69	35 MUN SER	339	27 FIC THO	190	1 ACA KAR	165	44 SEC VIR	237
8	ACA NIL	396	-407	181	412	37 OZO INS	320	41 RHU LAN	172	15 COM IMB	145	12 CAT ALE	197
9	BOS ALB	-101	-232	-56	-96	17 COM API	241	19 COM PYR	140	45 SCL BIR	129	10 CAR EDU	193
10	CAR EDU	-231	117	-44	193	45 SCL BIR	213	18 COM AFR	130	18 COM AFR	128	48 XIM CAF	183
11	CAS TRA	-177	5	-31	19	13 CIS JUT	192	10 CAR EDU	117	40 PEL AFR	117	37 OZO INS	170
12	CAT ALE	458	-370	-135	197	27 FIC THO	179	45 SCL BIR	117	17 COM API	116	32 GRE VIL	169
13	CIS JUT	192	197	244	-495	24 DOM ROT	174	23 DIO LYS	96	5 ACA HER	115	15 COM IMB	157
14	COM HER	23	-52	6	-43	19 COM PYR	166	26 EUC UND	84	28 GRE GLA	107	1 ACA KAR	136
15	COM IMB	394	-390	145	157	44 SEC VIR	161	1 ACA KAR	80	3 ACA MEL	89	24 DOM ROT	114

							!					!					!					!					!
16	COM	MOL	150	26	42	-399	!	36	OLE	EUR	152	!	24	DOM	ROT	63	!	32	GRE	VIL	63	!	43	RHU	PYR	73	!
17	COM	API	241	-65	116	-106	!	16	COM	MOL	150	!	40	PEL	AFR	60	!	50	ZIZ	MUC	61	!	22	DIC	CIN	68	!
18	COM	AFR	130	130	128	-411	!	3	ACA	MEL	133	!	48	XIM	CAF	57	!	31	GRE	RET	59	!	31	GRE	RET	58	!
19	COM	PYR	166	140	182	-395	!	18	COM	AFR	130	!	28	GRE	GLA	55	!	46	TAR	CAM	54	!	36	OLE	EUR	55	!
21	CRO	GRA	76	-32	-155	-117	!	23	DIO	LYS	129	!	29	GRE	FLS	42	!	23	DIO	LYS	51	!	3	ACA	MEL	53	!
22	DIC	CIN	-67	-74	-37	68	!	30	GRE	BIC	110	!	33	MAY	HET	37	!	33	MAY	HET	45	!	46	TAR	CAM	53	!
23	DIO	LYS	129	96	51	-146	!	50	ZIZ	MUC	107	!	16	COM	MOL	26	!	16	COM	MOL	42	!	11	CAS	TRA	19	!
24	DOM	ROT	174	63	-210	114	!	31	GRE	RET	97	!	46	TAR	CAM	10	!	14	COM	HER	6	!	50	ZIZ	MUC	12	!
25	EHR	RIG	-79	-134	-124	-120	!	4	ACA	REF	96	!	11	CAS	TRA	5	!	42	RHU	MAR	2	!	26	EUC	UND	5	!
26	EUC	UND	-6	84	-27	5	!	41	RHU	LAN	88	!	3	ACA	MEL	2	!	4	ACA	REF	0	!	49	XIM	AME	-5	!
27	FIC	THO	179	190	214	-376	!	21	CRO	GRA	76	!	21	CRO	GRA	-32	!	26	EUC	UND	-27	!	42	RHU	MAR	-15	!
28	GRE	GLA	-101	55	107	-30	!	34	MAY	SEN	60	!	42	RHU	MAR	-42	!	11	CAS	TRA	-31	!	28	GRE	GLA	-30	!
29	GRE	FLS	19	42	-71	-98	!	5	ACA	HER	43	!	2	ACA	TOR	-46	!	34	MAY	SEN	-35	!	33	MAY	HET	-32	!
30	GRE	BIC	110	-254	-120	-68	!	14	COM	HER	23	!	14	COM	HER	-52	!	22	DIC	CIN	-37	!	40	PEL	AFR	-32	!
31	GRE	RET	97	-88	59	58	!	42	RHU	MAR	21	!	17	COM	API	-65	!	10	CAR	EDU	-44	!	14	COM	HER	-43	!
32	GRE	VIL	-149	-239	63	169	!	48	XIM	CAF	20	!	22	DIC	CIN	-74	!	9	BOS	ALB	-56	!	2	ACA	TOR	-47	!
33	MAY	HET	-128	37	45	-32	!	29	GRE	FLS	19	!	43	RHU	PYR	-74	!	36	OLE	EUR	-68	!	41	RHU	LAN	-49	!
34	MAY	SEN	60	-254	-35	250	!	26	EUC	UND	-6	!	49	XIM	AME	-76	!	29	GRE	FLS	-71	!	4	ACA	REF	-63	!
35	MUN	SER	339	550	-444	492	!	1	ACA	KAR	-62	!	5	ACA	HER	-79	!	48	XIM	CAF	-111	!	30	GRE	BIC	-68	!
36	OLE	EUR	152	314	-68	55	!	22	DIC	CIN	-67	!	31	GRE	RET	-88	!	30	GRE	BIC	-120	!	7	ACA	ERU	-69	!
37	OZO	INS	320	-338	-179	170	!	40	PEL	AFR	-71	!	50	ZIZ	MUC	-130	!	25	EHR	RIG	-124	!	5	ACA	HER	-75	!
39	PAV	ZEY	380	614	-491	583	!	25	EHR	RIG	-79	!	25	EHR	RIG	-134	!	12	CAT	ALE	-135	!	9	BOS	ALB	-96	!
40	PEL	AFR	-71	60	117	-32	!	9	BOS	ALB	-101	!	4	ACA	REF	-143	!	21	CRO	GRA	-155	!	29	GRE	FLS	-98	!
41	RHU	LAN	88	172	195	-49	!	28	GRE	GLA	-101	!	7	ACA	ERU	-170	!	43	RHU	PYR	-166	!	17	COM	API	-106	!
42	RHU	MAR	21	-42	2	-15	!	43	RHU	PYR	-109	!	9	BOS	ALB	-232	!	37	OZO	INS	-179	!	21	CRO	GRA	-117	!
43	RHU	PYR	-109	-74	-166	73	!	2	ACA	TOR	-121	!	32	GRE	VIL	-239	!	49	XIM	AME	-179	!	25	EHR	RIG	-120	!
44	SEC	VIR	161	-285	256	237	!	33	MAY	HET	-128	!	30	GRE	BIC	-254	!	24	DOM	ROT	-210	!	23	DIO	LYS	-146	!
45	SCL	BIR	213	117	129	-883	!	32	GRE	VIL	-149	!	34	MAY	SEN	-254	!	6	ACA	HEB	-234	!	27	FIC	THO	-376	!
46	TAR	CAM	-151	10	54	53	!	46	TAR	CAM	-151	!	44	SEC	VIR	-285	!	2	ACA	TOR	-248	!	19	COM	PYR	-395	!
47	TER	PRU	380	614	-491	583	!	11	CAS	TRA	-177	!	37	OZO	INS	-338	!	7	ACA	ERU	-325	!	16	COM	MOL	-399	!
48	XIM	CAF	20	57	-111	183	!	7	ACA	ERU	-208	!	12	CAT	ALE	-370	!	35	MUN	SER	-444	!	18	COM	AFR	-411	!
49	XIM	AME	-218	-76	-179	-5	!	49	XIM	AME	-218	!	15	COM	IMB	-390	!	39	PAV	ZEY	-491	!	13	CIS	JUT	-495	!
50	ZIZ	MUC	107	-130	61	12	!	10	CAR	EDU	-231	!	8	ACA	NIL	-407	!	47	TER	PRU	-491	!	45	SCL	BIR	-883	!

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SPECIES - KARSTLAND DATA - APRIL/MAY 1986

CANOCO -- ANALYSIS 5 CANONICAL AXES 4 COVARIABLES 0 SCALING 1 CENT./STAND. BY SAMPLES: 0/0 BY SPECIES: 0/0 MULTIPLIER 100.
DETRENDING 0 DOWNWEIGHTING 0 RESCALING 0 SEGMENTS 0 THRESHOLD .00 RANKING BY SAMPLES/SPECIES: 0/0

TRANSFORMATION -1.00 .00

SAMPLE SCORES

N	NAME	AX1	AX2	AX3	AX4	!	RANKED 1			!	RANKED 2			!	RANKED 3			!	RANKED 4			!
						!			EIG= .177	!			EIG= .157	!			EIG= .115	!			EIG= .092	!
1	1	-33	5	-44	14	!	358	358	394	!	25	25	156	!	334	334	173	!	356	356	238	!
2	2	8	12	-49	-87	!	341	341	279	!	14	14	149	!	311	311	168	!	358	358	157	!
3	3	21	43	-73	-40	!	354	354	264	!	11	11	147	!	218	218	145	!	19	19	151	!
4	4	23	122	1	12	!	357	357	249	!	24	24	147	!	358	358	145	!	341	341	134	!
5	5	66	135	47	31	!	348	348	238	!	13	13	144	!	224	224	130	!	319	319	130	!
6	6	-22	66	18	15	!	334	334	223	!	16	16	142	!	304	304	128	!	313	313	119	!
7	7	6	80	12	24	!	349	349	213	!	19	19	141	!	299	299	127	!	17	17	108	!
8	8	-60	-20	-11	17	!	338	338	208	!	5	5	135	!	257	257	124	!	354	354	105	!
9	9	14	74	-31	23	!	356	356	174	!	304	304	130	!	357	357	121	!	16	16	103	!
10	10	3	35	-45	9	!	17	17	169	!	15	15	128	!	348	348	120	!	236	236	102	!
11	11	81	147	-26	3	!	368	368	157	!	28	28	127	!	354	354	117	!	318	318	98	!
12	12	-41	38	24	47	!	367	367	149	!	17	17	126	!	307	307	116	!	325	325	90	!
13	13	41	144	-29	12	!	273	273	133	!	18	18	126	!	319	319	116	!	320	320	89	!
14	14	107	149	-66	36	!	300	300	133	!	4	4	122	!	313	313	115	!	15	15	84	!
15	15	80	128	-11	84	!	303	303	133	!	235	235	120	!	296	296	107	!	357	357	84	!
16	16	105	142	-82	103	!	366	366	133	!	271	271	118	!	361	361	102	!	18	18	83	!
17	17	169	126	-177	108	!	267	267	132	!	250	250	111	!	349	349	101	!	24	24	82	!

18	18	99	126	-166	83 !	374	374	132 !	299	299	99 !	341	341	99 !	224	224	81 !
19	19	104	141	-149	151 !	304	304	130 !	247	247	93 !	232	232	98 !	331	331	80 !
20	20	42	65	-127	55 !	363	363	128 !	242	242	92 !	244	244	90 !	248	248	78 !
21	21	-5	32	-55	0 !	274	274	121 !	251	251	88 !	269	269	90 !	28	28	77 !
22	22	25	68	-53	-21 !	350	350	119 !	129	129	87 !	212	212	89 !	214	214	76 !
23	23	31	76	-57	55 !	335	335	118 !	218	218	86 !	273	273	89 !	360	360	75 !
24	24	67	147	-73	82 !	339	339	115 !	227	227	83 !	300	300	89 !	194	194	73 !
25	25	87	156	-60	18 !	272	272	110 !	356	356	81 !	303	303	89 !	311	311	73 !
26	26	50	76	-33	32 !	360	360	110 !	7	7	80 !	175	175	87 !	232	232	71 !
27	27	25	52	-47	10 !	379	379	109 !	264	264	79 !	272	272	85 !	338	338	71 !
28	28	62	127	0	77 !	14	14	107 !	269	269	77 !	197	197	83 !	181	181	70 !
29	29	-11	-1	-10	20 !	352	352	107 !	23	23	76 !	363	363	83 !	218	218	69 !
30	30	-30	-14	-80	-62 !	16	16	105 !	26	26	76 !	220	220	82 !	323	323	69 !
31	31	-5	7	-41	-133 !	276	276	105 !	277	277	75 !	199	199	81 !	359	359	69 !
32	32	34	-13	-92	-17 !	323	323	105 !	9	9	74 !	268	268	80 !	57	57	68 !
33	33	-9	-13	-49	-71 !	347	347	105 !	144	144	71 !	247	247	79 !	119	119	68 !
34	34	26	-42	-49	-61 !	19	19	104 !	145	145	71 !	274	274	79 !	176	176	68 !
35	35	-35	-39	-70	-26 !	284	284	103 !	257	257	69 !	217	217	77 !	290	290	68 !
36	36	-8	-65	-48	-53 !	285	285	103 !	22	22	68 !	208	208	73 !	310	310	68 !
37	37	-8	-30	-77	-57 !	361	361	101 !	230	230	68 !	213	213	73 !	312	312	68 !
38	38	-53	-4	-12	-13 !	400	400	100 !	6	6	66 !	338	338	73 !	333	333	68 !
39	39	17	-22	-23	-73 !	18	18	99 !	279	279	66 !	194	194	72 !	348	348	68 !
40	40	-76	-26	-21	-2 !	365	365	97 !	20	20	65 !	266	266	72 !	351	351	68 !
41	41	-51	-35	-55	-29 !	370	370	97 !	256	256	65 !	196	196	71 !	353	353	68 !
42	42	-72	-28	-79	-30 !	255	255	93 !	260	260	65 !	240	240	71 !	355	355	68 !
43	43	13	-27	-45	-67 !	340	340	92 !	265	265	64 !	350	350	71 !	361	361	67 !
44	44	2	-6	-38	-39 !	25	25	87 !	220	220	62 !	271	271	70 !	136	136	63 !
45	45	-23	24	-79	-9 !	232	232	87 !	315	315	61 !	231	231	69 !	328	328	62 !
46	46	-36	-4	-24	-13 !	223	223	86 !	223	223	60 !	253	253	69 !	329	329	61 !
47	47	-9	-30	-97	-50 !	346	346	86 !	134	134	59 !	288	288	69 !	397	397	61 !
48	48	-66	-21	-47	-57 !	325	325	84 !	276	276	59 !	301	301	68 !	183	183	60 !
49	49	-39	39	-38	-22 !	327	327	84 !	307	307	59 !	365	365	68 !	362	362	57 !
50	50	-69	-31	-35	-14 !	329	329	84 !	249	249	58 !	198	198	66 !	368	368	57 !
51	51	-92	3	-8	-57 !	362	362	83 !	259	259	57 !	236	236	64 !	127	127	56 !
52	52	-50	-1	-11	-56 !	11	11	81 !	293	293	55 !	289	289	64 !	349	349	56 !
53	53	33	-44	-57	-12 !	15	15	80 !	296	296	55 !	346	346	64 !	20	20	55 !
54	54	2	-7	-65	-23 !	331	331	79 !	253	253	54 !	155	155	63 !	23	23	55 !
55	55	-36	-26	-38	-35 !	324	324	78 !	245	245	53 !	310	310	63 !	84	84	55 !
56	56	-24	7	12	-10 !	268	268	77 !	27	27	52 !	368	368	63 !	274	274	55 !
57	57	-67	-74	-37	68 !	359	359	77 !	151	151	52 !	375	375	62 !	61	61	54 !
58	58	-7	-59	29	10 !	373	373	77 !	224	224	50 !	320	320	61 !	138	138	54 !
59	59	-41	20	1	-3 !	375	375	77 !	275	275	50 !	352	352	61 !	273	273	53 !
60	60	-84	9	33	28 !	254	254	74 !	305	305	50 !	226	226	60 !	300	300	53 !
61	61	7	-70	8	54 !	364	364	73 !	246	246	49 !	255	255	60 !	303	303	53 !
62	62	-65	-6	40	8 !	384	384	72 !	147	147	46 !	201	201	59 !	324	324	51 !
63	63	-45	-26	33	16 !	256	256	71 !	266	266	46 !	305	305	59 !	213	213	49 !
64	64	-10	-45	22	38 !	253	253	70 !	280	280	45 !	181	181	58 !	121	121	48 !
65	65	-8	-71	-20	8 !	380	380	70 !	3	3	43 !	362	362	58 !	228	228	48 !
66	66	-101	-36	-22	42 !	332	332	68 !	282	282	43 !	185	185	57 !	231	231	48 !
67	67	-140	-96	-134	10 !	24	24	67 !	313	313	42 !	234	234	57 !	12	12	47 !
68	68	-60	5	-23	-42 !	378	378	67 !	289	289	41 !	225	225	56 !	339	339	46 !
69	69	-47	-37	-6	24 !	395	395	67 !	130	130	40 !	360	360	56 !	398	398	46 !
70	70	-28	-1	-25	-16 !	5	5	66 !	49	49	39 !	176	176	54 !	179	179	45 !
71	71	-24	-26	-67	-39 !	242	242	65 !	12	12	38 !	214	214	54 !	363	363	45 !
72	72	-11	-22	-28	-51 !	345	345	64 !	149	149	38 !	293	293	53 !	369	369	45 !
73	73	-117	-24	-28	28 !	226	226	63 !	168	168	38 !	317	317	53 !	172	172	44 !
74	74	-75	-51	-10	1 !	376	376	63 !	10	10	35 !	179	179	52 !	367	367	44 !
75	75	-92	-33	-26	22 !	28	28	62 !	154	154	35 !	189	189	52 !	200	200	43 !
76	76	-102	-37	-13	42 !	264	264	62 !	84	84	34 !	200	200	52 !	309	309	43 !
77	77	32	-91	17	-7 !	292	292	59 !	171	171	34 !	203	203	52 !	347	347	43 !

