

https://dspace.org/

Incorporating Geographic Information Systems (GIS) and archaeological data to better understand spatial and temporal distributions of past societies in Mpumalanga, South Africa

Angel, Jessica

2014-06-12
http://hdl.handle.net10539/14755

Downloaded from a DSpace repository. https://dspace.org/

Incorporating Geographic Information Systems (GIS) and archaeological data to better understand spatial and temporal distributions of past societies in Mpumalanga, South Africa

Jessica Angel

A thesis submitted to the Faculty of Science, University of the Witwatersrand, in fulfilment of the requirements for the degree of

Master of Science

Johannesburg, 2014

DECLARATION BY THE CANDIDATE

I, Jessica Angel declare that this thesis is my own work. It is being submitted for the degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

_____

Jessica Angel

28th day of February, 2014

Abstract

The Mpumalanga escarpment hosts a series of stonewalled settlements that occur along a narrow belt between Carolina and Ohrigstad. These sites are unique as they have networks of linking roads, vast areas of terracing as well as large cattle kraals which do not occur in combination or to such an extent anywhere else in southern Africa. Furthermore these settlements occur at an altitude unfavourable for living or agricultural purposes. With the use of Geographic Information Systems (GIS) layers of data relating to the Mpumalanga escarpment and the settlements within the area over the past five hundred years are viewed and compared in order to further understand the placement and structure of these settlements.

ACKNOWLEDGEMENTS

The author extends her gratitude to the following individuals:

Dr Amanda Esterhuysen, final project supervisor, for her time, patience and academic advice.

Dr Charmaine Gordon, for her unbelievable amount of support and encouragement.

To my mother and Garry, for their patience and understanding.

DECLARATION **II**

ABSTRACT **III**

ACKNOWLEDGEMENTS **IV**

LIST OF FIGURES **VI**

LIST OF TABLES **IX**

TABLE OF CONTENTS **X**

List of Figures

Figure 3.1	Maps showing position of Mpumalanga within Southern Africa and the topographic zones	22
Figure 3.2	Google Earth image showing large cattle kraals	33
Figure 3.3	Google Earth image showing settlement patterns	34
Figure 3.4	Google earth image showing complex settlement design with extensive terracing	35
Figure 4.1	Superimposed deviations from mean annual rainfall smoothed with a 5-term bionomial filter for some stations in the summer rainfall region.	47
Figure 4.2	Correlation between lake levels in East Africa and speleothems in Southern Africa.	49
Figure 4.3	Climate time series are derived from analysis of stalagmites from Cold Air Cave together with historical information.	51
Figure 4.4	Properties of M1 and M2 plotted together with rainfall variations at Polokwane weather station and a regional rainfall index.	55
Figure 5.1	Malaria distribution before prevention control (1938)	64
Figure 5.2	The Nagana Zone in the Transvaal, after Fuller 1923.	67
Figure 6.1	The Mpumalanga escarpment with polygon defining research area.	73
Figure 6.2	Evers (1975) Distribution of Iron Age sites in the immediate vicinity of Lydenburg with polygon defining research area (Google Earth Maps	74
Figure 6.3	Google Earth image, showing the 11 subsections within the polygon.	75
Figure 6.4	Google Earth image with grid lines present at a spatial resolution of 278m.	76
Figure 6.5	Google Earth image of the research area showing “placemarks” representing the position of terraced sites.	77
Figure 6.6	Type A	79
Figure 6.7	Type B	79
Figure 6.8	Type C	80
Figure 6.9	Type D	80
Figure 6.10	Type E	80
Figure 6.11	Type F	81
Figure 6.12	Type G	81
Figure 6.13	Type H	81
Figure 6.14	Type I	82
Figure 6.15	Terracing type A	82
Figure 6.16	Terracing type B	82
Figure 6.17	De Vaal (1984) trade routes	89
Figure 6.18	Viewshed analysis, polylines running through site locations.	93
Figure 7.1	Site location over clay content in the Mpumalanga Region	96
Figure 7.2	Graph: site location over clay content (general extent)	97
Figure 7.3	Graph: terraced site location over clay content (area defined by Evers 1975)	97
Figure 7.4	Graph: site location over clay content (area defined by Evers 1975)	97
Figure 7.5	Site location over soil depth in the Mpumalanga region	98
Figure 7.6	Graph: site location over soil depth (general extent)	98
Figure 7.7	Graph: terraced site location over soil depth (area defined by Evers	99

1975)
Figure 7.8 Graph: site location over soil depth (area defined by Evers 1975) 99
Figure 7.9 Site location over soil potential in the Mpumalanga region 100
Figure 7.10 Graph: site location over soil potential (general extent) 100
Figure 7.11 Graph: terraced site location over soil potential (area defined by Evers 1975) 101
Figure 7.12 Graph: site location over soil potential (area defined by Evers 1975) 101
Figure 7.13 Sites located within a 1km buffer zone from rivers 102
Figure 7.14 Graph: Sites within a 1km buffer 103
Figure 7.15 Graph: Site proximity to waterfalls 103
Figure 7.16 Sites distributed unevenly over aspect of the Mpumalanga region 104
Figure 7.17 Graph: Number of sites on different aspects (general extent) 105
Figure 7.18 Graph: Number of sites on different aspects (area defined by Evers 1975) 105
Figure 7.19 Graph: Number of terraced sites on different aspects 106
Figure 7.20 Site location over geology in the Mpumalanga region 107
Figure 7.21 Graph: number of sites on various minerals (general extent) 107
Figure 7.22 Graph: number of terraced sites on various minerals (area defined by Evers 1975) 108
Figure 7.23 Graph: number of sites on various minerals (area defined by Evers 1975) 108
Figure 7.24 Graph: annual rain fall received at site locations 110
Figure 7.25 Rainfall averages for 1992. Data plotted from station records received from SAWS. 111
Figure 7.26 Rainfall averages for 2000. Data plotted from station records received from SAWS. 112
Figure 7.27 Average rainfall over the research area. 113
Figure 7.28 Min and Max Temperatures for 1992. 115
Figure 7.29 Max and min temperature for 2000. 116
Figure 7.30 Geologic Legend. Department of mineral and energy affairs 117
Figure 7.37 Detailed geological survey map with all sites. 118
Figure 7.32 Extents of malaria distribution 120
Figure 7.33 RH in the area for 1992. 121
Figure 7.34 RH in the area for 2000. 122
Figure 7.35 Extents of tsetse distribution 124
Figure 7.36 Tsetse at 920m ASL limit over vegetation biomes 125
Figure 7.37 Tsetse at 920m ASL limit over vegetation types 125
Figure 7.38 Historical tsetse belts compared 126
Figure 7.39 De Vaal (1984) trade routes and site location 127
Figure 7.40 Least-cost paths and trade routes through the interior (general observation) 128
Figure 7.41 Weighted analysis least-cost paths and trade routes through the interiour 129
Figure 7.42 Trade routes compared with tsetse distribution 130
Figure 7.43 Graph: altitude of site locations 131
Figure 7.44 Site types distributed on 0-9 percent slopes 132
Figure 7.45 Graph: Majority of sites occurring at a slope gradient of 0-9 percent 133

Figure 7.46	Graph: Terraced sites on slope (area defined by Evers 1975)	133
Figure 7.47	Graph: Site Types on slope (area defined by Evers 1975)	134
Figure 7.48	Cluster analysis: site types (area defined by Evers 1975)	135
Figure 7.49	Cluster analysis: terraced sites (area defined by Evers 1975)	135
Figure 7.50	Graph: area (m²) of site types in the area defined by Evers (1975)	136
Figure 7.51	Graph: Percentage of site types in realtion to terracing	137
Figure 7.52	Site types in relation to terracing with 150 m buffer around terraced sites	138
Figure 7.53	Viewshed analysis (general extent)	139
Figure 7.54	Four varients of viewshed analysis (area defined by Evers 1975)	140

List of Tables

Table 4.1	Outline of climatic changes over the last 1000 years. After Tyson *et al* 2000.	59
Table 5.1	Reports of malaria	63
Table 6.1	Data required with descriptions	71
Table 6.2	Requested climate stations around Mpumalanga	85
Table 6.3	Climate stations requested which have long term recorded history.	85
Table 6.4	Rainfall, maximum temperature and minimum temperature of selected stations.	86
Table 6.5	Paleo-climate data	86
Table 8.1	Summary of events that occur over the past 500 years	143

Table of Contents

1	**Introduction**	1
2	**The Development of Spatial Archaeology and the Incorporation of Geographic Information Systems (GIS)**	5
2.1	First Phase of Archaeological Modelling with a GIS	6
2.2	Second Phase of Archaeological Modelling with GIS	8
2.3	Incorporating Multiple Layers of Information	9
2.4	Inherent Benefits of GIS	10
2.4.1	*Remote Sensing*	10
2.4.2	*GIS and Landscape Archaeology*	11
2.4.3	*Line-of-sight and Viewshed Analysis*	13
2.4.4	*Cost Surface Analysis*	14
2.4.5	*Cluster Analysis*	15
2.4.6	*Google Earth*	15
2.5	Archaeological Thought Towards Mapping Spatial and Temporal Change	16
3	**Research Area**	22
3.1	Initial Research into Early Farming Societies	22
3.2	The History of Mpumalanga	23
3.3	Investigation of Sites	27
3.4	Agricultural Produce	32
3.4.1	*Maize*	36
3.4.2	*Sorghum and millet*	36
3.4.3	*Cucurbits*	36
3.4.4	*Legumes*	37
3.4.5	*Intercropping*	37
3.4.6	Could agriculture of maize, legumes and cucurbits occur on the Mpumalanga escarpment	37
3.5	Trade, Economic Relationships and Conflict	37
3.6	Summary	42
4	**Climatic reconstructions for Southern Africa**	43
4.1	Climate Variation as a Determinate in Site Selection	43
4.2	Further methods of determining paleo-climates	48
4.2.1	*An observation of the relationships between Southern and Eastern Africa*	48
4.2.2	*Speleothems*	49
4.2.3	*Dendrochronology*	52
4.3	Climatic Effects on Societies during the Late Farming Communities	59
4.4	Conclusion	
5	**The Role of Disease in Site Location**	60
5.1	Introduction	60

5.2 European Reports of Disease 60
5.3 Malaria 62
5.3.1 A Brief Description of Malaria 62
5.4 Distribution of the Tsetse Fly 66
5.4.1 A Brief Description of Tsetse 68
5.5 Impact on LFC 69

6 Methodology 71
6.1 Data Collection 71
6.2 Data Preparation 72
6.2.1 Research Area 72
6.2.2 Locating Stonewalled Sites 74
6.2.2.1 Placing the Sites into ArcMap and QGIS 83
6.2.2.2 Site Analysis 83
6.2.3 Vegetation and Soil Maps 83
6.2.4 Geology Maps 84
6.2.5 Climate 84
6.2.6 Disease 87
6.2.6.1 Malaria 87
6.2.6.2 Nagana 88
6.2.7 Access to Water 88
6.2.8 Trade 89
6.3 Data Analysis, Using the Created Layers to Determine Site Location 90
6.3.1 Agricultural Potential 90
6.3.2 Mining 91
6.3.3 Disease 91
6.3.4 Trade 92
6.3.5 Least-Cost Paths 92
6.3.6 Viewshed Analysis 93
6.3.7 Aspect 94
6.3.8 Altitude 94
6.3.9 Slope 94
6.4 Summary 94