78	78	-10	-36	-20	0 !	288	288	57 !	21	21	32 !	309	309	52 !	66	66	42 !
79	79	-62	-16	-3	-17 !	289	289	57 !	263	263	32 !	335	335	51 !	76	76	42 !
80	80	-62	-1	-22	-13 !	396	396	57 !	284	284	32 !	347	347	51 !	240	240	42 !
81	81	-11	-17	-53	9 !	369	369	56 !	286	286	32 !	178	178	50 !	141	141	40 !
82	82	-105	-27	-45	13 !	231	231	55 !	139	139	31 !	248	248	50 !	208	208	40 !
83	83	-102	-34	-56	18 !	326	326	55 !	177	177	30 !	359	359	50 !	350	350	40 !
84	84	-44	34	-119	55 !	372	372	55 !	189	189	30 !	195	195	49 !	364	364	39 !
85	85	-79	13	-71	-32 !	322	322	54 !	243	243	30 !	222	222	49 !	64	64	38 !
86	86	-84	-66	-100	33 !	371	371	54 !	217	217	29 !	327	327	49 !	170	170	38 !
87	87	-49	-23	-85	-47 !	399	399	54 !	261	261	29 !	167	167	48 !	174	174	38 !
88	88	-17	-23	-25	-22 !	269	269	52 !	155	155	28 !	190	190	48 !	180	180	38 !
89	89	-5	-57	-20	-33 !	250	250	51 !	201	201	28 !	229	229	48 !	249	249	37 !
90	90	-63	-18	-68	11 !	259	259	51 !	288	288	28 !	5	5	47 !	308	308	37 !
91	91	-67	-44	-30	30 !	26	26	50 !	219	219	27 !	126	126	47 !	14	14	36 !
92	92	8	-45	-40	-7 !	270	270	50 !	137	137	26 !	174	174	47 !	226	226	36 !
93	93	-18	-77	-79	-25 !	279	279	50 !	146	146	26 !	177	177	47 !	378	378	36 !
94	94	7	-28	-83	-13 !	344	344	50 !	148	148	26 !	238	238	47 !	337	337	35 !
95	95	-7	12	-30	-7 !	271	271	49 !	301	301	26 !	315	315	47 !	166	166	34 !
96	96	-15	22	-46	31 !	306	306	49 !	161	161	25 !	124	124	46 !	182	182	34 !
97	97	-19	-41	-56	20 !	299	299	48 !	45	45	24 !	228	228	46 !	198	198	34 !
98	98	-3	-5	-86	-35 !	135	135	47 !	258	258	24 !	246	246	46 !	392	392	34 !
99	99	-27	-18	-31	2 !	251	251	47 !	157	157	23 !	297	297	46 !	86	86	33 !
100	100	-50	-47	-100	-12 !	275	275	46 !	96	96	22 !	157	157	45 !	26	26	32 !
101	101	-15	-20	-53	-11 !	381	381	46 !	233	233	22 !	183	183	45 !	178	178	32 !
102	102	-21	19	-45	-31 !	391	391	46 !	285	285	22 !	210	210	45 !	388	388	32 !
103	103	-6	-35	-112	-70 !	229	229	44 !	158	158	21 !	364	364	45 !	5	5	31 !
104	104	-7	-47	-107	-22 !	252	252	44 !	59	59	20 !	162	162	44 !	96	96	31 !
105	105	-34	-37	-56	-9 !	387	387	43 !	128	128	20 !	191	191	44 !	156	156	31 !
106	106	16	-15	-68	-16 !	393	393	43 !	102	102	19 !	227	227	44 !	225	225	31 !
107	107	-47	-56	-69	-20 !	20	20	42 !	190	190	19 !	340	340	44 !	374	374	31 !
108	108	-33	-23	-43	-50 !	225	225	42 !	150	150	18 !	150	150	43 !	91	91	30 !
109	109	10	-31	-84	-52 !	243	243	42 !	191	191	18 !	186	186	43 !	193	193	30 !
110	110	-82	-61	-151	16 !	307	307	42 !	198	198	18 !	219	219	43 !	216	216	30 !
111	111	-76	2	-1	11 !	13	13	41 !	207	207	18 !	367	367	43 !	399	399	30 !
112	112	-33	-30	-61	-39 !	227	227	41 !	163	163	17 !	182	182	42 !	196	196	29 !
113	113	-18	-18	-94	14 !	230	230	41 !	159	159	16 !	204	204	42 !	321	321	29 !
114	114	-15	-44	-94	-11 !	261	261	40 !	221	221	15 !	325	325	42 !	327	327	29 !
115	115	-64	-13	-44	-14 !	388	388	40 !	244	244	15 !	163	163	41 !	60	60	28 !
116	116	15	-72	-95	-14 !	260	260	38 !	361	361	15 !	193	193	41 !	73	73	28 !
117	117	-8	-22	-90	-7 !	277	277	38 !	135	135	14 !	206	206	41 !	137	137	28 !
118	118	-26	-10	-67	2 !	390	390	37 !	85	85	13 !	207	207	41 !	365	365	28 !
119	119	-67	-74	-37	68 !	392	392	37 !	2	2	12 !	209	209	41 !	387	387	28 !
120	120	-16	-4	-71	-15 !	265	265	36 !	95	95	12 !	396	396	41 !	203	203	27 !
121	121	-68	-78	-100	48 !	238	238	35 !	173	173	12 !	62	62	40 !	335	335	27 !
122	122	-105	-16	-17	7 !	245	245	35 !	176	176	11 !	156	156	40 !	400	400	27 !
123	123	-46	-45	-45	26 !	32	32	34 !	298	298	11 !	245	245	40 !	123	123	26 !
124	124	-41	-7	46	26 !	235	235	34 !	164	164	10 !	275	275	40 !	124	124	26 !
125	125	-17	-19	-24	12 !	53	53	33 !	60	60	9 !	332	332	40 !	143	143	26 !
126	126	-53	9	47	-36 !	77	77	32 !	126	126	9 !	336	336	40 !	151	151	26 !
127	127	-50	-50	-23	56 !	234	234	32 !	254	254	9 !	173	173	39 !	128	128	25 !
128	128	-42	20	-9	25 !	23	23	31 !	143	143	8 !	342	342	39 !	164	164	25 !
129	129	23	87	-45	9 !	134	134	31 !	334	334	8 !	172	172	38 !	175	175	25 !
130	130	-35	40	-7	24 !	328	328	31 !	31	31	7 !	298	298	37 !	370	370	25 !
131	131	-11	-8	-36	5 !	382	382	31 !	56	56	7 !	339	339	37 !	7	7	24 !
132	132	-33	-10	-22	-5 !	336	336	30 !	167	167	7 !	395	395	37 !	69	69	24 !
133	133	2	-1	-58	-10 !	221	221	29 !	174	174	7 !	161	161	36 !	130	130	24 !
134	134	31	59	5	15 !	337	337	29 !	212	212	7 !	188	188	36 !	150	150	24 !
135	135	47	14	21	-5 !	389	389	29 !	268	268	7 !	216	216	36 !	152	152	24 !
136	136	-1	-49	5	63 !	282	282	28 !	278	278	7 !	158	158	35 !	157	157	24 !
137	137	17	26	13	28 !	294	294	28 !	292	292	7 !	170	170	35 !	161	161	24 !

138	138	-32	-55	-22	54 !	397	397	28 !	153	153	6 !	258	258	35 !	215	215	24 !
139	139	-26	31	-18	18 !	318	318	27 !	297	297	6 !	278	278	34 !	336	336	24 !
140	140	-75	-20	-51	19 !	34	34	26 !	311	311	6 !	343	343	34 !	9	9	23 !
141	141	-32	-13	4	40 !	175	175	26 !	1	1	5 !	369	369	34 !	171	171	23 !
142	142	-85	-5	10	7 !	22	22	25 !	68	68	5 !	60	60	33 !	177	177	23 !
143	143	-32	8	9	26 !	27	27	25 !	196	196	5 !	63	63	33 !	206	206	23 !
144	144	-34	71	-14	19 !	4	4	23 !	234	234	5 !	265	265	33 !	217	217	23 !
145	145	-33	71	-8	12 !	129	129	23 !	194	194	4 !	292	292	33 !	233	233	23 !
146	146	-49	26	21	0 !	222	222	23 !	51	51	3 !	344	344	33 !	316	316	23 !
147	147	-80	46	24	12 !	3	3	21 !	182	182	3 !	399	399	33 !	366	366	23 !
148	148	-73	26	23	16 !	377	377	19 !	208	208	3 !	306	306	32 !	75	75	22 !
149	149	-49	38	19	18 !	394	394	18 !	236	236	3 !	233	233	31 !	162	162	22 !
150	150	-40	18	43	24 !	39	39	17 !	111	111	2 !	267	267	31 !	188	188	22 !
151	151	-48	52	1	26 !	137	137	17 !	200	200	2 !	58	58	29 !	29	29	20 !
152	152	12	-72	0	24 !	106	106	16 !	213	213	2 !	205	205	29 !	97	97	20 !
153	153	-39	6	11	12 !	386	386	16 !	252	252	2 !	154	154	28 !	185	185	20 !
154	154	-68	35	28	7 !	116	116	15 !	270	270	2 !	235	235	28 !	192	192	20 !
155	155	-68	28	63	3 !	9	9	14 !	273	273	2 !	223	223	27 !	210	210	20 !
156	156	-16	-11	40	31 !	214	214	14 !	300	300	2 !	250	250	26 !	140	140	19 !
157	157	-38	23	45	24 !	43	43	13 !	303	303	2 !	242	242	25 !	144	144	19 !
158	158	-79	21	35	5 !	152	152	12 !	310	310	2 !	285	285	25 !	187	187	19 !
159	159	-111	16	22	7 !	311	311	11 !	197	197	1 !	12	12	24 !	195	195	19 !
160	160	-41	-24	18	-1 !	109	109	10 !	272	272	1 !	147	147	24 !	199	199	19 !
161	161	-65	25	36	24 !	209	209	10 !	199	199	0 !	148	148	23 !	202	202	19 !
162	162	-46	-5	44	22 !	278	278	10 !	232	232	0 !	256	256	23 !	239	239	19 !
163	163	-120	17	41	17 !	330	330	9 !	238	238	0 !	279	279	23 !	315	315	19 !
164	164	-68	10	16	25 !	2	2	8 !	291	291	0 !	64	64	22 !	375	375	19 !
165	165	-95	-50	-106	12 !	92	92	8 !	29	29	-1 !	159	159	22 !	25	25	18 !
166	166	-39	-20	3	34 !	61	61	7 !	52	52	-1 !	168	168	22 !	83	83	18 !
167	167	-75	7	48	13 !	94	94	7 !	70	70	-1 !	230	230	22 !	139	139	18 !
168	168	-40	38	22	14 !	263	263	7 !	80	80	-1 !	345	345	22 !	149	149	18 !
169	169	-36	-15	-22	15 !	283	283	7 !	133	133	-1 !	397	397	22 !	258	258	18 !
170	170	-31	-50	35	38 !	398	398	7 !	178	178	-1 !	135	135	21 !	314	314	18 !
171	171	-42	34	21	23 !	7	7	6 !	226	226	-1 !	146	146	21 !	326	326	18 !
172	172	-47	-14	38	44 !	241	241	6 !	241	241	-1 !	171	171	21 !	8	8	17 !
173	173	-43	12	39	17 !	302	302	5 !	317	317	-1 !	328	328	21 !	163	163	17 !
174	174	-71	7	47	38 !	305	305	5 !	183	183	-2 !	249	249	20 !	173	173	17 !
175	175	26	-14	87	25 !	385	385	5 !	216	216	-2 !	276	276	20 !	204	204	17 !
176	176	-71	11	54	68 !	233	233	4 !	372	372	-2 !	149	149	19 !	219	219	17 !
177	177	-66	30	47	23 !	295	295	4 !	179	179	-3 !	263	263	19 !	63	63	16 !
178	178	-42	-1	50	32 !	10	10	3 !	193	193	-3 !	388	388	19 !	110	110	16 !
179	179	-21	-3	52	45 !	44	44	2 !	306	306	-3 !	6	6	18 !	148	148	16 !
180	180	-39	-17	2	38 !	54	54	2 !	38	38	-4 !	160	160	18 !	243	243	16 !
181	181	-81	-8	58	70 !	133	133	2 !	46	46	-4 !	286	286	18 !	6	6	15 !
182	182	-72	3	42	34 !	293	293	2 !	120	120	-4 !	337	337	18 !	134	134	15 !
183	183	-37	-2	45	60 !	286	286	0 !	185	185	-4 !	379	379	18 !	169	169	15 !
184	184	-47	-17	17	12 !	136	136	-1 !	210	210	-4 !	77	77	17 !	346	346	15 !
185	185	-20	-4	57	20 !	281	281	-2 !	98	98	-5 !	184	184	17 !	1	1	14 !
186	186	-58	-16	43	1 !	98	98	-3 !	142	142	-5 !	164	164	16 !	113	113	14 !
187	187	-34	-49	16	19 !	194	194	-3 !	162	162	-5 !	187	187	16 !	168	168	14 !
188	188	-41	-12	36	22 !	224	224	-3 !	44	44	-6 !	283	283	15 !	209	209	14 !
189	189	-45	30	52	7 !	240	240	-3 !	62	62	-6 !	294	294	15 !	256	256	14 !
190	190	-75	19	48	0 !	320	320	-3 !	240	240	-6 !	387	387	14 !	82	82	13 !
191	191	-75	18	44	-4 !	383	383	-3 !	262	262	-6 !	400	400	14 !	167	167	13 !
192	192	-22	-61	-35	20 !	220	220	-4 !	54	54	-7 !	137	137	13 !	197	197	13 !
193	193	-15	-3	41	30 !	228	228	-4 !	124	124	-7 !	211	211	13 !	221	221	13 !
194	194	-3	4	72	73 !	301	301	-4 !	322	322	-7 !	7	7	12 !	340	340	13 !
195	195	-61	-12	49	19 !	21	21	-5 !	131	131	-8 !	56	56	12 !	4	4	12 !
196	196	-71	5	71	29 !	31	31	-5 !	181	181	-8 !	153	153	11 !	13	13	12 !
197	197	-32	1	83	13 !	89	89	-5 !	203	203	-8 !	239	239	11 !	125	125	12 !