7 Results 95
7.1 Agricultural Potential 96
7.1.1 Soils 96
7.1.2 Grazing Potential 101
7.1.3 Access to Water 102
7.1.4 Aspect 104
7.1.5 Geology 106
7.1.6 Climatic Influence on Agricultural Potential 109
7.1.6.1 Data from the South African Weather Service 109
7.1.6.2 Alternative Current Rainfall Maps 110

7.6.1.3 Temperature 114
7.2 Mining 117
7.2.1 Significance of Access to Surface Level Minerals Suitable for Mining 117
7.3 Prevalence of Disease 119
7.3.1 Distribution of Malaria 119
7.3.2 Distribution of Nagana 123
7.4 Influence of Trade 126
7.4.1 De Vaal's 1984 Trade Routes 126
7.4.2 Least-Cost Paths 128
7.4.3 Trade Routes and Tsetse 129
7.5 Distribution of Different types of Sites 130
7.5.1 Distribution and Altitude 130
7.5.2 Distribution and Slope 131
7.6 Cluster Analysis 134
7.7 Detailed Site Analysis 136
7.7.1 Area (m^2) of Individual Sites 136
7.7.2 Site Distribution in Relation to Terraces 137
7.8 Viewshed Analysis 139
7.9 Conclusion of Results 141

8 Discussion 142
8.1 Climate 145
8.1.1 Paleo-climates 145
8.1.2 Mist Belts 146
8.1.3 Contemporary Climate Data 146
8.2 Soil and Geology 147
8.3 Manipulation of the Environment 147
8.3.1 Intercropping 147
8.3.2 Terracing 147
8.4 Disease 148
8.4.1 Climate Influence on Disease 149
8.5 Minerals and Mining 149
8.6 Trade 149
8.7 Cattle 150
8.815 Social Pressure 150
8.9 Advantages of Settlement on the Mpumalanga Escarpment 151
8.9.1 Trade port? 153
8.1 Summary 153

9 Conclusion 153

References 159

Chapter One

Introduction

The focus area for this research is the Mpumalanga region (formerly the Eastern Transvaal), South Africa. Extensive pre-colonial stone walled settlements occur on the Mpumalanga escarpment between Carolina and Ohrigstad for a distance of approximately 160 km. These sites are considered to be unique because they have networks of linking roads, vast areas of terracing (Maggs, 2008) and large cattle kraals which do not occur in such combinations or to such an extent anywhere else in southern Africa. Maggs (2008) states that the road systems are more complex than other pre-colonial stone walled settlements around South Africa. Terracing sets these specific sites apart from others in South Africa as they are said to represent the only field systems to have survived from pre-colonial times (Maggs, 2008).

When viewed from Google Earth, the descriptions of the sites provided by Marker and Evers (1976) and Maggs (2008) become evidently clear. These descriptions include three settlement types, the first being the simplest pattern consisting of two concentric circles. The second pattern is slightly more complex revealing smaller circles around the central circle. Thirdly, an agglomeration of small circles that appear occur higher up on the sides of the valley. Among these patterns, extensive networks of linking roads are also visible. Finally, the terraces that set these sites apart from other southern African pre-colonial sites are clearly visible. These terraces clearly follow the natural contours of the land and are separated by terraces running down slope into what Maggs (2008) believes to be individual plots. These sites are located at altitudes of between 1191 m and 1907 m ASL, with most sites falling between 1500-1700 m ASL.

The Mpumalanga escarpment, and in particular the terraced sites, have attracted a fair amount of attention over the last 40 years (Collett, 1982; Delius and Schoeman, 2008; Evers, 1973, 1975, 1977; Hall, 1976, 1987; Maggs, 1976, 1984, 1991, 2008; Mason, 1963, 1968, 1974). However, very little is known as to why the terraced sites occur along the Mpumalanga escarpment at altitudes which are

unfavourable for agricultural practice, and nowhere else in southern Africa, and what benefits these terraces may have provided for the Later Farming Communities (LFC)[1] that occupied them.

The aim of this project is to investigate possible reasons as to why the sites on the Mpumalanga escarpment occur so extensively at this location and what benefits the terracing and large kraals might present. In order to fully investigate the above, a range of factors, such as climate, vegetation and endemic disease, were investigated.

This project set about investigating the following research questions:

- Why are the sites positioned on the Mpumalanga escarpment?
- What do the terracing structures represent?
- Do environmental factors such as climate, vegetation, and disease influence the choices made concerning site distribution?
- Did the environment shape social networking?
- Is the environment a primary determining factor in the selection of site distribution?
- Are the stone walled sites on the Mpumalanga escarpment representative of a central trading port?

Geographic Information Systems (GIS) is a form of technology that, through its application in several different fields, has proved to be a useful tool for geographically representing an array of factors under a variety of conditions comprehensively.

With the aid of a GIS, a variety of different layers of data relating to the area of concern can be viewed simultaneously or compared in order to gain further insight

[1] Mitchell (2002) contends that the term Iron Age in South Africa is borrowed from European prehistory and is considered to be problematic as emphasis is placed on iron working at the expense of other technologies, therefore the term farming communities is used instead. Mitchell (2002: 259) further explains that using the term farming communities "enables us to develop more flexible and creative approaches to the archaeological record".

into the sites themselves. The objective of this research was to gather data that may relate to the Mpumalanga escarpment over the past five hundred years and incorporate it into a GIS to see if it sheds any new light on the LFC of the Mpumalanga escarpment.

The remainder of the thesis will be structured as follows: Chapter Two discusses the benefits and applications of GIS, past and present. It further explores the development of spatial archaeology and how it is currently being used in a number of different disciplines. The inherent benefits of GIS and the need for archaeological data to be documented in a system that can easily manage or model data in a variety of ways in order to explore possible theories are also discussed.

In Chapter Three, the background to the LFC of Mpumalanga is explored. This includes a breakdown of the history of the area (e.g., its social politics, trade and conflict as well as its agricultural potential and practices).

Climate can be advocated as one of the primary influential site determining factors. Chapter Four focuses on past climates as determined by speleothems and dendrochronology, as an understanding thereof in greater detail is important because it affects agriculture, and a slight shift in the average temperature can alter the sphere of endemic diseases.

Chapter Five investigates specific diseases. Although the severity of diseases over the past 500 years is reported to have increased, this chapter focuses only on malaria and nagana as major influential diseases that affect site locations. The characteristics of the said diseases and the necessary environmental conditions required for both to successfully flourish are discussed in detail. The effects that these diseases had on the LFC are also investigated.

Chapter Six discusses the methodology, which includes the process of gathering the data and incorporating it into a GIS. The data gathered includes site locations, vegetation and soil, geology, climate, disease and trade. Thereafter, a data analysis is employed to describe the process of overlaying different data and determining any possible patterns or trends.

The results of the research are discussed in Chapter Seven. These include the agricultural potential, access to surface level minerals suitable for mining, prevalence of disease and connection with trade routes.

The outcomes of the GIS are discussed in Chapter Eight and the conclusions drawn from the project are presented in Chapter Nine.

Chapter Two

The Development of Spatial Archaeology and the Incorporation of Geographic Information Systems (GIS)

For archaeologists to make the most of the information they uncover and record they need a flexible environment within which to integrate, express, analyse and explore the full range of the data. This environment needs to be a platform where there are no restrictions in terms of the types of information one can incorporate (Wheately and Gillings 2002). By using a system where layers of different information are simultaneously represented, archaeologists are able to draw conclusions in a more holistic manner. Geographic Information Systems (GIS) constitute one of the newest ways that archaeologists can interpret raw data. GIS comprise software that performs tasks that many researchers, including archaeologists, have found to be useful in managing and analysing their data. This chapter briefly explores the various stages of this development.

The interpretation of behaviour and material culture across space and through time has always constituted one of the fundamental aspects of archaeology (Kamermans 2006). As far back as the 18th century there is evidence of archaeologists creating highly detailed and precise maps. On these maps they identified external factors that influenced behaviour, and in turn, behaviour patterns in space that could be objectively measured and quantified (Kvamme 1995).

Disciplines that are concerned with the interpretation of geographically located material such as archaeology are experiencing a rapid advance in the tools they use for spatial records and analysis (Wheately and Gillings 2002). The use of GIS in archaeology is highly beneficial as it is capable of incorporating different factors and ideas of space and it has helped researchers advance theoretical debates (Hu 2011).

An individual's view of the landscape is dependent upon the society from which they stem as well as the status they hold and the role they play in that society. The position

of humanity's place in nature will always vary and is also an important factor in the resultant landscape (Zubrow 2007). One of the trends of current GIS based archaeological studies is a movement towards understanding commonly used, but vaguely applied terms such as "state", "Chiefdom" and "ritual space" (Hu 2011). Hu continues that, instead of defining each of these terms based on localised research and then trying to apply them universally, GIS helps to approach each of these terms in an inductive manner and to understand the range of variation of social organisation and space (2011: 4). GIS is a tool that is able to incorporate many variables, which in turn will aid in the creation of less biased outcomes providing more complete data for interpretation.

GIS is widely used in a large variety of disciplines. The ability to manipulate and analyse basic data gives GIS its unique identity. Manipulation refers to the ability of a GIS to generate new layers of information for a specific area or topic from existing information. In the early stages GIS were only experimental tools, which required expensive work stations and were available to only a few specialist researchers (Wheately and Gillings 2002). In contrast, the modern archaeologist can use a GIS on a mobile phone in the field. This has allowed for their use to become widespread.

2.1 First Phase of Archaeological Modelling with a GIS

It is important to look at how GIS has been utilised up until now. Archaeology first started to use spatial analysis software in the 1970s. "Computer graphic and statistic programs such as SYMAP were used to calculate and display trend surfaces calculated through observations of archaeological data at known locations" (Wheately and Gillings 2002: 18). The 1980s brought about the first age of computer modelling. This phase was dominated mostly by the processualist school which advocated deductive behavioural statements as a basis for modelling (Kvamme 2006). Here the idea of using space as a neutral, abstract dimension, as was conducted in the 1960s and 1970s was abandoned. After this phase, considerable progress was made in GIS

by university research settings which were made possible by Cultural Research Management (CRM) projects. “Such advances included the recognition of sampling biases from maps generated in archaeological databases, the use of independent test samples for model performance assessments as well as other new pioneering applications of GIS technology in the discipline” (Kvamme 2006). Further insight into this topic is available in Gaffney and Stančič (1991), Judge and Sebastian (1988) and Kavamme (1995). The main pioneering GIS application that made GIS a mainstream tool in archaeology is that of predictive modelling. Predictive modelling refers to the practice of building models in order to indicate the likelihood of archaeological sites, cultural resources or past landscapes used across a region (Kamermans 2006).

In the process of predicting site location, a major determinant that must be considered is the seasonal distribution and location of resources in a given structure of economy. An example of this is a model presented by Jochim (1976). This model allowed for the operationalisation of specific expectations. The comparison of expectations with actual patterns of utilisation allows Jochim’s model to subsequently generate predictions regarding a variety of activities and products.

There are a few approaches that do not rely solely on artefactual evidence. One such example is the model developed by Thomas (1974) of the North American Great Basin. Thomas used ethnographic representations of subsistence patterns; he then operationalised patterns in computer models to produce predictive statements about the location and type of lithic deposition that would result. Through this process, Thomas was able to test if past economic strategies resembled those of recent times by comparing the archaeological remains with predictions based on ethnographic data.

The early predictive models presented above were quite general, taking into consideration only a few variables. To better understand cultural settlements all the possible influential factors that will play a role within that specific question needs to

be investigated. “For instance, elements of topography, vegetation, and animal resources in other environments could encourage a different set of choices and result in different strategies of subsistence and settlement” (Jochim 1976: 187). Jochim further explains that changes in the resource environment through time would also strongly impact subsistence and settlement. Jochim’s model possesses the capability of investigating differences in the environment and is a valuable aid to archaeological research, but it does not take all the valuable factors into account as a GIS would.

2.2 Second Phase of Archaeological Modelling with GIS

We are now in what is termed the second phase of modelling. According to Kvamme (2006), this phase is very different in form and orientation. With a large archaeological modelling industry one of the key benefits is the “collation and standardisation of archaeological data within modelling regions into computer data bases” (Kvamme 2006: 4). Contemporary modelling is more sophisticated and innovation is more apparent than in the previous phases. Such refinements include the development of new variables through GIS and the utilisation of new modelling approaches and algorithms as discussed below (Kvamme 2006).

Radar imaging is a relatively recent remote sensing technique; nonetheless it has already proven to hold much potential for forthcoming archaeological investigations as well as accounting for a number of important archaeological discoveries (Holcomb and Shingray 2007). For instance, radar images are used for “archaeological prospecting in regional surveys to detect cultural and natural features and sites, paleo-landscape reconstruction, cultural heritage monitoring as well as for navigation in an unknown terrain” (Holcomb and Shingray 2007: 11). In Africa, imaging radar has been critical in the detection of previously unknown paleodrainage channels and related Paleolithic and Neolithic sites in the eastern Sahara Desert (Mc Cauley *et al* 1986).

Lastly, “the availability of a near-global digital elevation model (DEM) derived from the Shuttle Radar Topography Mission (SRTM) provides archaeologists with a new tool to complement other remote sensing data” (Evans and Farr 2007: 89). SRTM data provides a regional context in which areas can be studied. By combining information such as slope elevation with factors such as water availability it is possible to identify potential archaeological sites (Evans and Farr 2007). This data could also be used to identify possible migration pathways or trade routes where settlements might occur (Evans and Farr 2007). This data allows for the comparison or linking of regions on a scale not available from other GIS methods, which are smaller in scale.

2.3 Incorporating Multiple Layers of Information

A factor that should be taken into account in any archaeological investigation is the importance of topography. This exerts an influence on factors such as soil development and erosion, and is a major factor in determining whether or not land is arable (Evans and Farr 2007). Topographical features of a landscape are an essential factor in archaeology for a number a reasons. They provide shelter from the elements, and influence the placement and design of formal architecture (Evans and Farr 2007). Topography will also create varied environments that will attract different assemblages of plants and animals (Evans and Farr 2007: 92).

Alongside topography, climate variables are vital when observing and analysing the behaviour and location of past societies. Climate will undoubtedly have exerted an influence on the vegetation of any area which in turn would have influenced past societies in their decisions. Such decisions could involve whether or not, or how, to utilise a given landscape. By including topography and past climate into a specific study area we are able to create a far more complex understanding of a past society. As mentioned below, topography viewed as a DEM has proved valuable and location

modelling is one of the most successful uses of GIS in heritage management (Fry *et al* 2004).

Other layers that will provide useful information to the better understanding of past societies include vegetation types, soil types, geology and hydrology. When observing placement of archaeological sites, the above mentioned layers are a vital aspect.

2.4 Inherent Benefits of GIS

Archaeological data needs to be placed into a system that can easily manage the data, alongside the above mentioned layers, in a variety of different ways in order to explore possible theories and model data with relative ease. Technology is constantly advancing at a rapid pace and the application and benefit of GIS in archaeology is evident in a number of studies (Blom *et al* 2007, Fry *et al* 2004, Gaffney and Stančič 1991, Howey 2007, Katsamudanga 2009, Kvamme 1989, 1990, Saturno *et al* 2007, and Van Leusen 2002), of which some are expanded upon below.

2.4.1 Remote Sensing

The first example of the benefits inherent in GIS is a remote sensing study of the Southern Arabian Desert trade routes. With the use of different fields of study and carefully enhanced Landsat Thematic Mapper (TM) imagery this research accorded a known archaeological site new significance (Blom *et al* 2007). This occurred through a "combination of historical research and the application of space technology in support of traditional archaeology" (Blom *et al* 2007: 71). With the use of the TM imagery, it became clear that there was a discontinuous network of trails that converge at the site; hence the significance of the site. The team of researchers in this case consisted of recognised experts in the fields of archaeology, geology and remote sensing, history and campaign organisation (Blom *et al* 2007). This example shows

the benefits of GIS in that it has the ability to integrate various disciplines to allow for the most accurate conclusion of a specific research question.

2.4.2 GIS and Landscape Archaeology

The following examples are concerned with the benefits of GIS when applied to landscape archaeology. Hu (2011) states that landscape archaeology is the study of "diffuse" human remains or the cultural spaces "between the sites". However, from a theoretical point of view "landscape" remains difficult to determine clearly as there are different conceptions of space and therefore of what a landscape is (Hu 2011, Witcher 1999). The importance of gaining familiarity with the landscapes under investigation is described by Llobera (2012) as a method of grounding ideas, identifying a range of new possibilities and gaining a better sense of scale. Landscape factors involved in the selection of settlement location are argued to be a key issue in the understanding of subsistence strategies and social organisation as site location preferences are the results of a complex decision making process (Garcia (2013). Llobera *et al* (2011) state that landscape analysis also helps with understanding movement. Movement is defined as how a landscape becomes ordered by defining a destination. The study of movement is considered an important aspect of modern archaeological approaches as movement represents a universal mechanism through which humans order their landscape (Llobera *et al* 2011). By order, Llobera *et al* (2011) refer to the creation of sequences that link locations across a landscape. This thesis employed various methods of landscape analysis to further understand the archaeological sites of the Mpumalanga region. An example of the aforesaid is a study conducted by Saturno *et al* (2007) and NASA.

According to Saturno *et al* (2007: 141) "landscape archaeology deals with the relationships between humans and their open and built up landscapes". Saturno *et al* (2007) adopted this approach in order to study ancient Maya sites, using a combination of remote sensing, GIS, GPS technology and climate analysis and modelling in order to understand the dynamics of how the Maya interacted with their

karst topography. This included the effects of natural and human induced changes to that landscape, the consequences of such changes, and lastly, the modelling of these changes for application by current societies (Saturno *et al* 2007: 144).

Specific NASA research objectives discussed in Saturno *et al* (2007: 144) included a variety of processes. These include a correlation of settlement patterns with vegetational, hydrological and geological features on the karst topography, mapping of drainage patterns that may provide insight into human settlement and water management, detection of linear features that may be related to roadways, and so forth. And lastly, the said processes include the creation of detailed vegetation maps in order to provide insight into possible relationships between land cover, paleo-hydrology and subsistence strategies.

The above is a good example of how the incorporation of different variables within a study area into a GIS could generate results that would not always have been possible with the use of traditional archaeological methods. Analysis by means of a GIS can also present results that may or may not have been considered as constituent of the original research questions, thus opening new possibilities and ideas previously not considered.

Fry *et al* (2004) presented a paper that looks at assisting the management of heritage resources by presenting a landscape approach to the identification of localities with high possibilities of possessing cultural heritage interests. GIS were used for the analysis and mapping of landscape characteristics that indicated zones with a high probability of possessing cultural heritage interest. It was concluded that new field work conducted after the above mentioned process confirmed the presence of new sites in the zones identified and that the results increased understanding of archaeological site location in Norway as well as the close links between landscape and archaeology (Fry *et al* 2004).

GIS is attractive to archaeologists because it provides a new means of interpreting historical landscapes. The volume of spatial data collected by archaeologists has been

growing dramatically. As a result, new methods for management and exploration of this increasing data base are essential (Wheately and Gillings, 2002). GIS technology allows for large amounts of data to be analysed and interpreted with ease and saves time. Furthermore GIS can combine point plotted data of artefacts or site locations (vector data) with geophysical data (raster data).

Fry *et al* (2004: 102) state that parallel to the increasing appreciation of the role of spatial relationships in the location of cultural monuments is the development of a variety of spatial analysis tools utilising digital maps. Examples of different types of tools include the cost path analysis tool which aids archaeologists to better understand if site distributions are random, clustered or regular (Cooper 2010).

The use of a DEM to calculate viewsheds or line-of-site analyses have also become well integrated into landscape archaeology (See Kvamme 1990, 1991, Llobera 1996, Van Leusen 2002 and Wheately 1995).

2.4.3 Line-of-sight and Viewshed Analysis

The discipline of archaeology attempts to explain the many variables of spatial organisation. The means through which such diverse hypotheses are explored have generally been distribution maps. However archaeologists are not only concerned with where things are positioned as the size and shape of settled areas are adapted to the physical land conditions as well as to neighbouring settlements (Sevanant and Antrop 2007). It is therefore important to combine spatial data with attribute data in order to engage in holistic research. Visibility studies have become a popular method for assessing the role of views to and from sites and features (Ogburn 2006) and they play an integral role in understanding past societies better. A general hypothesis of site distribution is that settlements generally occur in areas where more fertile and intensively used grounds can be easily controlled (Sevenant and Antrop 2007)

Viewshed analysis examines the locations that are visible from one or more specified points or lines. According to Fry *et al* (2004), viewsheds can be considered to be

visual territories. This tool was used by Fry *et al* (2004) in order to explore the importance of resource availability in the viewshed of the monuments concerned in their research. In this case, the amounts of agricultural soils and other resources within the viewshed were compared with the expected amounts based on the regional distribution of such soils. The results revealed that the viewsheds had a 34 % to 95 % cover of agricultural soils whereas the study area had only 30 % cultivatable soil. Furthermore, when compared to viewsheds of random points in the landscape, the average amount of agricultural soils in the viewsheds of monuments was three times higher than in the viewsheds of random points (Fry *et al* 2004).

Line-of-sight or single viewshed analysis is a line drawn between two points, an origin and a target, that is compared against a surface to indicate whether the target is visible from the origin and, if it is not visible, where the view is obstructed. It is the ability of GIS to calculate the intervisibility of two given points on a given DEM (Van Leusen 2002).

2.4.4 Cost Surface Analysis

Cost surface analysis is a tool that provides information about possible movement through space. It uses cost accumulation algorithms to calculate the cumulative cost of travelling over a digital cost landscape (Van Leusen 2002). Howey (2004) states that for archaeologists, analysis of movement has the potential to reveal important information on numerous aspects of past life. This aspect is important to observe as movement through physical landscapes formed a vital experience amongst past communities (Howey 2011). Howey (2004) examined the GIS applications of multi-criteria cost surface analysis as a robust technique for modelling past movement and exploring past social landscapes. Howey's approach was applied to the Late Prehistoric period (ca.AD 1200-1600) in Michigan as a case study. The results of this study showed that the multi-criteria analysis of the Late Woodland/Late Prehistoric movement in Michigan offers a conceptual framework for thinking more accurately about a proposed model of regional dynamics prior to the European contact in the

Great Lakes region. Further, it presents new information about the period that would have not been brought to light without the mobility analysis (Howey 2004).

2.4.5 Cluster Analysis

Cluster analysis tools are used to test spatial characteristics of the distribution of site data within GIS (Cooper 2010). As mentioned above, the aim of using this tool is to identify whether distribution of archaeological sites are random clustered or regular (Cooper 2010).