198	198	-71	18	66	34 !	103	103	-6 !	225	225	-9 !	254	254	11 !	145	145	12 !
199	199	-56	0	81	19 !	58	58	-7 !	118	118	-10 !	382	382	11 !	147	147	12 !
200	200	-22	2	52	43 !	95	95	-7 !	132	132	-10 !	394	394	11 !	153	153	12 !
201	201	-39	28	59	8 !	104	104	-7 !	375	375	-10 !	142	142	10 !	165	165	12 !
202	202	-31	-37	-20	19 !	257	257	-7 !	156	156	-11 !	243	243	10 !	184	184	12 !
203	203	-46	-8	52	27 !	317	317	-7 !	287	287	-11 !	143	143	9 !	352	352	12 !
204	204	-36	-15	42	17 !	36	36	-8 !	188	188	-12 !	370	370	9 !	90	90	11 !
205	205	-53	-40	29	0 !	37	37	-8 !	195	195	-12 !	61	61	8 !	111	111	11 !
206	206	-38	-35	41	23 !	65	65	-8 !	281	281	-12 !	221	221	6 !	211	211	11 !
207	207	-110	18	41	-12 !	117	117	-8 !	32	32	-13 !	252	252	6 !	237	237	11 !
208	208	-13	3	73	40 !	343	343	-8 !	33	33	-13 !	366	366	6 !	238	238	11 !
209	209	10	-67	41	14 !	33	33	-9 !	115	115	-13 !	134	134	5 !	396	396	11 !
210	210	-70	-4	45	20 !	47	47	-9 !	141	141	-13 !	136	136	5 !	27	27	10 !
211	211	-94	-14	13	11 !	237	237	-9 !	214	214	-13 !	215	215	5 !	58	58	10 !
212	212	-46	7	89	0 !	64	64	-10 !	222	222	-13 !	295	295	5 !	67	67	10 !
213	213	-61	2	73	49 !	78	78	-10 !	239	239	-13 !	141	141	4 !	385	385	10 !
214	214	14	-13	54	76 !	29	29	-11 !	30	30	-14 !	260	260	4 !	10	10	9 !
215	215	-58	-36	5	24 !	72	72	-11 !	172	172	-14 !	314	314	4 !	81	81	9 !
216	216	-39	-2	36	30 !	81	81	-11 !	175	175	-14 !	398	398	4 !	129	129	9 !
217	217	-38	29	77	23 !	131	131	-11 !	211	211	-14 !	166	166	3 !	62	62	8 !
218	218	-46	86	145	69 !	308	308	-11 !	255	255	-14 !	180	180	2 !	65	65	8 !
219	219	-70	27	43	17 !	319	319	-11 !	106	106	-15 !	371	371	2 !	201	201	8 !
220	220	-4	62	82	-24 !	239	239	-12 !	169	169	-15 !	4	4	1 !	122	122	7 !
221	221	29	15	6	13 !	342	342	-12 !	204	204	-15 !	59	59	1 !	142	142	7 !
222	222	23	-13	49	-15 !	208	208	-13 !	237	237	-15 !	151	151	1 !	154	154	7 !
223	223	86	60	27	0 !	280	280	-13 !	79	79	-16 !	282	282	1 !	159	159	7 !
224	224	-3	50	130	81 !	266	266	-14 !	122	122	-16 !	28	28	0 !	189	189	7 !
225	225	42	-9	56	31 !	96	96	-15 !	186	186	-16 !	152	152	0 !	395	395	6 !
226	226	63	-1	60	36 !	101	101	-15 !	295	295	-16 !	318	318	0 !	131	131	5 !
227	227	41	83	44	-97 !	114	114	-15 !	81	81	-17 !	383	383	0 !	158	158	5 !
228	228	-4	-20	46	48 !	193	193	-15 !	180	180	-17 !	111	111	-1 !	345	345	4 !
229	229	44	-21	48	1 !	316	316	-15 !	184	184	-17 !	302	302	-2 !	11	11	3 !
230	230	41	68	22	-55 !	120	120	-16 !	362	362	-17 !	330	330	-2 !	155	155	3 !
231	231	55	-31	69	48 !	156	156	-16 !	90	90	-18 !	79	79	-3 !	99	99	2 !
232	232	87	0	98	71 !	88	88	-17 !	99	99	-18 !	390	390	-3 !	118	118	2 !
233	233	4	22	31	23 !	125	125	-17 !	113	113	-18 !	372	372	-4 !	305	305	2 !
234	234	32	5	57	-35 !	298	298	-17 !	248	248	-18 !	386	386	-4 !	74	74	1 !
235	235	34	120	28	-23 !	93	93	-18 !	125	125	-19 !	259	259	-5 !	186	186	1 !
236	236	-65	3	64	102 !	113	113	-18 !	314	314	-19 !	69	69	-6 !	229	229	1 !
237	237	-9	-15	-51	11 !	97	97	-19 !	8	8	-20 !	262	262	-6 !	298	298	1 !
238	238	35	0	47	11 !	185	185	-20 !	101	101	-20 !	264	264	-6 !	21	21	0 !
239	239	-12	-13	11	19 !	102	102	-21 !	140	140	-20 !	280	280	-6 !	78	78	0 !
240	240	-3	-6	71	42 !	179	179	-21 !	166	166	-20 !	287	287	-6 !	146	146	0 !
241	241	6	-1	-15	-2 !	315	315	-21 !	228	228	-20 !	130	130	-7 !	190	190	0 !
242	242	65	92	25	-56 !	6	6	-22 !	48	48	-21 !	389	389	-7 !	205	205	0 !
243	243	42	30	10	16 !	192	192	-22 !	229	229	-21 !	51	51	-8 !	212	212	0 !
244	244	-24	15	90	-22 !	200	200	-22 !	39	39	-22 !	145	145	-8 !	223	223	0 !
245	245	35	53	40	-46 !	287	287	-22 !	72	72	-22 !	392	392	-8 !	381	381	0 !
246	246	-76	49	46	-55 !	45	45	-23 !	117	117	-22 !	128	128	-9 !	389	389	0 !
247	247	-29	93	79	-30 !	56	56	-24 !	87	87	-23 !	270	270	-9 !	160	160	-1 !
248	248	-26	-18	50	78 !	71	71	-24 !	88	88	-23 !	29	29	-10 !	251	251	-1 !
249	249	-27	58	20	37 !	244	244	-24 !	108	108	-23 !	74	74	-10 !	382	382	-1 !
250	250	51	111	26	-107 !	118	118	-26 !	73	73	-24 !	8	8	-11 !	386	386	-1 !
251	251	47	88	-55	-1 !	139	139	-26 !	160	160	-24 !	15	15	-11 !	393	393	-1 !
252	252	44	2	6	-31 !	248	248	-26 !	319	319	-24 !	52	52	-11 !	40	40	-2 !
253	253	70	54	69	-113 !	297	297	-26 !	363	363	-24 !	38	38	-12 !	241	241	-2 !
254	254	74	9	11	-24 !	99	99	-27 !	382	382	-24 !	76	76	-13 !	59	59	-3 !
255	255	93	-14	60	-41 !	249	249	-27 !	40	40	-26 !	331	331	-13 !	291	291	-3 !
256	256	71	65	23	14 !	262	262	-27 !	55	55	-26 !	144	144	-14 !	383	383	-3 !
257	257	-7	69	124	-49 !	70	70	-28 !	63	63	-26 !	308	308	-14 !	191	191	-4 !

258	258	-30	24	35	18 !	247	247	-29 !	71	71	-26 !	241	241	-15 !	342	342	-4 !
259	259	51	57	-5	-8 !	30	30	-30 !	294	294	-26 !	277	277	-15 !	132	132	-5 !
260	260	38	65	4	-57 !	258	258	-30 !	43	43	-27 !	324	324	-15 !	135	135	-5 !
261	261	40	29	-20	-33 !	170	170	-31 !	82	82	-27 !	291	291	-16 !	343	343	-5 !
262	262	-27	-6	-6	-39 !	202	202	-31 !	371	371	-27 !	122	122	-17 !	344	344	-5 !
263	263	7	32	19	-25 !	138	138	-32 !	380	380	-27 !	139	139	-18 !	77	77	-7 !
264	264	62	79	-6	-11 !	141	141	-32 !	42	42	-28 !	284	284	-18 !	92	92	-7 !
265	265	36	64	33	-81 !	143	143	-32 !	94	94	-28 !	326	326	-19 !	95	95	-7 !
266	266	-14	46	72	-48 !	197	197	-32 !	274	274	-28 !	65	65	-20 !	117	117	-7 !
267	267	132	-85	31	-22 !	1	1	-33 !	37	37	-30 !	78	78	-20 !	259	259	-8 !
268	268	77	7	80	-45 !	108	108	-33 !	47	47	-30 !	89	89	-20 !	45	45	-9 !
269	269	52	77	90	-183 !	112	112	-33 !	112	112	-30 !	202	202	-20 !	105	105	-9 !
270	270	50	2	-9	-22 !	132	132	-33 !	283	283	-30 !	261	261	-20 !	56	56	-10 !
271	271	49	118	70	-80 !	145	145	-33 !	50	50	-31 !	378	378	-20 !	133	133	-10 !
272	272	110	1	85	-55 !	105	105	-34 !	109	109	-31 !	393	393	-20 !	322	322	-10 !
273	273	133	2	89	53 !	144	144	-34 !	231	231	-31 !	40	40	-21 !	394	394	-10 !
274	274	121	-28	79	55 !	187	187	-34 !	365	365	-32 !	281	281	-21 !	101	101	-11 !
275	275	46	50	40	-68 !	35	35	-35 !	75	75	-33 !	385	385	-21 !	114	114	-11 !
276	276	105	59	20	-162 !	130	130	-35 !	83	83	-34 !	66	66	-22 !	264	264	-11 !
277	277	38	75	-15	-83 !	46	46	-36 !	323	323	-34 !	80	80	-22 !	53	53	-12 !
278	278	10	7	34	-110 !	55	55	-36 !	386	386	-34 !	132	132	-22 !	100	100	-12 !
279	279	50	66	23	-113 !	169	169	-36 !	41	41	-35 !	138	138	-22 !	207	207	-12 !
280	280	-13	45	-6	-28 !	204	204	-36 !	103	103	-35 !	169	169	-22 !	376	376	-12 !
281	281	-2	-12	-21	-35 !	183	183	-37 !	206	206	-35 !	39	39	-23 !	38	38	-13 !
282	282	28	43	1	-25 !	157	157	-38 !	66	66	-36 !	68	68	-23 !	46	46	-13 !
283	283	7	-30	15	-56 !	206	206	-38 !	78	78	-36 !	127	127	-23 !	80	80	-13 !
284	284	103	32	-18	-52 !	217	217	-38 !	215	215	-36 !	374	374	-23 !	94	94	-13 !
285	285	103	22	25	-152 !	49	49	-39 !	69	69	-37 !	46	46	-24 !	317	317	-13 !
286	286	0	32	18	-120 !	153	153	-39 !	76	76	-37 !	125	125	-24 !	379	379	-13 !
287	287	-22	-11	-6	-70 !	166	166	-39 !	105	105	-37 !	316	316	-24 !	50	50	-14 !
288	288	57	28	69	-206 !	180	180	-39 !	202	202	-37 !	70	70	-25 !	115	115	-14 !
289	289	57	41	64	-104 !	201	201	-39 !	389	389	-37 !	88	88	-25 !	116	116	-14 !
290	290	-67	-74	-37	68 !	216	216	-39 !	337	337	-38 !	391	391	-25 !	297	297	-14 !
291	291	-63	0	-16	-3 !	150	150	-40 !	395	395	-38 !	11	11	-26 !	120	120	-15 !
292	292	59	7	33	-110 !	168	168	-40 !	35	35	-39 !	75	75	-26 !	222	222	-15 !
293	293	2	55	53	-131 !	12	12	-41 !	336	336	-39 !	373	373	-27 !	70	70	-16 !
294	294	28	-26	15	-62 !	59	59	-41 !	205	205	-40 !	72	72	-28 !	106	106	-16 !
295	295	4	-16	5	-114 !	124	124	-41 !	320	320	-40 !	73	73	-28 !	32	32	-17 !
296	296	-101	55	107	-30 !	160	160	-41 !	373	373	-40 !	384	384	-28 !	79	79	-17 !
297	297	-26	6	46	-14 !	188	188	-41 !	97	97	-41 !	13	13	-29 !	390	390	-18 !
298	298	-17	11	37	1 !	128	128	-42 !	34	34	-42 !	322	322	-29 !	107	107	-20 !
299	299	48	99	127	-250 !	171	171	-42 !	53	53	-44 !	91	91	-30 !	22	22	-21 !
300	300	133	2	89	53 !	178	178	-42 !	91	91	-44 !	95	95	-30 !	302	302	-21 !
301	301	-4	26	68	-66 !	173	173	-43 !	114	114	-44 !	9	9	-31 !	49	49	-22 !
302	302	5	-57	-2	-21 !	84	84	-44 !	64	64	-45 !	99	99	-31 !	88	88	-22 !
303	303	133	2	89	53 !	63	63	-45 !	92	92	-45 !	26	26	-33 !	104	104	-22 !
304	304	130	130	128	-411 !	189	189	-45 !	123	123	-45 !	376	376	-33 !	244	244	-22 !
305	305	5	50	59	2 !	123	123	-46 !	309	309	-45 !	50	50	-35 !	267	267	-22 !
306	306	49	-3	32	-60 !	162	162	-46 !	376	376	-45 !	192	192	-35 !	270	270	-22 !
307	307	42	59	116	-91 !	203	203	-46 !	394	394	-46 !	323	323	-35 !	371	371	-22 !
308	308	-11	-95	-14	37 !	212	212	-46 !	100	100	-47 !	380	380	-35 !	54	54	-23 !
309	309	-47	-45	52	43 !	218	218	-46 !	104	104	-47 !	131	131	-36 !	235	235	-23 !
310	310	-53	2	63	68 !	69	69	-47 !	397	397	-47 !	57	57	-37 !	220	220	-24 !
311	311	11	6	168	73 !	107	107	-47 !	399	399	-47 !	119	119	-37 !	254	254	-24 !
312	312	-67	-74	-37	68 !	172	172	-47 !	136	136	-49 !	290	290	-37 !	93	93	-25 !
313	313	-63	42	115	119 !	184	184	-47 !	187	187	-49 !	312	312	-37 !	263	263	-25 !
314	314	-98	-19	4	18 !	309	309	-47 !	377	377	-49 !	333	333	-37 !	282	282	-25 !
315	315	-21	61	47	19 !	151	151	-48 !	127	127	-50 !	351	351	-37 !	391	391	-25 !
316	316	-15	-62	-24	23 !	87	87	-49 !	165	165	-50 !	353	353	-37 !	35	35	-26 !
317	317	-7	-1	53	-13 !	146	146	-49 !	170	170	-50 !	355	355	-37 !	280	280	-28 !