A case study conducted by Cooper (2010) observed movement and exchange between 102 pre-colonial sites in an area of 9,280km² in northern Cuba. In this case, cluster analyses as well as veiwshed analyses and cost maps were used as a means of further understanding the archaeology in the area. Cooper (2010) selected the kernel density analysis in order to conduct the cluster analysis. Kernel density analysis is a two-dimensional intensity analysis in ArcGIS. Cooper (2010: 125) selected this method as it provides a more sophisticated density measure which produces smoother and more readily interpreted results than simple density techniques such as nearest neighbour analysis. The results of this analysis showed three specific clusters of sites in the Cuban interior with dispersed individual sites on the coast and offshore islands. It is important to note that Cooper (2010) emphasises that cluster analysis is based on distance and do not take into account factors such as the complex nature of the landscape. It is therefore essential to undertake further analysis such as viewshed analysis and cost surface analysis in order to gain a comprehensive understanding of past societies.

2.4.6 Google Earth

Google Earth is a virtual globe and GIS that allows researchers the opportunity to view the landscape through satellite imagery. In the past, air photos were used to plot distribution maps of pre-colonial structures in order to study social behaviour over a landscape (Sadr and Rodier 2012). According to Sadr and Rodier (2012), new

technologies such as Google Earth satellite imagery justify revisiting past structures as they facilitate more complex analyses of larger databases. In their study of stone-walled structures in southern Gauteng, South Africa, Sadr and Rodier (2012) explain that the use of Google Earth imagery surpassed what was possible in the pioneering studies of previous researchers who used air photos. The above study demonstrated that the analytic capabilities of GIS have revealed an apparent sequence, which suggests a trend from small, dispersed, less agriculturally oriented homesteads to highly stratified nucleated "towns" aggregated near the most arable soils (Sadr and Rodier 2012:1041).

2.5 Archaeological Thought Towards Mapping Spatial and Temporal Change

It is important to understand how archaeological thought has changed and evolved over time. There is dense literature on the process of archaeological thought evolution; however, this paper focuses only briefly upon the processes that have led to the current need to incorporate GIS in further research in the field.

For most of the 20th century archaeology falls under what is known as the classificatory-historical or culture history phase (Trigger 1989). This phase orders structures and artefacts into a basic sequence of events in time and space. Normally this is a generalised description of human achievement under broad period-based headings (Darvill 2003). The culture history phase has been criticised by processualist archaeologists and post processualist archaeologists (which is discussed below) as being descriptions of events rather than understandings or explanations of events. However, the development of a robust culture history remains key to certain archaeological work, especially the geographical and chronological mapping of cultures and cultural influences (Darvill 2003).

Due to a concern of mapping prehistoric settlements against environmental variables, there was an emphasis upon the role of landscape and geography as factors

influencing the form of historic settlement patterns. This type of research can be seen in the years between 1900 and 1920 (Trigger 1989).

With previous research such as that carried out by Crawford (1923 and 1924), aerial photography was acquired and used. It can be noted that from "the air an orderly system is visible" (Crawford 1923: 342). This simple yet powerful realisation has since changed the face of archaeology. At that time, the maps created by such researchers were intended to show possibilities rather than establish conclusions (Evans et al 2007: 143) as opposed to using a GIS to mathematically determine possibilities, location of sites or situations. "It is the great merit of air photographers that they reveal earthworks upon ploughed land which are invisible to the observer on the ground, or which appear to him only as a confused tangle " (Crawford, 1924).

At the time, air photographs provided a new instrument of research comparable only to that provided by excavation. However they were not considered to be a substitute for field work but rather as the most powerful ally of the field archaeologist (Crawford 1924).

Later in the 1940s there was a decline in interest in spatiality with a move away from diffusionist modes of explanation. This occurred more so within British archaeology than North American archaeology. The study of patterns and environment continued through the 20th Century in American archaeology known as the "ecological approach". This was where the mapping of archaeological sites was conducted on a regional scale, the main purpose being to study the adaptation of social and settlement patterns within an environmental context (Clarke 1977, Wheately and Gillings 2002).

At the start of the 1960s there was a move away from viewing material culture as a direct and unproblematic reflection of a specific group of people to being viewed as a result of a series of past processes where spatial relationships were seen as a spatial impact of behavioural activities and processes (for review see Hodder and Orton 1976). This more scientific approach is characteristic of the group of approaches that are labelled new or processualist archaeology. Basically, emphasis and value were

placed upon formulating hypotheses, and subsequently testing them against the data. "The processualists believe that archaeology is a science and should follow scientific procedure" (Huffman 2007: 325).

The concept of landscape studies had been popular for some time, gaining favour during the late 1960s and early 1970s in the era of new archaeology. Here the emphasis was placed on explanation, quantitative thinking, and a scientific perspective of the past. It was during this time that archaeologists turned to other fields, in particular geography, for tools and ideas of spatial analysis (Aldenderfer 1996).

Archaeologists had been previously aware of the hidden importance of spatial configurations and had been developing new and more accurate methods of recording. David Clarke (1977) claims that the retrieval of information from spatial relationships should comprise the central aspect of the archaeological discipline. However, with new archaeology, "space was defined as a neutral, abstract dimension in which human action took place" (Wheately and Gillings 2002: 8). During this era of thought, spaces of different periods were considered to be identical (Clarke 1977).

During the new archaeology phase, the environment was the prime external factor assumed to have affected the distribution of people in an otherwise homogenous space. It was during this time that archaeology first started to use spatial analysis software.

Since the 1980s, this non-problematic notion began to be questioned which led to the next change in archaeological thought. This is termed post-processual archaeology. The post-processualists believed that "archaeology is not and should not be a science" (Huffman 2007: 325). It was during this time that GIS became more prominent in archaeology.

Over the past thirty years, the quality and volume of the spatial data collected has increased dramatically as new surveying techniques and equipment have become

more available to archaeologists. However, as Katsamudanga (2009: 293) states, the status and impact of GIS in developing countries are still to be fully appraised. Katsamudanga (2009) explains that although the basic principles of GIS have been in existence for some time, there is still only a limited occurrence of its application in Africa, partly owing to inadequate resources. Case studies of GIS in Zimbabwean archaeology observed by Katsamudanga reveal that the investigations are focused mainly on environmental data and to research issues of subsistence. This is due to the fact that the bulk of the effort invested in the use of GIS was spent on learning the technology, which required data that was easily accessible (Katsamudanga 2009).

Likewise, South African archaeologists need to incorporate GIS into their research on a larger scale as similar problems occur here as in Zimbabwe. There are however, projects underway, such as the Mossel Bay Archaeological Project (MAP), which excavates a series of caves and rock shelters along South Africa's southern coast to understand more about the origins and behaviour of modern *Homo sapiens*. However, Katsamudanga (2009) mentions the need for the development of a sound geodatabase of cultural and environmental data that would make it possible to conduct spatial analyses in Zimbabwe. South Africa is no exception.

There is so much information available in various aspects of archaeology and it needs to be placed in a more coherent system. This process will be to the advantage of the discipline as a whole as it allows for data that is already available to be re-examined and new questions formulated and potentially answered and will undoubtedly result in answers to questions, some of which may never have been thought of to ask. As the concept space has always been of concern to archaeologists GIS offers the ability to view space in all shapes and forms, as neutral or as a determinant or both.

Archaeologists have been experimenting with different ways of manipulating mapping and representing data since the 1920s. Thought patterns have changed from processual to post-processual in attempts to better understand and rebuild the past. GIS is a technology that can incorporate all these past attempts in the most refined

manner to date and will allow for an extended range of new opportunities for the modern archaeologist.

Chapter Three

Research Area

The focus of this project falls on the Mpumalanga region (formally known as the Eastern Transvaal), South Africa (Figure 3.1). Mitchell (2002) asserts that the term Iron Age in South Africa is borrowed from European prehistory and is considered to be problematic as emphasis is placed on iron works at the expense of other technologies; therefore, the term farming communities is used instead. Mitchell (2002: 259) further explains that using the term farming communities "enables us to develop more flexible and creative approaches to the archaeological record". As this study is concerned with the farming communities in the post 1500 period, they are referred to as the Late Farming Communities (LFC) of Southern Africa.

> The phrase 'Iron Age' [farming communities] in the South African context refers to a technology that led to the earliest major transformation of human society in South Africa. Iron Age technology was based on farming and metal production, which led to fundamental changes in the South African economy, South African politics and South African social relationships (Mason 1974: 211).

The reason why this area has been selected is because little is currently known about the unique terraced sites that occur in the Mpumalanga area, why there was a need for such extensive agricultural practices, or what encouraged people to develop the sites at this particular location.

Mpumalanga is situated in the north-east of South Africa, mainly on the high plateau grasslands. The Mpumalanga area can be divided into various topographical zones which comprise different farming economies. The two major topographical zones are the low-lying sub-tropical Lowveld and the escarpment, and the interior plateau or Highveld (Evers 1973a). Mpumalanga contains two main river basins; the Olifants and the Komati basins. As a result of these large rivers, the area is rich in resources and has been utilised extensively by farming communities over the last 500 years.

The geology of Mpumalanga is diverse and the rich deposits of ochre, copper and iron have always attracted people to the area (Esterhuysen and Smith 2007). Hall (1987: 47) describes the topography of the area as a complex network of dolerite sills and dykes which indicate where the volcanic lavas pushed through the sedimentary rocks of the Karoo series millions of years ago.

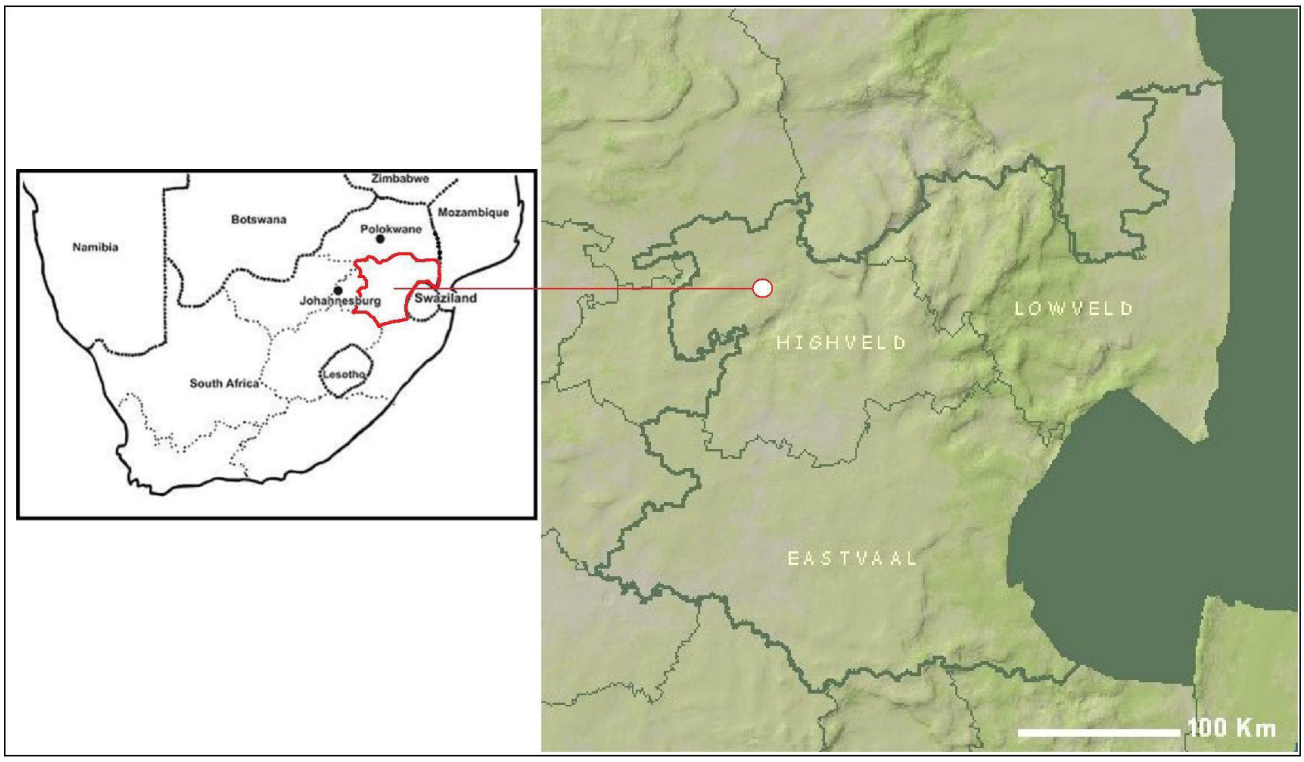


Figure 3.1: Maps showing position of Mpumalanga within Southern Africa and the topographic zones (Source: saexplorer.co.za)

3.1 Initial Research into Early Farming Societies

Iron Age research in the former Transvaal Province began in 1828 with Robert Moffat's descriptions of the recently destroyed settlements that were similar to Kurrichane, an Iron Age settlement built by the Hurutse tribe (Mason 1968). Early research conducted on the LFC in Mpumalanga include the 1912 descriptions of Trevor and Hall regarding prehistoric copper, gold and iron mines in the Mpumalanga region (Evers 1975). Some of the earlier research, specifically on the escarpment, was conducted by Laidler in 1932 and Van Hoepen in 1939. In 1950, Revil Mason initiated the Transvaal Iron Age Project, which subsequently

launched large-scale excavations and topographic surveys of Iron Age or farming community sites in South Africa with the aim of uncovering possible behavioural evidence. The latter was achieved by finding and investigating material artefacts and their spatial disposition on sites, together with the associated food waste deposits and the topographic location of living sites (Mason 1968). This project became the basis for the planning of a programme of future fieldwork as previous research on farming community sites was limited and inadequately controlled (Maggs 1974).

Following the initiation of the above mentioned project, Mason (1968) carried out an extensive aerial survey of the area, one of the first of its kind in the Mpumalanga area, because he believed that it would be the best way to approach the Iron Age Project. The photographs for this survey were taken by the South African Air Force and from the series of images gathered, Mason concluded that walled sites were generally located on high ground and concentrated in drainage areas, which is thought to have facilitated the watering of cattle. Mason (1968) presumed that the behaviour of the farmers of that time was linked to the environmental variations existing between the different areas. Evers (1973a, 1975) subsequently contributed to Mason's research by conducting another aerial survey of the area between Lydenburg and Machadodorp. These images revealed that the sites were generally clustered unevenly on the eastern slopes of hillsides. However, this site distribution pattern is not ubiquitous throughout the area, as research undertaken by Collett (1982) in the Badfontien Valley shows sites situated on western facing slopes. It can thus be concluded that the determining factor in site location was water availability rather than direction or anything else (Collett 1982).

3.2 The History of Mpumalanga

When observing the history of Mpumalanga over the past 1 000 years it is evident that the LFC migrated to the area when climatic conditions became better suited to their agricultural needs (Huffman 2007). These populations had obtained new

improved methods of agriculture when compared with Early Farming Communities (EFC) that previously occurred resided in Southern Africa. These improved methods are evident when observing the terraced agriculture and substantial increases in the number of cattle as suggested by the unusually large kraals on the escarpment. The latter can be seen on Google images (see figures 3.2 and 3.3).

There is a dense history surrounding Mpumalanga over the last 1 000 years. Delius (2007) mentions that populations of the LFC would have migrated to Mpumalanga during times of climate shift and political instability from around the beginning of the sixteenth century. At around 1640, during a warmer phase within the Little Ice Age, the population growth showed a considerable increase. As the population increased, the frequency of interactions dealing with land and resources between various groups also intensified. Furthermore, it is believed that climatic conditions, agricultural potential and trade networks would have further intensified these social interactions among the LFC.

Maggs (1976) opines that the Highveld areas of Mpumalanga were not occupied by the EFC due to the existing environment. The extensive grassland endemic to this area was of little value to their economy as they were dependent on slash-and-burn agriculture, also known as swidden agriculture. Radiocarbon dating from pottery places the EFC in the first millennium (Evers 1977); however, the land became valuable only when LFC populations had increased livestock numbers to the point that they formed a principal resource. It is during this time that the LFC populations would have migrated to the high grasslands of the Highveld to take advantage of the open grazing lands (Hall 1987).

There is some debate over which cultural group occupied the Highveld and the escarpment during the last 500 years. The most common assumption is that the area was dominated by an essentially Pedi culture during the second millennium (Mason 1963). However, it is now believed by some that the BoKoni were responsible for the terracing and road networks in the area (see for example Maggs, 2008, Delius and Schoeman 2007, Huffman 2007). Oral traditions have also placed the Koni in the escarpment area before the Pedi (Huffman 2008). If

this is the case, some sites would be dated around AD 1600-1650 (Huffman 2007). According to Huffman (2007), the Koni are "Sotho-ised Nguni, Koni" meaning Nguni in the Sotho-Tswana language.

It is therefore not entirely clear who occupied the sites and when, but it can be assumed that the sites were not all occupied simultaneously nor were they occupied permanently. It is also likely that the terracing agriculture only occurred seasonally, with farmers utilising the warmer climate at higher altitudes without the threat of disease. Political strife may also have led to an abandonment of sites. Delius and Schoeman mention two violent periods, the first in the seventeenth century and the second in the mid eighteenth century which may well have led to the abandonment of the Komati River Valley. As stated previously, times of occupation were also uncertain. Some oral sources state that the Maroteng (who later established the Pedi Kingdom) settled in the area in 1650 (Delius and Schoeman 2008). However, according to Delius and Schoeman (2007), Pedi tradition relates that Koni groups were encountered when the Maroteng first moved into the area which suggests that the area had been occupied since the early 1600s. Other evidence of occupation includes documents of active trade within the area. The 1810s and 1820s are reputed to have been a time when "as the tempo of political change accelerated in the wider region, it seems likely that a municipality of groups travelled, raided and even settled for periods of time in Mpumalanga" (Delius and Schoeman 2007: 150). Lastly, missionary sources place occupation of the area at 1860 (Delius and Schoeman 2007).

Archaeological evidence suggests that the EFC in the Lowveld area would have continued to exist until the fifteenth century AD, while they ceased to exist on the Highveld by AD 1100. The Highveld area, according to Esterhuysen and Smith (2007), became active again from the fifteenth century onwards. The LFC sites of this period can be recognised by their extensive stone walled settlements that appear to have occurred from AD 1400 to the mid nineteenth century, ending with the Difaqaune and thereafter being succeeded by European occupation (Marker and Evers 1976).

Scholfield (1935, 1936, 1948), Dart and Beaumont (1969), Beaumont and Vogel (1972) and Maggs (1973) observed and documented a range of different walled sites in Mpumalanga. The complex terraced and stone walled sites found between Orighstad and Carolina in particular caught their attention. Yet, despite repeated studies to understand these unique sites, many questions remain unanswered, including who built the sites and why.

This area of closely situated pre-colonial stone ruins extends along the escarpment, which separates the Lowveld from the Highveld in the Mpumalanga Province (Maggs 2008). In comparison with the EFC, the LFC had a substantially larger population and the sites are accordingly significantly bigger. These more extensive sites include agricultural land defined by terraces as well as trade and social networks in the form of cattle tracks (Marker and Evers 1976, Delius and Schoeman 2008). According to Marker and Evers (1976), the most prominent differences between the occupations of the LFC and that of the EFC in this area are that the LFC possessed more livestock, and terracing agriculture was initiated during their occupation.

Delius and Schoeman (2008) argue that terracing represents a difference in agricultural strategy and the extent of terracing seen in this area suggests that the aim was production beyond local need. Likewise, the extensive cattle control measures exercised here, such as cattle paths designed to prevent crops from being trampled, indicate that large numbers of cattle were present (Delius and Schoeman 2008). Maggs (2008) also emphasises the extent of the terraces and the networks of linking roads. He believes that the terraces represent one of the only South African field systems that survived from pre-colonial times. He also compares this terracing method with that of eastern Africa, claiming that the thousands of hectares of terraces and long distance roads represent a massive investment in landesque capital. This infrastructure would also have required a substantial mobilisation of labour and it is the scale of this investment that sets the BoKoni apart from other pre-colonial societies in South Africa (Maggs 2008: 179).

3.3 Investigation of Sites

The importance of investigating the terraced sites of Mpumalanga stems from a lack of previous research on these sites and on the environmental implications of site distribution. A greater understanding of the environmental effects on these sites will explain why the LFC selected these specific locations for their sites.

Studies of twentieth century settlements have demonstrated a relationship between the physical layout of the settlement, the belief system of the society, and the socio-economic and political circumstances of the time (Kuper 1980). Hammond-Tooke (1993: 56) discusses the importance of Kuper's (1982) statements with regard to our understanding of the spatial symbolism of the homestead layout as despite differences in detail, there is an underlying organisational pattern. Mason (1968: 168) mentions that "[a] settlement plan is a function of social organisation and a key to understanding early farming social behaviour". Research conducted by Kuper (1980, 1982) has profoundly influenced the anner in which archaeologists view the use of space, and the spatial layout of ancient and modern settlements and households (see for example, Huffman 1982, 2007, Hall 1981, 1998 and Pistorius, 1992).

Marker and Evers (1976) contend that the distribution of LFC terraced sites in Mpumalanga were restricted as most of them occur in valley tributaries on the escarpment when they are generally located on higher ground next to major drainage channels (Marker and Evers 1976, Mason 1968). Delius and Schoeman (2007) mention that due to the river valleys containing very high magnesium levels, the said valleys were regarded as unfavourable for agriculture as the high levels of magnesium present in the area would stunt plant development. The hill slopes were better suited to crop production as leaching in the soil minimised the magnesium levels. Delius and Schoeman (2007: 163) further stated that "as the population grew and with this the need for more intensive farming developed, they optimised hill slope crop production through terracing".

Dolerite is a common feature on the landscape of the Mpumalanga escarpment. It is a medium-grained igneous rock consisting of pyroxene (calcium, magnesium

and iron silicate) (McCarthy and Rubidge 2005). The dolerites in the area have broken into blocks which are sub-rounded and brown to red-brown from the oxidation of ferro-magnesium minerals (Cairncross 2004) which serve as a convenient building material. Hall (1987: 48) claims that this is why the dolerite intrusions were the favoured places for farming settlements rather than those that they initially occupied.

The research conducted by Marker and Evers (1976) focused mainly on the differences between the simple and more complex ruins (Delius and Schoeman 2008). Marker and Evers (1976) identified three different settlement patterns in the Lydenburg area. These three patterns have been further divided into different levels of complexity. The first pattern is the simplest and consists of two concentric circles; the inner circle is believed to be the cattle kraal and the area between the inner and outer circle is believed to be the residential area (where the huts were built). The second pattern is slightly more complex as the inner circle has smaller enclosures attached to it, and lastly, the third pattern is a conglomeration of small circles that do not follow the same pattern of the previous two (figures 3.3 and 3.4). The third type are found on terraced slopes with lines of stones running along the contour (Marker and Evers 1976, Esterhuysen and Smith 2007).