318	318	27	-99	0	98 !	149	149	-49 !	390	390	-50 !	44	44	-38 !	330	330	-28 !
319	319	-11	-24	116	130 !	52	52	-50 !	74	74	-51 !	49	49	-38 !	41	41	-29 !
320	320	-3	-40	61	89 !	100	100	-50 !	383	383	-51 !	55	55	-38 !	42	42	-30 !
321	321	-85	-65	-107	29 !	127	127	-50 !	379	379	-52 !	92	92	-40 !	247	247	-30 !
322	322	54	-7	-29	-10 !	41	41	-51 !	384	384	-54 !	31	31	-41 !	296	296	-30 !
323	323	105	-34	-35	69 !	38	38	-53 !	138	138	-55 !	108	108	-43 !	102	102	-31 !
324	324	78	-126	-15	51 !	126	126	-53 !	107	107	-56 !	1	1	-44 !	252	252	-31 !
325	325	84	-131	42	90 !	205	205	-53 !	89	89	-57 !	115	115	-44 !	85	85	-32 !
326	326	55	-137	-19	18 !	310	310	-53 !	302	302	-57 !	10	10	-45 !	89	89	-33 !
327	327	84	-89	49	29 !	199	199	-56 !	330	330	-57 !	43	43	-45 !	261	261	-33 !
328	328	31	-82	21	62 !	186	186	-58 !	332	332	-57 !	82	82	-45 !	55	55	-35 !
329	329	84	-162	-65	61 !	215	215	-58 !	369	369	-58 !	102	102	-45 !	98	98	-35 !
330	330	9	-57	-2	-28 !	8	8	-60 !	391	391	-58 !	123	123	-45 !	234	234	-35 !
331	331	79	-125	-13	80 !	68	68	-60 !	58	58	-59 !	129	129	-45 !	281	281	-35 !
332	332	68	-57	40	-67 !	195	195	-61 !	393	393	-59 !	96	96	-46 !	126	126	-36 !
333	333	-67	-74	-37	68 !	213	213	-61 !	378	378	-60 !	27	27	-47 !	380	380	-36 !
334	334	223	8	173	-257 !	79	79	-62 !	388	388	-60 !	48	48	-47 !	44	44	-39 !
335	335	118	-147	51	27 !	80	80	-62 !	110	110	-61 !	36	36	-48 !	71	71	-39 !
336	336	30	-39	40	24 !	90	90	-63 !	192	192	-61 !	2	2	-49 !	112	112	-39 !
337	337	29	-38	18	35 !	291	291	-63 !	396	396	-61 !	33	33	-49 !	262	262	-39 !
338	338	208	-216	73	71 !	313	313	-63 !	316	316	-62 !	34	34	-49 !	372	372	-39 !
339	339	115	-146	37	46 !	115	115	-64 !	370	370	-62 !	140	140	-51 !	3	3	-40 !
340	340	92	-81	44	13 !	62	62	-65 !	366	366	-63 !	237	237	-51 !	255	255	-41 !
341	341	279	-311	99	134 !	161	161	-65 !	36	36	-65 !	22	22	-53 !	68	68	-42 !
342	342	-12	-76	39	-4 !	236	236	-65 !	321	321	-65 !	81	81	-53 !	377	377	-43 !
343	343	-8	-72	34	-5 !	48	48	-66 !	86	86	-66 !	101	101	-53 !	268	268	-45 !
344	344	50	-73	33	-5 !	177	177	-66 !	209	209	-67 !	356	356	-54 !	245	245	-46 !
345	345	64	-129	22	4 !	57	57	-67 !	364	364	-68 !	21	21	-55 !	87	87	-47 !
346	346	86	-79	64	15 !	91	91	-67 !	61	61	-70 !	41	41	-55 !	266	266	-48 !
347	347	105	-144	51	43 !	119	119	-67 !	65	65	-71 !	251	251	-55 !	257	257	-49 !
348	348	238	-231	120	68 !	290	290	-67 !	116	116	-72 !	83	83	-56 !	47	47	-50 !
349	349	213	-225	101	56 !	312	312	-67 !	152	152	-72 !	97	97	-56 !	108	108	-50 !
350	350	119	-168	71	40 !	333	333	-67 !	343	343	-72 !	105	105	-56 !	72	72	-51 !
351	351	-67	-74	-37	68 !	351	351	-67 !	392	392	-72 !	23	23	-57 !	109	109	-52 !
352	352	107	-130	61	12 !	353	353	-67 !	398	398	-72 !	53	53	-57 !	284	284	-52 !
353	353	-67	-74	-37	68 !	355	355	-67 !	344	344	-73 !	133	133	-58 !	36	36	-53 !
354	354	264	-194	117	105 !	121	121	-68 !	57	57	-74 !	25	25	-60 !	230	230	-55 !
355	355	-67	-74	-37	68 !	154	154	-68 !	119	119	-74 !	112	112	-61 !	246	246	-55 !
356	356	174	81	-54	238 !	155	155	-68 !	290	290	-74 !	54	54	-65 !	272	272	-55 !
357	357	249	-207	121	84 !	164	164	-68 !	312	312	-74 !	329	329	-65 !	52	52	-56 !
358	358	394	-390	145	157 !	50	50	-69 !	333	333	-74 !	381	381	-65 !	242	242	-56 !
359	359	77	-89	50	69 !	210	210	-70 !	351	351	-74 !	14	14	-66 !	283	283	-56 !
360	360	110	-89	56	75 !	219	219	-70 !	353	353	-74 !	71	71	-67 !	37	37	-57 !
361	361	101	15	102	67 !	174	174	-71 !	355	355	-74 !	118	118	-67 !	48	48	-57 !
362	362	83	-17	58	57 !	176	176	-71 !	342	342	-76 !	90	90	-68 !	51	51	-57 !
363	363	128	-24	83	45 !	196	196	-71 !	93	93	-77 !	106	106	-68 !	260	260	-57 !
364	364	73	-68	45	39 !	198	198	-71 !	121	121	-78 !	107	107	-69 !	306	306	-60 !
365	365	97	-32	68	28 !	42	42	-72 !	346	346	-79 !	35	35	-70 !	34	34	-61 !
366	366	133	-63	6	23 !	182	182	-72 !	340	340	-81 !	85	85	-71 !	373	373	-61 !
367	367	149	-117	43	44 !	148	148	-73 !	381	381	-81 !	120	120	-71 !	30	30	-62 !
368	368	157	-153	63	57 !	74	74	-75 !	328	328	-82 !	3	3	-73 !	294	294	-62 !
369	369	56	-58	34	45 !	140	140	-75 !	387	387	-83 !	24	24	-73 !	301	301	-66 !
370	370	97	-62	9	25 !	167	167	-75 !	267	267	-85 !	37	37	-77 !	43	43	-67 !
371	371	54	-27	2	-22 !	190	190	-75 !	385	385	-86 !	42	42	-79 !	332	332	-67 !
372	372	55	-2	-4	-39 !	191	191	-75 !	327	327	-89 !	45	45	-79 !	275	275	-68 !
373	373	77	-40	-27	-61 !	40	40	-76 !	359	359	-89 !	93	93	-79 !	103	103	-70 !
374	374	132	-89	-23	31 !	111	111	-76 !	360	360	-89 !	30	30	-80 !	287	287	-70 !
375	375	77	-10	62	19 !	246	246	-76 !	374	374	-89 !	16	16	-82 !	33	33	-71 !
376	376	63	-45	-33	-12 !	85	85	-79 !	77	77	-91 !	94	94	-83 !	39	39	-73 !
377	377	19	-49	-107	-43 !	158	158	-79 !	308	308	-95 !	109	109	-84 !	271	271	-80 !

378	378	67	-60	-20	36 !	147	147	-80 !	67	67	-96 !	87	87	-85 !	265	265	-81 !
379	379	109	-52	18	-13 !	181	181	-81 !	318	318	-99 !	98	98	-86 !	277	277	-83 !
380	380	70	-27	-35	-36 !	110	110	-82 !	367	367	-117 !	117	117	-90 !	2	2	-87 !
381	381	46	-81	-65	0 !	60	60	-84 !	331	331	-125 !	32	32	-92 !	384	384	-90 !
382	382	31	-24	11	-1 !	86	86	-84 !	324	324	-126 !	113	113	-94 !	307	307	-91 !
383	383	-3	-51	0	-3 !	142	142	-85 !	345	345	-129 !	114	114	-94 !	227	227	-97 !
384	384	72	-54	-28	-90 !	321	321	-85 !	400	400	-129 !	116	116	-95 !	289	289	-104 !
385	385	5	-86	-21	10 !	51	51	-92 !	352	352	-130 !	47	47	-97 !	250	250	-107 !
386	386	16	-34	-4	-1 !	75	75	-92 !	325	325	-131 !	86	86	-100 !	278	278	-110 !
387	387	43	-83	14	28 !	211	211	-94 !	326	326	-137 !	100	100	-100 !	292	292	-110 !
388	388	40	-60	19	32 !	165	165	-95 !	347	347	-144 !	121	121	-100 !	253	253	-113 !
389	389	29	-37	-7	0 !	314	314	-98 !	339	339	-146 !	165	165	-106 !	279	279	-113 !
390	390	37	-50	-3	-18 !	66	66	-101 !	335	335	-147 !	104	104	-107 !	295	295	-114 !
391	391	46	-58	-25	-25 !	296	296	-101 !	368	368	-153 !	321	321	-107 !	286	286	-120 !
392	392	37	-72	-8	34 !	76	76	-102 !	329	329	-162 !	377	377	-107 !	293	293	-131 !
393	393	43	-59	-20	-1 !	83	83	-102 !	350	350	-168 !	103	103	-112 !	31	31	-133 !
394	394	18	-46	11	-10 !	82	82	-105 !	354	354	-194 !	84	84	-119 !	285	285	-152 !
395	395	67	-38	37	6 !	122	122	-105 !	357	357	-207 !	20	20	-127 !	276	276	-162 !
396	396	57	-61	41	11 !	207	207	-110 !	338	338	-216 !	67	67	-134 !	269	269	-183 !
397	397	28	-47	22	61 !	159	159	-111 !	349	349	-225 !	19	19	-149 !	288	288	-206 !
398	398	7	-72	4	46 !	73	73	-117 !	348	348	-231 !	110	110	-151 !	299	299	-250 !
399	399	54	-47	33	30 !	163	163	-120 !	341	341	-311 !	18	18	-166 !	334	334	-257 !
400	400	100	-129	14	27 !	67	67	-140 !	358	358	-390 !	17	17	-177 !	304	304	-411 !

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SPECIES - KARSTLAND DATA - APRIL/MAY 1986

CANOCO -- ANALYSIS 5 CANONICAL AXES 4 COVARIABLES 0 SCALING 1 CENT./STAND. BY SAMPLES: 0/0 BY SPECIES: 0/0 MULTIPLIER 1000.
DETRENDING 0 DOWNWEIGHTING 0 RESCALING 0 SEGMENTS 0 THRESHOLD .00 RANKING BY SAMPLES/SPECIES: 0/0

TRANSFORMATION -1.00 .00

REGRESSION/CANONICAL COEFFICIENTS FOR STANDARDIZED VARIABLES

N	NAME	AX1	AX2	AX3	AX4 !	RANKED 1		!	RANKED 2		!	RANKED 3		!	RANKED 4		!
					!		EIG=	.177 !		EIG=	.157 !		EIG=	.115 !		EIG=	.092 !
1	RAI1SEA	-289	178	-229	-89 !	2	RAI3SEA	-25 !	2	RAI3SEA	197 !	2	RAI3SEA	229 !	10	CONTA	13 !
2	RAI3SEA	-25	197	229	-173 !	3	A1	-49 !	1	RAI1SEA	178 !	3	A1	193 !	1	RAI1SEA	-89 !
3	A1	-49	-352	193	-233 !	11	PLAIN	-51 !	7	RENS	51 !	7	RENS	152 !	11	PLAIN	-143 !
4	MISP	-355	-110	-145	-636 !	8	MILK	-90 !	10	CONTA	3 !	11	PLAIN	139 !	2	RAI3SEA	-173 !
5	HUTT	-405	-342	30	-499 !	10	CONTA	-149 !	8	MILK	2 !	10	CONTA	123 !	6	GLEN	-179 !
6	GLEN	-168	-103	-80	-179 !	6	GLEN	-168 !	11	PLAIN	-101 !	5	HUTT	30 !	8	MILK	-201 !
7	RENS	-510	51	152	-284 !	1	RAI1SEA	-289 !	6	GLEN	-103 !	6	GLEN	-80 !	3	A1	-233 !
8	MILK	-90	2	-89	-201 !	4	MISP	-355 !	4	MISP	-110 !	8	MILK	-89 !	7	RENS	-284 !
10	CONTA	-149	3	123	13 !	5	HUTT	-405 !	5	HUTT	-342 !	4	MISP	-145 !	5	HUTT	-499 !
11	PLAIN	-51	-101	139	-143 !	7	RENS	-510 !	3	A1	-352 !	1	RAI1SEA	-229 !	4	MISP	-636 !

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SPECIES - KARSTLAND DATA - APRIL/MAY 1986

CANOCO -- ANALYSIS 5 CANONICAL AXES 4 COVARIABLES 0 SCALING 1 CENT./STAND. BY SAMPLES: 0/0 BY SPECIES: 0/0 MULTIPLIER 100.
DETRENDING 0 DOWNWEIGHTING 0 RESCALING 0 SEGMENTS 0 THRESHOLD .00 RANKING BY SAMPLES/SPECIES: 0/0

TRANSFORMATION -1.00 .00

T-VALUES OF REGRESSION COEFFICIENTS

N	NAME	AX1	AX2	AX3	AX4 !	RANKED 1		!	RANKED 2		!	RANKED 3		!	RANKED 4		!
					!	FR EXPLAINED=		.236 !	FR EXPLAINED=		.209 !	FR EXPLAINED=		.154 !	FR EXPLAINED=		.122 !
1	RAI1SEA	-966	579	-769	-308 !	2	RAI3SEA	-76 !	1	RAI1SEA	579 !	2	RAI3SEA	692 !	10	CONTA	32 !
2	RAI3SEA	-76	575	692	-541 !	11	PLAIN	-99 !	2	RAI3SEA	575 !	3	A1	445 !	11	PLAIN	-290 !
3	A1	-112	-788	445	-555 !	3	A1	-112 !	7	RENS	54 !	10	CONTA	293 !	1	RAI1SEA	-308 !
4	MISP	-344	-104	-141	-639 !	8	MILK	-255 !	10	CONTA	7 !	11	PLAIN	274 !	7	RENS	-324 !
5	HUTT	-472	-388	35	-604 !	4	MISP	-344 !	8	MILK	5 !	7	RENS	168 !	6	GLEN	-461 !
6	GLEN	-414	-247	-199	-461 !	10	CONTA	-353 !	4	MISP	-104 !	5	HUTT	35 !	2	RAI3SEA	-541 !
7	RENS	-561	54	168	-324 !	6	GLEN	-414 !	11	PLAIN	-192 !	4	MISP	-141 !	3	A1	-555 !

8	MILK	-255	5	-253	-590	!	5	HUTT	-472	!	6	GLEN	-247	!	6	GLEN	-199	!	8	MILK	-590	!
10	CONTA	-353	7	293	32	!	7	RENS	-561	!	5	HUTT	-388	!	8	MILK	-253	!	5	HUTT	-604	!
11	PLAIN	-99	-192	274	-290	!	1	RAI1SEA	-966	!	3	A1	-788	!	1	RAI1SEA	-769	!	4	MISP	-639	!

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SPECIES - KARSTLAND DATA - APRIL/MAY 1986

CANOCO -- ANALYSIS 5 CANONICAL AXES 4 COVARIABLES 0 SCALING 1 CENT./STAND. BY SAMPLES: 0/0 BY SPECIES: 0/0 MULTIPLIER 1000.

DETRENDING 0 DOWNWEIGHTING 0 RESCALING 0 SEGMENTS 0 THRESHOLD .00 RANKING BY SAMPLES/SPECIES: 0/0

TRANSFORMATION -1.00 .00

INTER SET CORRELATIONS OF ENVIRONMENTAL VARIABLES WITH AXES

N	NAME	AX1	AX2	AX3	AX4	!	RANKED 1			!	RANKED 2			!	RANKED 3			!	RANKED 4			!
						!	FR EXTRACTED= .132			!	FR EXTRACTED= .051			!	FR EXTRACTED= .054			!	FR EXTRACTED= .035			!
1	RAI1SEA	-699	80	-181	-94	!	4	MISP	562	!	2	RAI3SEA	537	!	3	A1	418	!	7	RENS	265	!
2	RAI3SEA	236	537	160	-329	!	2	RAI3SEA	236	!	4	MISP	140	!	7	RENS	364	!	10	CONTA	76	!
3	A1	-71	-374	418	-36	!	10	CONTA	98	!	1	RAI1SEA	80	!	2	RAI3SEA	160	!	6	GLEN	2	!
4	MISP	562	140	-50	-169	!	8	MILK	93	!	8	MILK	47	!	10	CONTA	119	!	3	A1	-36	!
5	HUTT	-272	-184	-306	-36	!	3	A1	-71	!	7	RENS	45	!	11	PLAIN	61	!	5	HUTT	-36	!
6	GLEN	-86	-86	-244	2	!	6	GLEN	-86	!	10	CONTA	-2	!	8	MILK	42	!	1	RAI1SEA	-94	!
7	RENS	-471	45	364	265	!	5	HUTT	-272	!	6	GLEN	-86	!	4	MISP	-50	!	4	MISP	-169	!
8	MILK	93	47	42	-248	!	11	PLAIN	-362	!	11	PLAIN	-116	!	1	RAI1SEA	-181	!	11	PLAIN	-247	!
10	CONTA	98	-2	119	76	!	7	RENS	-471	!	5	HUTT	-184	!	6	GLEN	-244	!	8	MILK	-248	!
11	PLAIN	-362	-116	61	-247	!	1	RAI1SEA	-699	!	3	A1	-374	!	5	HUTT	-306	!	2	RAI3SEA	-329	!

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SPECIES - KARSTLAND DATA - APRIL/MAY 1986

CANOCO -- ANALYSIS 5 CANONICAL AXES 4 COVARIABLES 0 SCALING 1 CENT./STAND. BY SAMPLES: 0/0 BY SPECIES: 0/0 MULTIPLIER 1000.

DETRENDING 0 DOWNWEIGHTING 0 RESCALING 0 SEGMENTS 0 THRESHOLD .00 RANKING BY SAMPLES/SPECIES: 0/0

TRANSFORMATION -1.00 .00

BIPLOT SCORES OF ENVIRONMENTAL VARIABLES

N	NAME	AX1	AX2	AX3	AX4	!	RANKED 1			!	RANKED 2			!	RANKED 3			!	RANKED 4			!
						!	R(SPEC,ENV) = .778			!	R(SPEC,ENV) = .746			!	R(SPEC,ENV) = .696			!	R(SPEC,ENV) = .661			!
1	RAI1SEA	-343	39	-83	-41	!	4	MISP	275	!	2	RAI3SEA	262	!	3	A1	192	!	7	RENS	116	!
2	RAI3SEA	116	262	74	-144	!	2	RAI3SEA	116	!	4	MISP	68	!	7	RENS	167	!	10	CONTA	33	!
3	A1	-35	-183	192	-16	!	10	CONTA	48	!	1	RAI1SEA	39	!	2	RAI3SEA	74	!	6	GLEN	1	!
4	MISP	275	68	-23	-74	!	8	MILK	46	!	8	MILK	23	!	10	CONTA	55	!	3	A1	-16	!
5	HUTT	-133	-90	-141	-16	!	3	A1	-35	!	7	RENS	22	!	11	PLAIN	28	!	5	HUTT	-16	!
6	GLEN	-42	-42	-112	1	!	6	GLEN	-42	!	10	CONTA	-1	!	8	MILK	19	!	1	RAI1SEA	-41	!
7	RENS	-231	22	167	116	!	5	HUTT	-133	!	6	GLEN	-42	!	4	MISP	-23	!	4	MISP	-74	!
8	MILK	46	23	19	-108	!	11	PLAIN	-178	!	11	PLAIN	-56	!	1	RAI1SEA	-83	!	8	MILK	-108	!
10	CONTA	48	-1	55	33	!	7	RENS	-231	!	5	HUTT	-90	!	6	GLEN	-112	!	11	PLAIN	-108	!
11	PLAIN	-178	-56	28	-108	!	1	RAI1SEA	-343	!	3	A1	-183	!	5	HUTT	-141	!	2	RAI3SEA	-144	!

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SPECIES - KARSTLAND DATA - APRIL/MAY 1986

CANOCO -- ANALYSIS 5 CANONICAL AXES 4 COVARIABLES 0 SCALING 1 CENT./STAND. BY SAMPLES: 0/0 BY SPECIES: 0/0 MULTIPLIER 1000.

DETRENDING 0 DOWNWEIGHTING 0 RESCALING 0 SEGMENTS 0 THRESHOLD .00 RANKING BY SAMPLES/SPECIES: 0/0

TRANSFORMATION -1.00 .00

CENTROIDS OF ENVIRONMENTAL VARIABLES (MEAN.GT.0) IN ORDINATION DIAGRAM

N	NAME	AX1	AX2	AX3	AX4	!	RANKED 1			!	RANKED 2			!	RANKED 3			!	RANKED 4			!
						!	R(SPEC,ENV) = .778			!	R(SPEC,ENV) = .746			!	R(SPEC,ENV) = .696			!	R(SPEC,ENV) = .661			!
1	RAI1SEA	-25	3	-6	-3	!	8	MILK	376	!	8	MILK	185	!	7	RENS	330	!	7	RENS	222	!
2	RAI3SEA	2	4	1	-2	!	4	MISP	307	!	4	MISP	74	!	8	MILK	149	!	10	CONTA	64	!
3	A1	-10	-50	50	-4	!	10	CONTA	102	!	7	RENS	45	!	10	CONTA	108	!	6	GLEN	6	!
4	MISP	307	74	-24	-75	!	2	RAI3SEA	2	!	2	RAI3SEA	4	!	3	A1	50	!	2	RAI3SEA	-2	!
5	HUTT	-383	-252	-376	-41	!	3	A1	-10	!	1	RAI1SEA	3	!	11	PLAIN	24	!	1	RAI1SEA	-3	!
6	GLEN	-302	-292	-747	6	!	1	RAI1SEA	-25	!	10	CONTA	-2	!	2	RAI3SEA	1	!	3	A1	-4	!
7	RENS	-490	45	330	222	!	11	PLAIN	-160	!	3	A1	-50	!	1	RAI1SEA	-6	!	5	HUTT	-41	!

8	MILK	376	185	149	-809	!	6	GLEN	-302	!	11	PLAIN	-50	!	4	MISP	-24	!	4	MISP	-75	!				
10	CONTA	102	-2	108	64	!	5	HUTT	-383	!	5	HUTT	-252	!	5	HUTT	-376	!	11	PLAIN	-88	!				
11	PLAIN	-160	-50	24	-88	!	7	RENS	-490	!	6	GLEN	-292	!	6	GLEN	-747	!	8	MILK	-809	!				

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SPECIES - KARSTLAND DATA - APRIL/MAY 1986

CANOCO -- ANALYSIS 5 CANONICAL AXES 4 COVARIABLES 0 SCALING 1 CENT./STAND. BY SAMPLES: 0/0 BY SPECIES: 0/0 MULTIPLIER 100.
DETRENDING 0 DOWNWEIGHTING 0 RESCALING 0 SEGMENTS 0 THRESHOLD .00 RANKING BY SAMPLES/SPECIES: 0/0
TRANSFORMATION -1.00 .00