In these early settlements, the crops cultivated on the built terraces would have had to be protected from being trampled by livestock. Marker and Evers (1976) state that stone walled tracks were built for this purpose. Terracing generally consists of lines of stones running roughly parallel to the contour (Marker and Evers 1976). Terraces that occur on steeper locations consisted of proper walls, and more often than not, the outermost terrace wall adjacent to the exit of the cattle tracks was of this sort (Marker and Evers 1976). The terraces were divided into stone lines that run across their length and would have reflected the land tenure system that was in place at the time (Marker and Evers 1976). The extensive terracing in this area may have been especially adapted to the cultivation of maize, which requires more water, and sorghum, in which case it is likely that some of the sites may date back as early as AD 1550 when the

Portuguese introduced maize to Southern Africa through Delagoa Bay. As BoKoni is situated directly opposite Maputu on the escarpment, the first introduction of maize to this area is highly possible (Maggs 2008). Maggs (2008) further argues that the higher rainfall and mist-belt conditions of the Mpumalanga escarpment were not favourable for the production of sorghum and accordingly the production of maize was more likely. However, Delius (1983) mentions that by the beginning of the 1860s only some maize was being produced, but its production did not appear to challenge the dominant position of crops such as sorghums and millets. Later, in the mid-1860s, there was an increase in the spread of maize but to what extent is not clear (Delius 1983). It is, however, believed that this increase was due to an increase in population (Delius 1983). This will be discussed further below.

Maggs (2008) has combined the earlier aerial survey information compiled by Mason (1968) and Evers (1973a, 1975) with new spatial distribution research. The maps in the article of Maggs (2008) are one of the first attempts to show a complete distribution of this settlement type. The results indicate a virtually continuous belt from Lydenburg to Carolina, a distance of 150 Km. Maggs also mentions that there are a few clusters that lead eastwards down the Komati Valley and the upper tributaries of the Crocodile River.

It is evident that the sites are linked to agro-pastoralism due to the cattle kraals being incorporated into the structures, as well as the sites being within close proximity to water. The terraced sites also suggest large-scale agricultural production, as previously mentioned. The conditions that would have allowed for such large-scale production needs to be seriously considered.

Maggs (2008) mentions that little research has been conducted on the environmental implications of site distribution, but great potential exists for doing so. He explains that "[an] escarpment setting is exceptional as no other LFC in South Africa was so closely associated with this major South African topographical feature" (Maggs 2008: 172). Huffman (2007), like Maggs (2008), maintains that the mist belt that drifts over the area may have provided essential

moisture during drier, cooler times. This may be another reason why the area was settled.

Esterhuysen and Smith (2008) argue that the density of the LFC sites between Carolina and Lydenburg suggests a substantial increase in population or the movement of people in the area. Esterhuysen and Smith (2007) further state that trade would have played an important role in the economy of the LFC as control over resources such as metals allowed a secure livelihood even during climatic events such as drought. The above statement presents yet another reason behind possible site selection. If the sites were near trade routes or part of trade networks, their economic stability would increase. Further, if specialist items such as metals were present in the selected area, this would further increase the economic stability of the area.

Finally, in order to understand the Mpumalanga escarpment terraced sites more fully, it is vital to observe other similarly terraced sites in Africa, including the abandoned agronomy at Nyanga in Zimbabwe and Engaruka in Tanzania (Stump 2010). Stump (2010) and Maggs (2007) note that although comparisons have been drawn between the above mentioned sites, there is no cultural affiliation between them (see also, Evers 1973 and Sutton 1985). One of the similarities between the Mpumalanga and the Nyanga sites is a widespread development of labour-intensive agricultural practices, including terracing and mounding of earth beds for crops (Maggs 2007:4). Another similarity, and possibly the most obvious one, is that both sites reveal a specific type of escarpment distribution. Nonertheless, a general question regarding the sites is whether they represent intensive agricultural systems, and whether these can be linked to social, economic and ecological circumstances (Stump 2010).

As further investigation into these sites takes place, new and more refined explanations emerge. Stump contends that at Engaruka perceptions changed from the belief that the agronomy was a result of an insular and defensive community forced to intensify production to the point of systemic collapse, to the belief that the society may have been well adapted to the prevailing ecological and climatic conditions, and may also have maintained long-term trade relationships with

neighbouring groups (Stump 2010: 257). Similarly, further investigations at Nyanga have questioned the assumption that the large area of terracing present at this site required the resources of a large population, as the sequence in which these features were possibly constructed and abandoned as well as their relationship to dateable settlement sites, suggest a relatively small community periodically moving around the landscape rather than an expanding population forced to intensify agricultural practices in order to feed greater numbers of people (Stump 2010: 258).

Stump also remarks on the importance of comparing the findings of the Mpumalanga sites with research on specialised technologies and techniques commonly associated with labour intensive or high yield local agriculture in eastern Africa. However, it is important to note that not a single type of technology or practice can be taken as unequivocal evidence of intensification in the absence of information regarding the time frame in which these practices were introduced (Stump 2010: 259). Stump refers to the example of the Nyanga sites, explaining that although they may appear to be more labour intensive than pastoral production within the same landscape they are not. The terraced area was in fact constructed cumulatively and partly as a consequence of stone clearance in the field areas, and was never all farmed in any given year, which demonstrates that the system was less intensive in terms of labour input than what is evidenced from survey information alone (Stump 2010: 260). Further research at this site indicates that other functions may have been performed such as anti-erosion methods and levelling fields that require frequent irrigation.

The current research observed the Mpumalanga sites with the aid of a GIS. Stump (2010), however, avers that it is essential to conduct excavations on the targeted sites in order to examine the relationships between cattle keeping and arable aspects of the economy. Secondly, evidence of economic exchange and production could possibly be found through the recovery of archaeofaunal, archaeobotanical and artefactual remains (Stump 2010). Research on the latter needs to be conducted in detail in the future in order to gain a deeper insight into the Mpumalanga sites.

3.4 Agricultural produce

As mentioned above, the escarpment may have been chosen for occupation due to its unique ability to produce maize and because of its position in the mist belt frequently enveloping the area which resulted in higher rainfall in the area, and also because of the lower levels of magnesium in the soil caused by soil leaching at higher altitudes. Agricultural potential is an important aspect to consider when determining the reasons behind site locations. Huffman (2007) contends that the incorporation of maize could possibly have led to an increase in the population as its crop yield was higher than sorghum and millet with the same labour force. However, Fagan (1965) reports that in the case of the Nyanga site, sorghum, millet, maize and various cucurbits were cultivated on terraced fields. Nowadays, these crops are grown in almost any part of Zimbabwe and do not require very fertile conditions; hence, they were also suitable for the Nyanga hillsides of long ago (Fagan 1965). Maggs (2008) mentions the recovery of large, "birdbath"-type lower grindstones and two-handed upper grindstones from some BoKoni sites. These grindstones were normally required for the grinding of maize rather than the softer African cereals (Maggs 2008). However, so far only sorghum has been recovered from a BoKoni site. Therefore, further excavations are required to determine whether maize was present on the escarpment (Maggs 2008). For the purpose of this research only a few species that are possible choices for agriculture are observed in order to determine whether the area was selected for agricultural purposes or not.

Historical documentation on agricultural practices in Southern Africa mention that *Sorghum bicolor* (sorghum), *Pennistrum glaucum* (pearl millet or bush millet) and *Zea mays* (maize) are the most used grains, with maize being used as an additional crop (Smith 2005). These grains are generally included in the practice of mixed cropping by growing them with melon, pumpkin, cowpeas, calabash, beans or legumes, and nuts (Smith 2005, Huffman 2007).

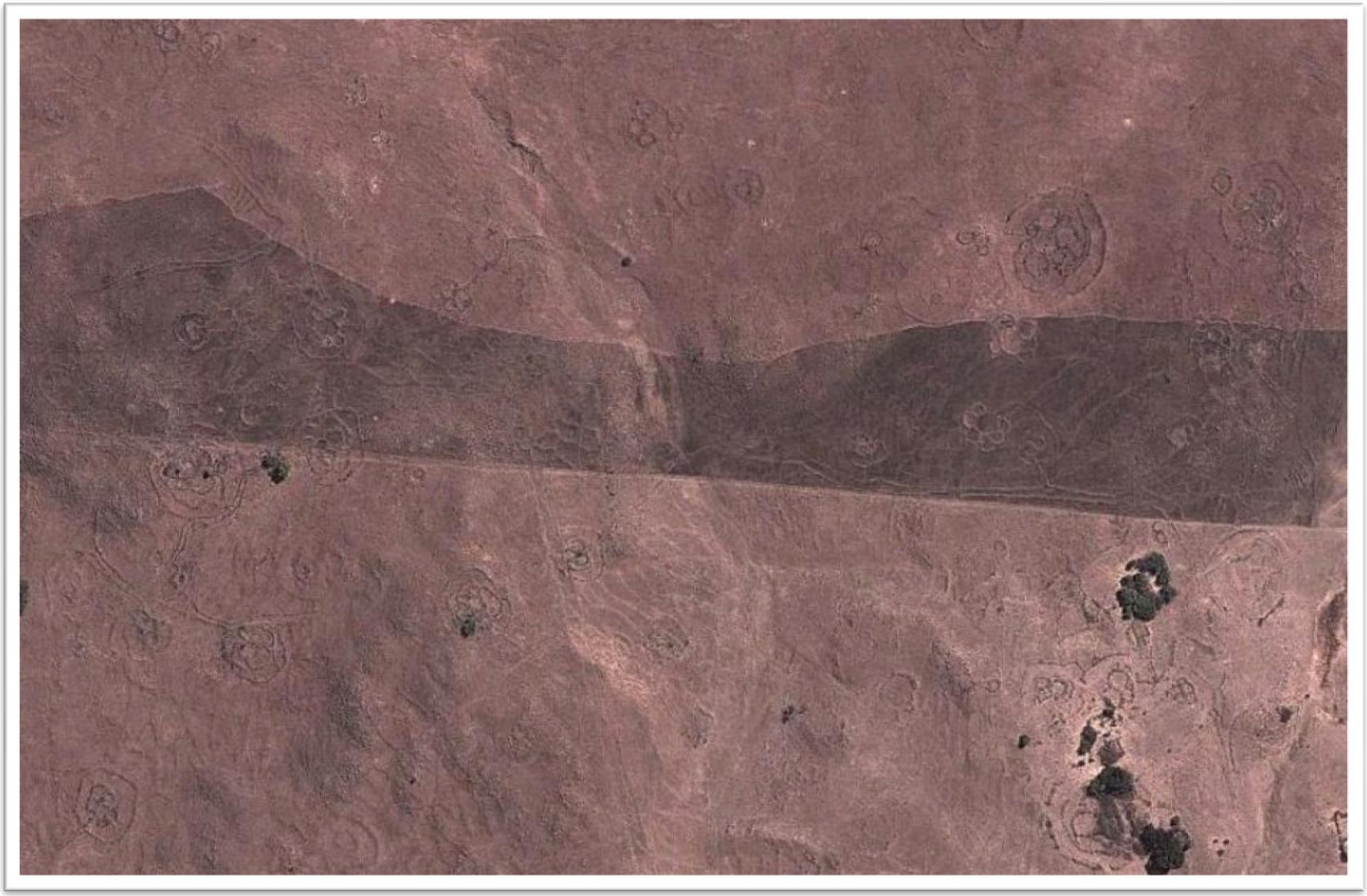


Figure 3.2: Google Earth image showing large cattle kraals



Figure 3.3: Google Earth image showing settlement patterns. A: Simple design, showing concentric circles. B: Slightly more complex design. C: Conglomeration of circles on terraced slopes



Figure 3.4: Google Earth image showing complex settlement design with extensive terracing

3.4.1 Maize

The incorporation of maize as a crop was beneficial as it allowed for the expansion of populated areas as argued by Maggs (1984), Smith (2005) and Huffman (2007). It was easier to harvest and process, and under optimum conditions produced higher yields than sorghum and millet. Therefore, it had commercial uses to support export trade and it could be eaten green if other crops failed (Smith 2005).