SAMPLE SCORES - WHICH ARE LINEAR COMBINATIONS OF ENVIRONMENTAL VARIABLES

N	NAME	AX1	AX2	AX3	AX4	!	RANKED 1			!	RANKED 2			!	RANKED 3			!	RANKED 4			!
						!		EIG= .177		!		EIG= .157		!		EIG= .115		!		EIG= .092		!
1	1	23	25	11	9	!	353	353	137	!	13	13	96	!	308	308	97	!	353	353	92	!
2	2	23	25	11	9	!	354	354	137	!	14	14	96	!	309	309	97	!	354	354	92	!
3	3	23	25	11	9	!	355	355	137	!	15	15	96	!	310	310	97	!	355	355	92	!
4	4	23	25	11	9	!	356	356	137	!	16	16	96	!	311	311	97	!	356	356	92	!
5	5	23	25	11	9	!	357	357	137	!	17	17	96	!	312	312	97	!	357	357	92	!
6	6	23	25	11	9	!	358	358	137	!	18	18	96	!	313	313	97	!	358	358	92	!
7	7	23	25	11	9	!	359	359	137	!	19	19	96	!	314	314	97	!	359	359	92	!
8	8	23	25	11	9	!	360	360	137	!	20	20	96	!	315	315	97	!	360	360	92	!
9	9	23	25	11	9	!	361	361	137	!	21	21	96	!	316	316	97	!	361	361	92	!
10	10	23	25	11	9	!	362	362	137	!	22	22	96	!	317	317	97	!	362	362	92	!
11	11	23	25	11	9	!	322	322	81	!	23	23	96	!	318	318	97	!	308	308	59	!
12	12	23	25	11	9	!	323	323	81	!	24	24	96	!	319	319	97	!	309	309	59	!
13	13	67	96	-57	53	!	324	324	81	!	25	25	96	!	353	353	62	!	310	310	59	!
14	14	67	96	-57	53	!	325	325	81	!	26	26	96	!	354	354	62	!	311	311	59	!
15	15	67	96	-57	53	!	326	326	81	!	27	27	96	!	355	355	62	!	312	312	59	!
16	16	67	96	-57	53	!	327	327	81	!	28	28	96	!	356	356	62	!	313	313	59	!
17	17	67	96	-57	53	!	328	328	81	!	29	29	96	!	357	357	62	!	314	314	59	!
18	18	67	96	-57	53	!	329	329	81	!	217	217	53	!	358	358	62	!	315	315	59	!
19	19	67	96	-57	53	!	330	330	81	!	218	218	53	!	359	359	62	!	316	316	59	!
20	20	67	96	-57	53	!	331	331	81	!	219	219	53	!	360	360	62	!	317	317	59	!
21	21	67	96	-57	53	!	332	332	81	!	220	220	53	!	361	361	62	!	318	318	59	!
22	22	67	96	-57	53	!	366	366	81	!	221	221	53	!	362	362	62	!	319	319	59	!
23	23	67	96	-57	53	!	367	367	81	!	222	222	53	!	138	138	29	!	13	13	53	!
24	24	67	96	-57	53	!	368	368	81	!	223	223	53	!	139	139	29	!	14	14	53	!
25	25	67	96	-57	53	!	369	369	81	!	224	224	53	!	140	140	29	!	15	15	53	!
26	26	67	96	-57	53	!	370	370	81	!	225	225	53	!	141	141	29	!	16	16	53	!
27	27	67	96	-57	53	!	371	371	81	!	226	226	53	!	142	142	29	!	17	17	53	!
28	28	67	96	-57	53	!	372	372	81	!	227	227	53	!	143	143	29	!	18	18	53	!
29	29	67	96	-57	53	!	373	373	81	!	228	228	53	!	144	144	29	!	19	19	53	!
30	30	-5	-25	-36	-42	!	374	374	81	!	229	229	53	!	145	145	29	!	20	20	53	!
31	31	-5	-25	-36	-42	!	375	375	81	!	230	230	53	!	146	146	29	!	21	21	53	!
32	32	-5	-25	-36	-42	!	376	376	81	!	231	231	53	!	147	147	29	!	22	22	53	!
33	33	-5	-25	-36	-42	!	377	377	81	!	232	232	53	!	148	148	29	!	23	23	53	!
34	34	-5	-25	-36	-42	!	333	333	70	!	233	233	53	!	149	149	29	!	24	24	53	!
35	35	-5	-25	-36	-42	!	334	334	70	!	234	234	53	!	150	150	29	!	25	25	53	!
36	36	-5	-25	-36	-42	!	335	335	70	!	235	235	53	!	151	151	29	!	26	26	53	!
37	37	-5	-25	-36	-42	!	336	336	70	!	236	236	53	!	152	152	29	!	27	27	53	!
38	38	-5	-25	-36	-42	!	337	337	70	!	237	237	53	!	153	153	29	!	28	28	53	!
39	39	-5	-25	-36	-42	!	338	338	70	!	238	238	53	!	154	154	29	!	29	29	53	!
40	40	-5	-25	-36	-42	!	339	339	70	!	239	239	53	!	155	155	29	!	57	57	27	!
41	41	-5	-25	-36	-42	!	340	340	70	!	240	240	53	!	156	156	29	!	58	58	27	!
42	42	-5	-25	-36	-42	!	341	341	70	!	241	241	53	!	157	157	29	!	125	125	27	!
43	43	-5	-25	-36	-42	!	342	342	70	!	242	242	53	!	158	158	29	!	126	126	27	!
44	44	-5	-25	-36	-42	!	343	343	70	!	243	243	53	!	159	159	29	!	127	127	27	!
45	45	-5	-25	-36	-42	!	344	344	70	!	244	244	53	!	160	160	29	!	320	320	21	!
46	46	-5	-25	-36	-42	!	345	345	70	!	245	245	53	!	161	161	29	!	321	321	21	!
47	47	-5	-25	-36	-42	!	346	346	70	!	246	246	53	!	162	162	29	!	378	378	21	!

48	48	-5	-25	-36	-42 !	347	347	70 !	247	247	53 !	163	163	29 !	379	379	21 !
49	49	-34	-39	-17	-33 !	348	348	70 !	248	248	53 !	164	164	29 !	380	380	21 !
50	50	-34	-39	-17	-33 !	349	349	70 !	128	128	33 !	165	165	29 !	381	381	21 !
51	51	-34	-39	-17	-33 !	350	350	70 !	129	129	33 !	166	166	29 !	382	382	21 !
52	52	-34	-39	-17	-33 !	351	351	70 !	130	130	33 !	167	167	29 !	383	383	21 !
53	53	-34	-39	-17	-33 !	352	352	70 !	131	131	33 !	168	168	29 !	384	384	21 !
54	54	-34	-39	-17	-33 !	363	363	70 !	132	132	33 !	169	169	29 !	385	385	21 !
55	55	-34	-39	-17	-33 !	364	364	70 !	133	133	33 !	170	170	29 !	386	386	21 !
56	56	-34	-39	-17	-33 !	365	365	70 !	134	134	33 !	171	171	29 !	387	387	21 !
57	57	-61	-5	-38	27 !	13	13	67 !	135	135	33 !	172	172	29 !	388	388	21 !
58	58	-61	-5	-38	27 !	14	14	67 !	136	136	33 !	173	173	29 !	389	389	21 !
59	59	-37	-27	-38	-6 !	15	15	67 !	137	137	33 !	174	174	29 !	390	390	21 !
60	60	-37	-27	-38	-6 !	16	16	67 !	249	249	31 !	175	175	29 !	391	391	21 !
61	61	-37	-27	-38	-6 !	17	17	67 !	250	250	31 !	176	176	29 !	392	392	21 !
62	62	-37	-27	-38	-6 !	18	18	67 !	251	251	31 !	177	177	29 !	393	393	21 !
63	63	-37	-27	-38	-6 !	19	19	67 !	252	252	31 !	178	178	29 !	394	394	21 !
64	64	-37	-27	-38	-6 !	20	20	67 !	253	253	31 !	179	179	29 !	395	395	21 !
65	65	-37	-27	-38	-6 !	21	21	67 !	254	254	31 !	180	180	29 !	396	396	21 !
66	66	-37	-27	-38	-6 !	22	22	67 !	255	255	31 !	181	181	29 !	397	397	21 !
67	67	-37	-27	-38	-6 !	23	23	67 !	256	256	31 !	182	182	29 !	398	398	21 !
68	68	-37	-27	-38	-6 !	24	24	67 !	257	257	31 !	183	183	29 !	399	399	21 !
69	69	-37	-27	-38	-6 !	25	25	67 !	258	258	31 !	184	184	29 !	400	400	21 !
70	70	-37	-27	-38	-6 !	26	26	67 !	259	259	31 !	185	185	29 !	138	138	20 !
71	71	-37	-27	-38	-6 !	27	27	67 !	260	260	31 !	186	186	29 !	139	139	20 !
72	72	-37	-27	-38	-6 !	28	28	67 !	261	261	31 !	187	187	29 !	140	140	20 !
73	73	-37	-27	-38	-6 !	29	29	67 !	262	262	31 !	188	188	29 !	141	141	20 !
74	74	-37	-27	-38	-6 !	320	320	46 !	263	263	31 !	189	189	29 !	142	142	20 !
75	75	-37	-27	-38	-6 !	321	321	46 !	264	264	31 !	190	190	29 !	143	143	20 !
76	76	-37	-27	-38	-6 !	378	378	46 !	265	265	31 !	191	191	29 !	144	144	20 !
77	77	-37	-27	-38	-6 !	379	379	46 !	266	266	31 !	192	192	29 !	145	145	20 !
78	78	-37	-27	-38	-6 !	380	380	46 !	267	267	31 !	193	193	29 !	146	146	20 !
79	79	-37	-27	-38	-6 !	381	381	46 !	268	268	31 !	194	194	29 !	147	147	20 !
80	80	-37	-27	-38	-6 !	382	382	46 !	269	269	31 !	195	195	29 !	148	148	20 !
81	81	-37	-27	-38	-6 !	383	383	46 !	270	270	31 !	196	196	29 !	149	149	20 !
82	82	-37	-27	-38	-6 !	384	384	46 !	271	271	31 !	197	197	29 !	150	150	20 !
83	83	-37	-27	-38	-6 !	385	385	46 !	272	272	31 !	198	198	29 !	151	151	20 !
84	84	-37	-27	-38	-6 !	386	386	46 !	273	273	31 !	199	199	29 !	152	152	20 !
85	85	-37	-27	-38	-6 !	387	387	46 !	274	274	31 !	200	200	29 !	153	153	20 !
86	86	-37	-27	-38	-6 !	388	388	46 !	275	275	31 !	201	201	29 !	154	154	20 !
87	87	-37	-27	-38	-6 !	389	389	46 !	276	276	31 !	202	202	29 !	155	155	20 !
88	88	-37	-27	-38	-6 !	390	390	46 !	277	277	31 !	203	203	29 !	156	156	20 !
89	89	-37	-27	-38	-6 !	391	391	46 !	278	278	31 !	204	204	29 !	157	157	20 !
90	90	-37	-27	-38	-6 !	392	392	46 !	279	279	31 !	205	205	29 !	158	158	20 !
91	91	-37	-27	-38	-6 !	393	393	46 !	280	280	31 !	206	206	29 !	159	159	20 !
92	92	-37	-27	-38	-6 !	394	394	46 !	290	290	31 !	207	207	29 !	160	160	20 !
93	93	-37	-27	-38	-6 !	395	395	46 !	291	291	31 !	208	208	29 !	161	161	20 !
94	94	-37	-27	-38	-6 !	396	396	46 !	292	292	31 !	209	209	29 !	162	162	20 !
95	95	-37	-27	-38	-6 !	397	397	46 !	293	293	31 !	210	210	29 !	163	163	20 !
96	96	-37	-27	-38	-6 !	398	398	46 !	294	294	31 !	211	211	29 !	164	164	20 !
97	97	-37	-27	-38	-6 !	399	399	46 !	295	295	31 !	212	212	29 !	165	165	20 !
98	98	-37	-27	-38	-6 !	400	400	46 !	296	296	31 !	213	213	29 !	166	166	20 !
99	99	-37	-27	-38	-6 !	281	281	38 !	297	297	31 !	214	214	29 !	167	167	20 !
100	100	-37	-27	-38	-6 !	282	282	38 !	298	298	31 !	215	215	29 !	168	168	20 !
101	101	-37	-27	-38	-6 !	283	283	38 !	299	299	31 !	216	216	29 !	169	169	20 !
102	102	-37	-27	-38	-6 !	284	284	38 !	300	300	31 !	217	217	28 !	170	170	20 !
103	103	-37	-27	-38	-6 !	285	285	38 !	301	301	31 !	218	218	28 !	171	171	20 !
104	104	-37	-27	-38	-6 !	286	286	38 !	302	302	31 !	219	219	28 !	172	172	20 !
105	105	-37	-27	-38	-6 !	287	287	38 !	303	303	31 !	220	220	28 !	173	173	20 !
106	106	-37	-27	-38	-6 !	288	288	38 !	304	304	31 !	221	221	28 !	174	174	20 !
107	107	-37	-27	-38	-6 !	289	289	38 !	305	305	31 !	222	222	28 !	175	175	20 !

108	108	-37	-27	-38	-6 !	249	249	34 !	306	306	31 !	223	223	28 !	176	176	20 !
109	109	-37	-27	-38	-6 !	250	250	34 !	307	307	31 !	224	224	28 !	177	177	20 !
110	110	-37	-27	-38	-6 !	251	251	34 !	1	1	25 !	225	225	28 !	178	178	20 !
111	111	-37	-27	-38	-6 !	252	252	34 !	2	2	25 !	226	226	28 !	179	179	20 !
112	112	-37	-27	-38	-6 !	253	253	34 !	3	3	25 !	227	227	28 !	180	180	20 !
113	113	-30	-29	-75	1 !	254	254	34 !	4	4	25 !	228	228	28 !	181	181	20 !
114	114	-30	-29	-75	1 !	255	255	34 !	5	5	25 !	229	229	28 !	182	182	20 !
115	115	-30	-29	-75	1 !	256	256	34 !	6	6	25 !	230	230	28 !	183	183	20 !
116	116	-30	-29	-75	1 !	257	257	34 !	7	7	25 !	231	231	28 !	184	184	20 !
117	117	-30	-29	-75	1 !	258	258	34 !	8	8	25 !	232	232	28 !	185	185	20 !
118	118	-30	-29	-75	1 !	259	259	34 !	9	9	25 !	233	233	28 !	186	186	20 !
119	119	-30	-29	-75	1 !	260	260	34 !	10	10	25 !	234	234	28 !	187	187	20 !
120	120	-30	-29	-75	1 !	261	261	34 !	11	11	25 !	235	235	28 !	188	188	20 !
121	121	-30	-29	-75	1 !	262	262	34 !	12	12	25 !	236	236	28 !	189	189	20 !
122	122	-30	-29	-75	1 !	263	263	34 !	281	281	18 !	237	237	28 !	190	190	20 !
123	123	-37	-27	-38	-6 !	264	264	34 !	282	282	18 !	238	238	28 !	191	191	20 !
124	124	-37	-27	-38	-6 !	265	265	34 !	283	283	18 !	239	239	28 !	192	192	20 !
125	125	-61	-5	-38	27 !	266	266	34 !	284	284	18 !	240	240	28 !	193	193	20 !
126	126	-61	-5	-38	27 !	267	267	34 !	285	285	18 !	241	241	28 !	194	194	20 !
127	127	-61	-5	-38	27 !	268	268	34 !	286	286	18 !	242	242	28 !	195	195	20 !
128	128	-24	33	-56	15 !	269	269	34 !	287	287	18 !	243	243	28 !	196	196	20 !
129	129	-24	33	-56	15 !	270	270	34 !	288	288	18 !	244	244	28 !	197	197	20 !
130	130	-24	33	-56	15 !	271	271	34 !	289	289	18 !	245	245	28 !	198	198	20 !
131	131	-24	33	-56	15 !	272	272	34 !	138	138	9 !	246	246	28 !	199	199	20 !
132	132	-24	33	-56	15 !	273	273	34 !	139	139	9 !	247	247	28 !	200	200	20 !
133	133	-24	33	-56	15 !	274	274	34 !	140	140	9 !	248	248	28 !	201	201	20 !
134	134	-24	33	-56	15 !	275	275	34 !	141	141	9 !	249	249	28 !	202	202	20 !
135	135	-24	33	-56	15 !	276	276	34 !	142	142	9 !	250	250	28 !	203	203	20 !
136	136	-24	33	-56	15 !	277	277	34 !	143	143	9 !	251	251	28 !	204	204	20 !
137	137	-24	33	-56	15 !	278	278	34 !	144	144	9 !	252	252	28 !	205	205	20 !
138	138	-52	9	29	20 !	279	279	34 !	145	145	9 !	253	253	28 !	206	206	20 !
139	139	-52	9	29	20 !	280	280	34 !	146	146	9 !	254	254	28 !	207	207	20 !
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142	142	-52	9	29	20 !	292	292	34 !	149	149	9 !	257	257	28 !	210	210	20 !
143	143	-52	9	29	20 !	293	293	34 !	150	150	9 !	258	258	28 !	211	211	20 !
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145	145	-52	9	29	20 !	295	295	34 !	152	152	9 !	260	260	28 !	213	213	20 !
146	146	-52	9	29	20 !	296	296	34 !	153	153	9 !	261	261	28 !	214	214	20 !
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152	152	-52	9	29	20 !	302	302	34 !	159	159	9 !	267	267	28 !	325	325	18 !
153	153	-52	9	29	20 !	303	303	34 !	160	160	9 !	268	268	28 !	326	326	18 !
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157	157	-52	9	29	20 !	307	307	34 !	164	164	9 !	272	272	28 !	330	330	18 !
158	158	-52	9	29	20 !	1	1	23 !	165	165	9 !	273	273	28 !	331	331	18 !
159	159	-52	9	29	20 !	2	2	23 !	166	166	9 !	274	274	28 !	332	332	18 !
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161	161	-52	9	29	20 !	4	4	23 !	168	168	9 !	276	276	28 !	367	367	18 !
162	162	-52	9	29	20 !	5	5	23 !	169	169	9 !	277	277	28 !	368	368	18 !
163	163	-52	9	29	20 !	6	6	23 !	170	170	9 !	278	278	28 !	369	369	18 !
164	164	-52	9	29	20 !	7	7	23 !	171	171	9 !	279	279	28 !	370	370	18 !
165	165	-52	9	29	20 !	8	8	23 !	172	172	9 !	280	280	28 !	371	371	18 !
166	166	-52	9	29	20 !	9	9	23 !	173	173	9 !	290	290	28 !	372	372	18 !
167	167	-52	9	29	20 !	10	10	23 !	174	174	9 !	291	291	28 !	373	373	18 !

168	168	-52	9	29	20 !	11	11	23 !	175	175	9 !	292	292	28 !	374	374	18 !
169	169	-52	9	29	20 !	12	12	23 !	176	176	9 !	293	293	28 !	375	375	18 !
170	170	-52	9	29	20 !	217	217	10 !	177	177	9 !	294	294	28 !	376	376	18 !
171	171	-52	9	29	20 !	218	218	10 !	178	178	9 !	295	295	28 !	377	377	18 !
172	172	-52	9	29	20 !	219	219	10 !	179	179	9 !	296	296	28 !	128	128	15 !
173	173	-52	9	29	20 !	220	220	10 !	180	180	9 !	297	297	28 !	129	129	15 !
174	174	-52	9	29	20 !	221	221	10 !	181	181	9 !	298	298	28 !	130	130	15 !
175	175	-52	9	29	20 !	222	222	10 !	182	182	9 !	299	299	28 !	131	131	15 !
176	176	-52	9	29	20 !	223	223	10 !	183	183	9 !	300	300	28 !	132	132	15 !
177	177	-52	9	29	20 !	224	224	10 !	184	184	9 !	301	301	28 !	133	133	15 !
178	178	-52	9	29	20 !	225	225	10 !	185	185	9 !	302	302	28 !	134	134	15 !
179	179	-52	9	29	20 !	226	226	10 !	186	186	9 !	303	303	28 !	135	135	15 !
180	180	-52	9	29	20 !	227	227	10 !	187	187	9 !	304	304	28 !	136	136	15 !
181	181	-52	9	29	20 !	228	228	10 !	188	188	9 !	305	305	28 !	137	137	15 !
182	182	-52	9	29	20 !	229	229	10 !	189	189	9 !	306	306	28 !	1	1	9 !
183	183	-52	9	29	20 !	230	230	10 !	190	190	9 !	307	307	28 !	2	2	9 !
184	184	-52	9	29	20 !	231	231	10 !	191	191	9 !	281	281	15 !	3	3	9 !
185	185	-52	9	29	20 !	232	232	10 !	192	192	9 !	282	282	15 !	4	4	9 !
186	186	-52	9	29	20 !	233	233	10 !	193	193	9 !	283	283	15 !	5	5	9 !
187	187	-52	9	29	20 !	234	234	10 !	194	194	9 !	284	284	15 !	6	6	9 !
188	188	-52	9	29	20 !	235	235	10 !	195	195	9 !	285	285	15 !	7	7	9 !
189	189	-52	9	29	20 !	236	236	10 !	196	196	9 !	286	286	15 !	8	8	9 !
190	190	-52	9	29	20 !	237	237	10 !	197	197	9 !	287	287	15 !	9	9	9 !
191	191	-52	9	29	20 !	238	238	10 !	198	198	9 !	288	288	15 !	10	10	9 !
192	192	-52	9	29	20 !	239	239	10 !	199	199	9 !	289	289	15 !	11	11	9 !
193	193	-52	9	29	20 !	240	240	10 !	200	200	9 !	333	333	14 !	12	12	9 !
194	194	-52	9	29	20 !	241	241	10 !	201	201	9 !	334	334	14 !	113	113	1 !
195	195	-52	9	29	20 !	242	242	10 !	202	202	9 !	335	335	14 !	114	114	1 !
196	196	-52	9	29	20 !	243	243	10 !	203	203	9 !	336	336	14 !	115	115	1 !
197	197	-52	9	29	20 !	244	244	10 !	204	204	9 !	337	337	14 !	116	116	1 !
198	198	-52	9	29	20 !	245	245	10 !	205	205	9 !	338	338	14 !	117	117	1 !
199	199	-52	9	29	20 !	246	246	10 !	206	206	9 !	339	339	14 !	118	118	1 !
200	200	-52	9	29	20 !	247	247	10 !	207	207	9 !	340	340	14 !	119	119	1 !
201	201	-52	9	29	20 !	248	248	10 !	208	208	9 !	341	341	14 !	120	120	1 !
202	202	-52	9	29	20 !	30	30	-5 !	209	209	9 !	342	342	14 !	121	121	1 !
203	203	-52	9	29	20 !	31	31	-5 !	210	210	9 !	343	343	14 !	122	122	1 !
204	204	-52	9	29	20 !	32	32	-5 !	211	211	9 !	344	344	14 !	59	59	-6 !
205	205	-52	9	29	20 !	33	33	-5 !	212	212	9 !	345	345	14 !	60	60	-6 !
206	206	-52	9	29	20 !	34	34	-5 !	213	213	9 !	346	346	14 !	61	61	-6 !
207	207	-52	9	29	20 !	35	35	-5 !	214	214	9 !	347	347	14 !	62	62	-6 !
208	208	-52	9	29	20 !	36	36	-5 !	215	215	9 !	348	348	14 !	63	63	-6 !
209	209	-52	9	29	20 !	37	37	-5 !	216	216	9 !	349	349	14 !	64	64	-6 !
210	210	-52	9	29	20 !	38	38	-5 !	57	57	-5 !	350	350	14 !	65	65	-6 !
211	211	-52	9	29	20 !	39	39	-5 !	58	58	-5 !	351	351	14 !	66	66	-6 !
212	212	-52	9	29	20 !	40	40	-5 !	125	125	-5 !	352	352	14 !	67	67	-6 !
213	213	-52	9	29	20 !	41	41	-5 !	126	126	-5 !	363	363	14 !	68	68	-6 !
214	214	-52	9	29	20 !	42	42	-5 !	127	127	-5 !	364	364	14 !	69	69	-6 !
215	215	-52	9	29	20 !	43	43	-5 !	30	30	-25 !	365	365	14 !	70	70	-6 !
216	216	-52	9	29	20 !	44	44	-5 !	31	31	-25 !	320	320	13 !	71	71	-6 !
217	217	10	53	28	-13 !	45	45	-5 !	32	32	-25 !	321	321	13 !	72	72	-6 !
218	218	10	53	28	-13 !	46	46	-5 !	33	33	-25 !	378	378	13 !	73	73	-6 !
219	219	10	53	28	-13 !	47	47	-5 !	34	34	-25 !	379	379	13 !	74	74	-6 !
220	220	10	53	28	-13 !	48	48	-5 !	35	35	-25 !	380	380	13 !	75	75	-6 !
221	221	10	53	28	-13 !	308	308	-6 !	36	36	-25 !	381	381	13 !	76	76	-6 !
222	222	10	53	28	-13 !	309	309	-6 !	37	37	-25 !	382	382	13 !	77	77	-6 !
223	223	10	53	28	-13 !	310	310	-6 !	38	38	-25 !	383	383	13 !	78	78	-6 !
224	224	10	53	28	-13 !	311	311	-6 !	39	39	-25 !	384	384	13 !	79	79	-6 !
225	225	10	53	28	-13 !	312	312	-6 !	40	40	-25 !	385	385	13 !	80	80	-6 !
226	226	10	53	28	-13 !	313	313	-6 !	41	41	-25 !	386	386	13 !	81	81	-6 !
227	227	10	53	28	-13 !	314	314	-6 !	42	42	-25 !	387	387	13 !	82	82	-6 !

228	228	10	53	28	-13 !	315	315	-6 !	43	43	-25 !	388	388	13 !	83	83	-6 !
229	229	10	53	28	-13 !	316	316	-6 !	44	44	-25 !	389	389	13 !	84	84	-6 !
230	230	10	53	28	-13 !	317	317	-6 !	45	45	-25 !	390	390	13 !	85	85	-6 !
231	231	10	53	28	-13 !	318	318	-6 !	46	46	-25 !	391	391	13 !	86	86	-6 !
232	232	10	53	28	-13 !	319	319	-6 !	47	47	-25 !	392	392	13 !	87	87	-6 !
233	233	10	53	28	-13 !	128	128	-24 !	48	48	-25 !	393	393	13 !	88	88	-6 !
234	234	10	53	28	-13 !	129	129	-24 !	59	59	-27 !	394	394	13 !	89	89	-6 !
235	235	10	53	28	-13 !	130	130	-24 !	60	60	-27 !	395	395	13 !	90	90	-6 !
236	236	10	53	28	-13 !	131	131	-24 !	61	61	-27 !	396	396	13 !	91	91	-6 !
237	237	10	53	28	-13 !	132	132	-24 !	62	62	-27 !	397	397	13 !	92	92	-6 !
238	238	10	53	28	-13 !	133	133	-24 !	63	63	-27 !	398	398	13 !	93	93	-6 !
239	239	10	53	28	-13 !	134	134	-24 !	64	64	-27 !	399	399	13 !	94	94	-6 !
240	240	10	53	28	-13 !	135	135	-24 !	65	65	-27 !	400	400	13 !	95	95	-6 !
241	241	10	53	28	-13 !	136	136	-24 !	66	66	-27 !	1	1	11 !	96	96	-6 !
242	242	10	53	28	-13 !	137	137	-24 !	67	67	-27 !	2	2	11 !	97	97	-6 !
243	243	10	53	28	-13 !	113	113	-30 !	68	68	-27 !	3	3	11 !	98	98	-6 !
244	244	10	53	28	-13 !	114	114	-30 !	69	69	-27 !	4	4	11 !	99	99	-6 !
245	245	10	53	28	-13 !	115	115	-30 !	70	70	-27 !	5	5	11 !	100	100	-6 !
246	246	10	53	28	-13 !	116	116	-30 !	71	71	-27 !	6	6	11 !	101	101	-6 !
247	247	10	53	28	-13 !	117	117	-30 !	72	72	-27 !	7	7	11 !	102	102	-6 !
248	248	10	53	28	-13 !	118	118	-30 !	73	73	-27 !	8	8	11 !	103	103	-6 !
249	249	34	31	28	-45 !	119	119	-30 !	74	74	-27 !	9	9	11 !	104	104	-6 !
250	250	34	31	28	-45 !	120	120	-30 !	75	75	-27 !	10	10	11 !	105	105	-6 !
251	251	34	31	28	-45 !	121	121	-30 !	76	76	-27 !	11	11	11 !	106	106	-6 !
252	252	34	31	28	-45 !	122	122	-30 !	77	77	-27 !	12	12	11 !	107	107	-6 !
253	253	34	31	28	-45 !	49	49	-34 !	78	78	-27 !	322	322	-16 !	108	108	-6 !
254	254	34	31	28	-45 !	50	50	-34 !	79	79	-27 !	323	323	-16 !	109	109	-6 !
255	255	34	31	28	-45 !	51	51	-34 !	80	80	-27 !	324	324	-16 !	110	110	-6 !
256	256	34	31	28	-45 !	52	52	-34 !	81	81	-27 !	325	325	-16 !	111	111	-6 !
257	257	34	31	28	-45 !	53	53	-34 !	82	82	-27 !	326	326	-16 !	112	112	-6 !
258	258	34	31	28	-45 !	54	54	-34 !	83	83	-27 !	327	327	-16 !	123	123	-6 !
259	259	34	31	28	-45 !	55	55	-34 !	84	84	-27 !	328	328	-16 !	124	124	-6 !
260	260	34	31	28	-45 !	56	56	-34 !	85	85	-27 !	329	329	-16 !	333	333	-12 !
261	261	34	31	28	-45 !	59	59	-37 !	86	86	-27 !	330	330	-16 !	334	334	-12 !
262	262	34	31	28	-45 !	60	60	-37 !	87	87	-27 !	331	331	-16 !	335	335	-12 !
263	263	34	31	28	-45 !	61	61	-37 !	88	88	-27 !	332	332	-16 !	336	336	-12 !
264	264	34	31	28	-45 !	62	62	-37 !	89	89	-27 !	366	366	-16 !	337	337	-12 !
265	265	34	31	28	-45 !	63	63	-37 !	90	90	-27 !	367	367	-16 !	338	338	-12 !
266	266	34	31	28	-45 !	64	64	-37 !	91	91	-27 !	368	368	-16 !	339	339	-12 !
267	267	34	31	28	-45 !	65	65	-37 !	92	92	-27 !	369	369	-16 !	340	340	-12 !
268	268	34	31	28	-45 !	66	66	-37 !	93	93	-27 !	370	370	-16 !	341	341	-12 !
269	269	34	31	28	-45 !	67	67	-37 !	94	94	-27 !	371	371	-16 !	342	342	-12 !
270	270	34	31	28	-45 !	68	68	-37 !	95	95	-27 !	372	372	-16 !	343	343	-12 !
271	271	34	31	28	-45 !	69	69	-37 !	96	96	-27 !	373	373	-16 !	344	344	-12 !
272	272	34	31	28	-45 !	70	70	-37 !	97	97	-27 !	374	374	-16 !	345	345	-12 !
273	273	34	31	28	-45 !	71	71	-37 !	98	98	-27 !	375	375	-16 !	346	346	-12 !
274	274	34	31	28	-45 !	72	72	-37 !	99	99	-27 !	376	376	-16 !	347	347	-12 !
275	275	34	31	28	-45 !	73	73	-37 !	100	100	-27 !	377	377	-16 !	348	348	-12 !
276	276	34	31	28	-45 !	74	74	-37 !	101	101	-27 !	49	49	-17 !	349	349	-12 !
277	277	34	31	28	-45 !	75	75	-37 !	102	102	-27 !	50	50	-17 !	350	350	-12 !
278	278	34	31	28	-45 !	76	76	-37 !	103	103	-27 !	51	51	-17 !	351	351	-12 !
279	279	34	31	28	-45 !	77	77	-37 !	104	104	-27 !	52	52	-17 !	352	352	-12 !
280	280	34	31	28	-45 !	78	78	-37 !	105	105	-27 !	53	53	-17 !	363	363	-12 !
281	281	38	18	15	-81 !	79	79	-37 !	106	106	-27 !	54	54	-17 !	364	364	-12 !
282	282	38	18	15	-81 !	80	80	-37 !	107	107	-27 !	55	55	-17 !	365	365	-12 !
283	283	38	18	15	-81 !	81	81	-37 !	108	108	-27 !	56	56	-17 !	217	217	-13 !
284	284	38	18	15	-81 !	82	82	-37 !	109	109	-27 !	30	30	-36 !	218	218	-13 !
285	285	38	18	15	-81 !	83	83	-37 !	110	110	-27 !	31	31	-36 !	219	219	-13 !
286	286	38	18	15	-81 !	84	84	-37 !	111	111	-27 !	32	32	-36 !	220	220	-13 !
287	287	38	18	15	-81 !	85	85	-37 !	112	112	-27 !	33	33	-36 !	221	221	-13 !