Normally maize requires a temperature range of 20°C – 22°C for germination continuing at high temperatures, with an annual precipitation of 500 mm - 1000 mm; however, some varieties of maize can produce sustainable harvests with only 250 mm of annual precipitation and growth temperatures as low as 10 °C (Smith 2005, http://www.fao.org). The maize plant has a shallow root system and requires well-drained soils (Hadfield 2001). In addition, it also grows well when paired with cucurbits (squashes) and beans as mentioned below.

3.4.2 Sorghum and millet

Sorghum and millet can grow in hot dry regions that receive an annual precipitation of 250 mm – 700 mm, with day temperatures of approximately 30 °C and above; however, sorghum is not very flexible with cooler climates (Smith 2005). Therefore, maize would have been a better cultivar on the cooler Mpumalanga escarpment.

3.4.3 Cucurbits

Cucurbits require temperatures ranging from 21 °C - 27 °C and full sun as well as deep consistent watering for optimum growth. Moreover, medium rich well-drained soils are required. Cucurbits are often paired with maize as the latter provides good ground cover and consequently inhibits evaporation by providing shade over the soil (Hadfield 2001).

3.4.4 Legumes

Beans or legumes require well-drained slightly acidic soils, a temperature range of 21 °C - 27 °C and an annual rainfall of 300 mm - 500 mm. They are often grown with other crops, especially maize, in order to restore nitrogen to the soil. They have shallow root systems (Hadfield 2001, www://fao.org).

3.4.5 Intercropping

It is important to note the practice of intercropping of different plants in the same field section, which Smith (2005) reports had been in effect in the Mpumalanga area according to historical documentation. This method of agriculture is significant as it maximises to use of limited land resources and unpredictable precipitation as well as replacing soil nutrients and nitrogen with the inclusion of beans, nuts, cowpeas and legumes, as mentioned above (Smith 2005).

3.4.6 Could agriculture of sorghum, maize, legumes and cucurbit production succeed on the Mpumalanga escarpment?

The cultivation of sorghum, maize, beans or other legumes, and cucurbits would have succeeded on the Mpumalanga escarpment if environmental conditions were favourable for the growth of these plants. Delius (1983) notes that the preferred soils for agriculture are usually black peat or turf, and red clay. The above mentioned plants all generally require shallow, well-drained moderately fertile soils with annual rainfalls of 500 mm or greater per growing season and a temperature range of 21 °C - 27 °C. With the use of GIS, the obove mentioned factors will be observed to determine if agricultural production is possible on the escarpment.

3.5 Trade, Economic Relationships and Conflict

A comprehensive understanding of the terraced sites of Mpumalanga cannot simply be derived from the observations of environmental implications even though they are vital determinants. The other primary factors that must be taken

into consideration are trade, economic relationships and conflict. It is evident that intensive trade networks existed and that Mpumalanga was an important thoroughfare for long distance trade as the historical trade routes reveal (Esterhuysen and Smith 2007). A complex localised trade system created economic security during times of famine. And lastly, the importance of cattle in trade and economic, and territorial conflicts needs to be considered. Delius (2007) argues that the presence of myriad exotic beads and marine shells in the Mpumalanga region reveal that intensive trade networks operated from the coastal regions into the far interior, with Mpumalanga being a vital trading channel.

History and archaeology demonstrate that people in the past moved between inland areas such as Mpumalanga and the coast to obtain and trade in a variety of resources (Esterhuysen and Smith 2007). As mentioned above, Mpumalanga became an important thoroughfare for local and foreign traders as economically driven centres of control began to emerge in Mpumalanga in conjunction with the establishment of Portuguese trade posts at Delagoa Bay at the start of the 1700s (Esterhuysen and Smith 2007). The routes cut through the Lubombo mountains at Sabiepoort and moved inland towards the Sabie and Lydenburg areas. These routes would then either turn north towards Phalaborwa or to the regions northwest, towards Polokwane and Rooiberg (De Vaal 1984).

Two forms of trade would have taken place. The first being the local trade in the interior of foodstuffs and other commodities for specialist made articles such as metal tools and salt. The second being long distance trade through Delagoa Bay where ivory, furs, rhino horns and metals were exchanged for European items such as cloth and glass beads (Evers 1973b). Trading in copper between the traders of Mpumalanga and the Europeans at Delagoa Bay began around AD 1720 during the occupation of the Dutch East India Company in the Bay (1721-1729) (Eldredge 1992). However, copper trading occurrences have been recorded as early as AD 1544 during the Lourenço Marques and Antonio Caldeira expeditions (Evers 1973b).

Furthermore, minerals may have played an important role during the settlement of the LFC in Mpumalanga. Delius and Schoeman (2008) argue that it was likely

that the BoKoni had access to local iron sources or imported iron. The main sources of iron would have been the iron deposits between Barberton and the Komati River to the east, and the iron-ore bearing hills at KoNomtjarhelo, the mid-Steelpoort valley to the west and the Strydpoortberge to the north. Hammel *et al* (2000) note that iron ores were widespread and readily available throughout the region (Hammel *et al* 2000). The majority of pre-colonial mines for non-ferrous ores in Zimbabwe mined for gold, while in northern South Africa the majority mined for copper and tin (Hammel *et al* 2000). The main sources of copper production in South Africa were in the Messina and Phalaborwa regions (Hammel *et al* 2000). The main area for pre-colonial tin production was the Rooiberg area.

Iron working appears to have been one of the core elements in Maroteng identity and perhaps in the growth of their economic and political power (Delius and Schoeman 2008). However, it is believed by Delius and Schoeman (2008) that iron working was not a monopoly, suggesting that the Baroka groups were the iron smelters and smiths in the land, while Phalaborwa remained the centre of a major metal manufacturing and exploiting industry. Furthermore, evidence suggests that the Pedi played a key intermediary role between the metal industries in the Lowveld and the societies to the south and west (Delius and Schoeman 2008: 162). It is also mentioned that iron working was probably a dry-season activity that was afforded more attention when crops had been harvested (Hall 1987). People requiring iron implements either worked for the smiths as payment for the implement, or goods were exchanged in their finished form for the implements required (Hall 1987).

From the mid sixteenth century increased activity was reported from the Portuguese and other European traders at Inhambane and Delagoa Bay. The trade centred on the exchange of beads, cloth and copper for ivory and rhino horns from the interior (Delius 1983) as mentioned previously. From the mid eighteenth century, increased European competition resulted in an increase in trade where the price of ivory doubled and networks of exchange throughout the interior were increasingly linked to the east coast (Delius 1983).

Local trade, *inter alia* in metals, was vital as it provided a secure livelihood regardless of localised crop failure. By concentrating efforts on a narrow range of food plants the LFC placed themselves at risk in case their crops failed due to unpredictable and unforeseen climatic conditions (Hall 1987). The author further claims that the LFC would have suffered periodic food shortages due to the unpredictable climate in Southern Africa which would have had a large impact on their lifestyle as they would have had to find other sources of sustenance. Managing such risks would have been a prevalent concern of the LFC; hence, one of the methods of mitigating such a risk would have been the accumulation of food supplies. This stockpile would have been useful during times of food shortages as well as to gain the indebtedness of others with less foresight. By providing food for others during times of famine, certain groups could create obligations that could later be claimed in times of need (Hall 1987, Maggs and Whitelaw 1991).

The economic security provided by local trade is an important factor to consider in understanding the LFC of Mpumalanga. These interlinked economic relationships may well have influenced site distribution. They would also have influenced the ability of certain groups to continue inhabiting an area despite local climatic environmental variability.

According to Delius (1983), there is evidence of competition for trade amongst the chiefdoms in the area during this time. The bulk of the trade passed through the Tsonga intermediaries who travelled to and settled amongst the societies of Mpumalanga (Delius 1983). He refers to the escarpment as the gateway to the interior and claims that the chiefdoms in control of this area were well placed and the chiefs appeared to have secured a partial monopoly over trade. Trade most likely facilitated some form of differentiation in wealth and power within and between chiefdoms in the context of social relationships of production existing in Mpumalanga (Delius 1983). It assisted rulers to accumulate prestige goods to attract and control subjects and clients and to entrench their crucial position in internal systems of exchange and redistribution (Delius 1983: 19).

Domestic stock also played a large role in the resilience of the LFC to continue occupying certain sites, despite a hostile local environment, as increased holdings of domestic stock further enhanced economic security (Hall 1987). Domestic herds could be moved into areas with better resources and could therefore survive despite harsh local conditions. It is also likely that seasonal cattle transhumance was practised (Delius and Schoeman 2007). Cattle could also be used in transactions between villages, creating reciprocal obligations and debts (Kuper 1982). Hall (1987: 46) describes the use of livestock to secure transactions between people as a qualitative change from simple food production.

Cattle were probably the main cause of endemic conflict between various groups within the LFC on several occasions (Mason 1968). On a general level, the need to water cattle would have influenced the need to settle in drainage areas, and competition over these areas would have occurred. There is also evidence that a rapid increase in cattle raiding took place from about 1780 AD to 1800 AD in order to supply European, American and French whalers with meat (Bonner 1983, Eldredge 1992, Wright and Hamilton 1989). This demand for beef expanded to such an extent that by AD 1800 the ivory trade was surpassed by the demand for cattle (Huffman 2007). Cattle were extremely important to the LFC as they symbolised wealth and were vital in the matrimonial custom of lobola. As a result of the growing demand for beef the social order of the LFC was disturbed and widespread conflict and violence erupted (Huffman 2007).

Site design and placement of LFC in Mpumalanga may have been largely influenced by inter settlement conflict over cattle and other resources, as defence against sudden attacks became more important (Mason 1968). Defence would have depended upon having a view that provided sufficient warning in order to prepare an immediate counter-attack, and not upon the great battlements required for a prolonged siege (Mason 1968). Lastly, according to Delius (1983), it can be assumed that the regional hegemony achieved by the BoKoni is due to their domain being positioned in the Steelpoort River valley which encompassed a superior pastoral and agricultural environment and lay across a key trade route linking the coast to the societies of the interior (Delius 1983: 19).

3.6 Summary

When observing the occupation period of LFC on the Mpumalanga escarpment it becomes evident that these societies were heterogeneous as constricted interrelationships existed between settlement locations and plan forms. The extensive terraces, cattle tracks and evidence that major trade routes passed through the area substantiate this observation. Climate, conflict and trade also affected each society differently and therefore each society responded differently to these factors as well. The terraces suggest intensive agriculture; however, what is significant is that this intensification is not noted anywhere else in Southern Africa. Furthermore, little is understood about the reason why the terraced sites occur in Mpumalanga and not elsewhere. It is due to the unusual nature and specific placement of the LFC sites that a comprehensive representation of the sites as well as factors such as climate, soil type and the presence of disease needs to be created. These factors will be expanded upon and explored in greater detail in the succeeding chapters.