288	288	38	18	15	-81 !	86	86	-37 !	123	123	-27 !	34	34	-36 !	222	222	-13 !
289	289	38	18	15	-81 !	87	87	-37 !	124	124	-27 !	35	35	-36 !	223	223	-13 !
290	290	34	31	28	-45 !	88	88	-37 !	113	113	-29 !	36	36	-36 !	224	224	-13 !
291	291	34	31	28	-45 !	89	89	-37 !	114	114	-29 !	37	37	-36 !	225	225	-13 !
292	292	34	31	28	-45 !	90	90	-37 !	115	115	-29 !	38	38	-36 !	226	226	-13 !
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306	306	34	31	28	-45 !	104	104	-37 !	55	55	-39 !	60	60	-38 !	240	240	-13 !
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308	308	-6	-59	97	59 !	106	106	-37 !	320	320	-57 !	62	62	-38 !	242	242	-13 !
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316	316	-6	-59	97	59 !	124	124	-37 !	384	384	-57 !	70	70	-38 !	50	50	-33 !
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319	319	-6	-59	97	59 !	140	140	-52 !	387	387	-57 !	73	73	-38 !	53	53	-33 !
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322	322	81	-58	-16	18 !	143	143	-52 !	390	390	-57 !	76	76	-38 !	56	56	-33 !
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337	337	70	-79	14	-12 !	158	158	-52 !	326	326	-58 !	91	91	-38 !	44	44	-42 !
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345	345	70	-79	14	-12 !	166	166	-52 !	367	367	-58 !	99	99	-38 !	252	252	-45 !
346	346	70	-79	14	-12 !	167	167	-52 !	368	368	-58 !	100	100	-38 !	253	253	-45 !
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353	353	137	-93	62	92 !	174	174	-52 !	375	375	-58 !	107	107	-38 !	260	260	-45 !
354	354	137	-93	62	92 !	175	175	-52 !	376	376	-58 !	108	108	-38 !	261	261	-45 !
355	355	137	-93	62	92 !	176	176	-52 !	377	377	-58 !	109	109	-38 !	262	262	-45 !
356	356	137	-93	62	92 !	177	177	-52 !	308	308	-59 !	110	110	-38 !	263	263	-45 !
357	357	137	-93	62	92 !	178	178	-52 !	309	309	-59 !	111	111	-38 !	264	264	-45 !
358	358	137	-93	62	92 !	179	179	-52 !	310	310	-59 !	112	112	-38 !	265	265	-45 !
359	359	137	-93	62	92 !	180	180	-52 !	311	311	-59 !	123	123	-38 !	266	266	-45 !
360	360	137	-93	62	92 !	181	181	-52 !	312	312	-59 !	124	124	-38 !	267	267	-45 !
361	361	137	-93	62	92 !	182	182	-52 !	313	313	-59 !	125	125	-38 !	268	268	-45 !
362	362	137	-93	62	92 !	183	183	-52 !	314	314	-59 !	126	126	-38 !	269	269	-45 !
363	363	70	-79	14	-12 !	184	184	-52 !	315	315	-59 !	127	127	-38 !	270	270	-45 !
364	364	70	-79	14	-12 !	185	185	-52 !	316	316	-59 !	128	128	-56 !	271	271	-45 !
365	365	70	-79	14	-12 !	186	186	-52 !	317	317	-59 !	129	129	-56 !	272	272	-45 !
366	366	81	-58	-16	18 !	187	187	-52 !	318	318	-59 !	130	130	-56 !	273	273	-45 !
367	367	81	-58	-16	18 !	188	188	-52 !	319	319	-59 !	131	131	-56 !	274	274	-45 !
368	368	81	-58	-16	18 !	189	189	-52 !	333	333	-79 !	132	132	-56 !	275	275	-45 !
369	369	81	-58	-16	18 !	190	190	-52 !	334	334	-79 !	133	133	-56 !	276	276	-45 !
370	370	81	-58	-16	18 !	191	191	-52 !	335	335	-79 !	134	134	-56 !	277	277	-45 !
371	371	81	-58	-16	18 !	192	192	-52 !	336	336	-79 !	135	135	-56 !	278	278	-45 !
372	372	81	-58	-16	18 !	193	193	-52 !	337	337	-79 !	136	136	-56 !	279	279	-45 !
373	373	81	-58	-16	18 !	194	194	-52 !	338	338	-79 !	137	137	-56 !	280	280	-45 !
374	374	81	-58	-16	18 !	195	195	-52 !	339	339	-79 !	13	13	-57 !	290	290	-45 !
375	375	81	-58	-16	18 !	196	196	-52 !	340	340	-79 !	14	14	-57 !	291	291	-45 !
376	376	81	-58	-16	18 !	197	197	-52 !	341	341	-79 !	15	15	-57 !	292	292	-45 !
377	377	81	-58	-16	18 !	198	198	-52 !	342	342	-79 !	16	16	-57 !	293	293	-45 !
378	378	46	-57	13	21 !	199	199	-52 !	343	343	-79 !	17	17	-57 !	294	294	-45 !
379	379	46	-57	13	21 !	200	200	-52 !	344	344	-79 !	18	18	-57 !	295	295	-45 !
380	380	46	-57	13	21 !	201	201	-52 !	345	345	-79 !	19	19	-57 !	296	296	-45 !
381	381	46	-57	13	21 !	202	202	-52 !	346	346	-79 !	20	20	-57 !	297	297	-45 !
382	382	46	-57	13	21 !	203	203	-52 !	347	347	-79 !	21	21	-57 !	298	298	-45 !
383	383	46	-57	13	21 !	204	204	-52 !	348	348	-79 !	22	22	-57 !	299	299	-45 !
384	384	46	-57	13	21 !	205	205	-52 !	349	349	-79 !	23	23	-57 !	300	300	-45 !
385	385	46	-57	13	21 !	206	206	-52 !	350	350	-79 !	24	24	-57 !	301	301	-45 !
386	386	46	-57	13	21 !	207	207	-52 !	351	351	-79 !	25	25	-57 !	302	302	-45 !
387	387	46	-57	13	21 !	208	208	-52 !	352	352	-79 !	26	26	-57 !	303	303	-45 !
388	388	46	-57	13	21 !	209	209	-52 !	363	363	-79 !	27	27	-57 !	304	304	-45 !
389	389	46	-57	13	21 !	210	210	-52 !	364	364	-79 !	28	28	-57 !	305	305	-45 !
390	390	46	-57	13	21 !	211	211	-52 !	365	365	-79 !	29	29	-57 !	306	306	-45 !
391	391	46	-57	13	21 !	212	212	-52 !	353	353	-93 !	113	113	-75 !	307	307	-45 !
392	392	46	-57	13	21 !	213	213	-52 !	354	354	-93 !	114	114	-75 !	281	281	-81 !
393	393	46	-57	13	21 !	214	214	-52 !	355	355	-93 !	115	115	-75 !	282	282	-81 !
394	394	46	-57	13	21 !	215	215	-52 !	356	356	-93 !	116	116	-75 !	283	283	-81 !
395	395	46	-57	13	21 !	216	216	-52 !	357	357	-93 !	117	117	-75 !	284	284	-81 !
396	396	46	-57	13	21 !	57	57	-61 !	358	358	-93 !	118	118	-75 !	285	285	-81 !
397	397	46	-57	13	21 !	58	58	-61 !	359	359	-93 !	119	119	-75 !	286	286	-81 !
398	398	46	-57	13	21 !	125	125	-61 !	360	360	-93 !	120	120	-75 !	287	287	-81 !
399	399	46	-57	13	21 !	126	126	-61 !	361	361	-93 !	121	121	-75 !	288	288	-81 !
400	400	46	-57	13	21 !	127	127	-61 !	362	362	-93 !	122	122	-75 !	289	289	-81 !

1

TYPE
0 = STOP
1 = MORE ANALYSES WITH CURRENT DATA
2 = PASSIVE ANALYSIS OF OTHER ENVIRONMENTAL VARIABLES
3 = AS 2, BUT WITH REGRESSIONS
ANSWER =   1

TYPE 1 IF YOU ONLY WISH TO DELETE ENVIRONMENTAL VARIABLES, ELSE PRESS RETURN
ANSWER = 0

*** MONTE CARLO PERMUTATION TEST ***
0 = NO SIGNIFICANCE TEST
1 = TEST OF SIGNIFICANCE OF FIRST CANONICAL AXIS
2 = OVERALL TEST USING THE TRACE STATISTIC
3 = BOTH 1 AND 2
ANSWER = 3

TYPE NUMBER OF RANDOM PERMUTATIONS

ANSWER = 99

TYPE TWO INTEGERS (1-30000) AS SEEDS FOR THE RANDOM NUMBER SEQUENCE,
ON A SINGLE LINE OR PRESS RETURN FOR DEFAULT SEEDS.

SEEDS: 23239 945

NO	TRACE	FIRST EIGENVALUE
DATA	.750	.177
1	.213	.037
2	.216	.034
3	.189	.028
4	.227	.033
5	.242	.036
6	.197	.038
7	.205	.039
8	.206	.030
9	.205	.039
10	.207	.032
11	.261	.040
12	.219	.031
13	.211	.037
14	.214	.033
15	.203	.033
16	.178	.025
17	.215	.034
18	.223	.039
19	.209	.034
20	.231	.036
21	.210	.040
22	.241	.041
23	.200	.031
24	.224	.044
25	.222	.035
26	.228	.046
27	.215	.033
28	.211	.031
29	.214	.030
30	.209	.035
31	.257	.041
32	.241	.038
33	.224	.036
34	.186	.027
35	.247	.036

36	.180	.028
37	.212	.033
38	.221	.031
39	.215	.036
40	.238	.049
41	.206	.034
42	.176	.031
43	.212	.030
44	.233	.039
45	.205	.029
46	.183	.031
47	.224	.036
48	.215	.029
49	.219	.032
50	.230	.033
51	.216	.031
52	.198	.029
53	.209	.028
54	.227	.029
55	.224	.032
56	.193	.037
57	.228	.029
58	.178	.032
59	.243	.043
60	.191	.033
61	.236	.041
62	.179	.024
63	.207	.036
64	.230	.036
65	.223	.032
66	.248	.045
67	.222	.031
68	.196	.034
69	.225	.038
70	.210	.029
71	.234	.065
72	.205	.028
73	.223	.031
74	.209	.050
75	.205	.037
76	.233	.037
77	.197	.038
78	.186	.031
79	.197	.029
80	.198	.032
81	.204	.038
82	.211	.036
83	.215	.033
84	.219	.029
85	.190	.031
86	.211	.030
87	.257	.038
88	.225	.030
89	.240	.035
90	.219	.039
91	.230	.036
92	.205	.027
93	.205	.034
94	.215	.038
95	.228	.030

96	.229	.042
97	.217	.050
98	.229	.029
99	.190	.026
P-VALUE	.01	.01

ITERATION REPORT AXIS 1
RESIDUAL .028066 AT ITERATION 0
RESIDUAL .008048 AT ITERATION 1
RESIDUAL .000950 AT ITERATION 2
RESIDUAL .000168 AT ITERATION 3
RESIDUAL .000031 AT ITERATION 4
EIGENVALUE .17673

ITERATION REPORT AXIS 2
RESIDUAL .010049 AT ITERATION 0
RESIDUAL .000216 AT ITERATION 1
RESIDUAL .000009 AT ITERATION 2
EIGENVALUE .15712

ITERATION REPORT AXIS 3
RESIDUAL .005208 AT ITERATION 0
RESIDUAL .000016 AT ITERATION 1
EIGENVALUE .11549

ITERATION REPORT AXIS 4
RESIDUAL .002081 AT ITERATION 0
RESIDUAL .000007 AT ITERATION 1
EIGENVALUE .09163