Chapter 4

Climatic reconstructions for Southern Africa

4.1 Climate Variation as a Determinant in Site Selection

Climate variation over time is one of the most important factors to take account of in an attempt to understand the geospatial patterns of LFC habitation on the Mpumalanga escarpment. Changing weather patterns influence the adaptation and growth of vegetation as well as the distribution and severity of endemic diseases, and subsequently these factors have a profound effect on societal organisation. All these factors must be linked together in order to develop a comprehensive understanding of settlement distribution throughout the ages. The causal chain linking these factors must also be explored in order to uncover why the LFC of Mpumalanga settled in particular areas. Climate and elevation determine the density and variation of vegetation in any particular area. Moreover, the quality and quantity of arable grassland in various areas are directly linked to the number of cattle that the land can sustain. This allows for a link between the LFC site distributions and those areas that climatically allowed for large scale cattle grazing. Likewise, endemic diseases are dependent on a particular set of climatic and environmental conditions in order to thrive. Therefore, by developing an understanding of past climatic environments it is possible to gain an awareness of the conditions which shaped LFC site distribution throughout the Mpumalanga escarpment.

It must however be noted that although climate is directly linked to the environment, the LFC possessed the ability to manipulate the environment to suit their needs. Nonetheless, various methods are generally employed to reconstruct past climatic conditions, as will be discussed below.

Radiocarbon dating has been a great impetus to new interpretations of archaeology as a whole. Although this paper is more focused on investigating the effects and determining the factors that influenced LFC, Vogel (1995) states that radiocarbon dating has great potential to determine the distribution of farming

communities through the ages. This, however, is only true if the site investigation and sample collection have been reasonably random over the last four decades, in which case the temporal patterning can be expected to reveal an expansion in the early farming populations and the effect that climate would have had on their development (Vogel 1995). The premise behind the findings of Vogel are that the spatial and temporal distribution of a large number of radiocarbon dates should reveal information about the movement and development of past communities (1995). The importance of this method is that one can correlate the movement of societies and environmental influences, climate being one of the determining factors. It must be noted, however, that for the last 500 years radiocarbon dates have not been beneficial due to the large fluctuations in the radiocarbon calibration curve after 250 BP that do not allow for any subdivision of sites during the final phase after AD 1670 (Vogel 1995).

There is little evidence of rainfall fluctuations during the period of the LFC settlements in Mpumalanga. This is problematic as the most influential factor in respect of subsistence farmers on the subcontinent is the amount and regularity of rainfall (Vogel 1995). Tyson (1986) claims that a correlation exists between summer rainfall and mean annual temperature, but the changes in temperature have been better understood than that of rainfall. This insight into the temperatures can be used to assist in determining past climates.

Climate records from equatorial eastern Africa and subtropical Southern Africa have shown that temperatures and rainfall have varied inversely over the past millennium (Holmgrenand Öberg 2006: 185). As South Africa does not have many detailed records of past climates over the last 500 years, looking to the eastern regions of the African continent will help to address many of the shortcomings. Detailed analyses of the historical and paleo-climate evidence from these areas over the last millennium indicates that depending on the vulnerability of a society, climate variability can exert an immense impact on societies (Holmgren and Öberg 2006: 185). This impact tends to result in mass movements of populations. This type of significant change in climate and therefore the

environment is one of the main determining factors in respect of the placement of LFC sites in Mpumalanga.

Although extensive paleo-climate research has been and is currently still being conducted, there is limited information available on paleo-climates for the last 500 years. This is especially true for Southern Africa. Inferring climatic conditions from sources such as travellers' journals, missionary records, early newspapers and other historical sources has allowed researchers to qualitatively reconstruct the climate of the nineteenth century for the Cape Province (Vogel 1989). However, due to the limited records available for areas beyond the Cape, a similar detailed analysis for the rest of southern Africa does not exist (Tyson 1991). Thus, climatic reconstructions for Southern Africa have been derived from climate models, lake levels, speleothems and tree-ring series.

Present day rainfall over Southern Africa is a summer phenomenon with the exception of the Western Cape where more than 70 % of the rain falls in winter. A narrow belt along the southern Cape also receives rain throughout the year (Cockcroft *et al.* 1987). The annual rainfall at present varies from more than 800 mm over the eastern subcontinent to less than 100 mm over the western regions (Cockcroft *et al.* 1987). In general, high precipitation is recorded over mountain ranges whereas inter-montane regions and deep valleys may be much drier than surrounding areas (Cockcroft *et al.* 1987). Rainfall has varied on a near decadal scale throughout the twentieth century (Cockcroft *et al.* 1987). Precipitation over the interior northern regions of South Africa where Mpumalanga is situated follows an annual cycle and is almost entirely a summer phenomenon with over 80 % falling between October and March (Tyson 1986). The manner in which the air mass circulation generally occurs over the Southern African sector of the southern hemisphere has adjusted from time to time to produce extended wet and dry spells. This pattern over the subcontinent is relatively well understood (Tyson 1991) and is discussed in greater detail below.

There is worldwide evidence to demonstrate that temperatures fluctuated in the past. One such example is that of the transition from medieval warm times to the

Little Ice Age. Such climatic changes would have had profound effects on early societies; however, it is not clear what the extent of these effects would have been. It is due to these un-quantified effects that authors such as Holmgren and Öberg state the need to further explore the complex interactions between the different factors causing changes in social development (2006: 186).

There is an increasing quantity of high-resolution paleo-climatic data that provides fairly precise measurements of the timing, amplitude and the duration of past climatic events such as the Little Ice Age. The need to understand the impact of climate in societal rises and collapses is ever increasing (Holmgren and Öberg 2006: 186) as this not only promotes an understanding of the past more precisely but also aids in mitigating the effects of climate on society in the future. It becomes clear that with such an enormous volume of information, it is vital that it be placed in a coherent system in order to gain the full potential of analysis and results.

Before attempting to understand paleo-climates, it is perhaps necessary to first gain an insight into current climate patterns as recorded modern climate cycles are likely to be repetitions of what occurred historically. For the purpose of this chapter, only the 18-year oscillation of Tyson is discussed in further detail due to the significance it has in the reconstruction process of past climates. Tyson *et al.* (1975) conducted research on data from 157 weather stations during the period 1910 to 1972 which indicated that a series smoothed with a five-term binomial filter showed a great degree of systemic temporal variation (see Figure 4.1).

By determining runs of nine years in which cumulative deviations were maximised then minimised, the degree of temporal organisation was further illustrated. It can be observed that the stations conform to a pattern of being wet for nine years and dry for nine years in an oscillation of approximately 18 years (Tyson 1987). The spatial distribution of stations exhibiting an unambiguous 18-year oscillation reveals that they occur in the north-eastern summer rainfall regions of South Africa (Tyson 1987).

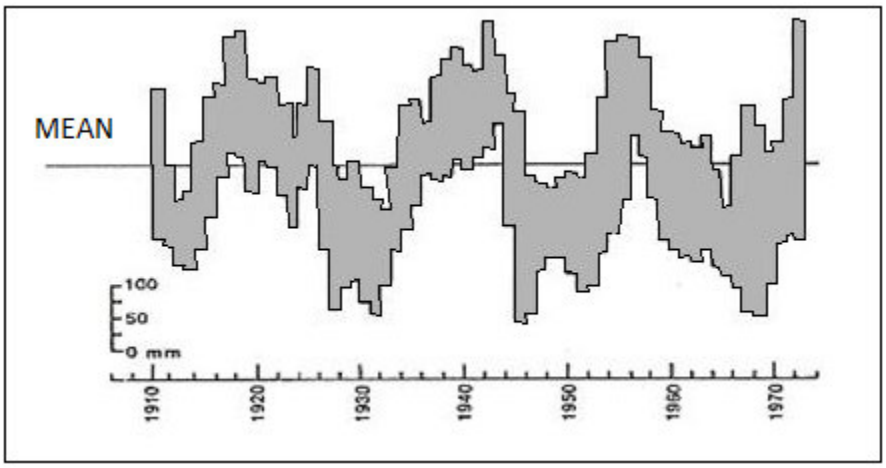


Figure 4.1: Showing superimposed deviations from mean annual rainfall smoothed with a 5-term bionomial filter for some stations in the summer rainfall region. Based on Tyson (1987: 69).

The 18-year oscillation has also been observed by various other researchers such as Zuchini and Adamson (1984), Vines (1980), van Rooy (1980), Thompson, 1981), Ngara *et al.* (1983) for Zimbabwe, and Reddy (1986) for Mozambique.

Unfortunately one cannot rely fully on the nine years dry, nine years wet phases as a static event that has remained constant throughout history. At the turn of the century the rhythm of change faltered (Tyson 1980) as backward extrapolation may suggest, the time period 1897 to 1905 was dry as opposed to wet and the oscillation underwent a phase shift (Tyson 1987). Since that time, however, the oscillation has been stable for over 80 years. Tyson (1987) states that this will require that we exercise caution when using such models to predict rainfall. Tyson further states that a point to consider during this phase shift is that it occurred at a time when temperatures began to rise in many parts of the world at the onset of the widespread period of warming that lasted approximately five decades in the northern hemisphere and may still be continuing in parts of the southern hemisphere (Mitchell 1963). This double dry spell clearly affected the growth patterns of the *Podocarpus* tree-ring series which is discussed further below.

4.2 Further methods of determining paleo-climates

4.2.1 An observation of the relationships between southern and eastern Africa

At this point, it becomes necessary to investigate other types of research that also seek to understand paleo-climates. Tyson *et al.* (2002) aver that the climates of equatorial East Africa and subtropical southern Africa have varied inversely over long periods. As there is limited data available for southern Africa it is useful to consider the climates of other countries and regions and thus gain a better understanding, by comparison, of southern African climates.

Two records are used to show the validity of the above statement, the high resolution $\delta^{18}O$ stalagmite record from the Cold Air Cave in the Makapansgat Valley in South Africa and a similar resolution lake level and salinity record from the Crescent Island crater sediments in Lake Naivasha in Kenya.

Dating of the Makapansgat record has been carried out by using high precision Thermal Ionisation Mass Spectrometry (TIMS) uranium-series dating to obtain a time resolution of approximately 10 years (Holmgren *et al.* 2001). The dating of Lake Naivasha sediments has been determined by ^{210}Pb and radiocarbon methods (Vershuren *et al.* 2000). Given the contrasting controls of weather in equatorial regions and subtropical Africa south of the equator, Tyson *et al.* (2002) claim that an inverse link between the climates of Kenya and South Africa may be expected as such a correlation has long been recognised during the period of meteorological record. They also believe that the changes in rainfall in the two regions on the multi-decadal to centennial scales have influenced both settlement patterns and livelihoods of the LFC, which is discussed in more detail below.

A commonly used proxy for paleotemperature is observing $\delta^{18}O$ composition of speleothems (Holmgren *et al.* 2001). Depleted δ^{18} O values in the Makapansgat stalagmite record are connected with drier colder conditions, whereas enrichment occurs with wetter conditions and persistent warm rainfall from middle-level stratiform clouds (Holmgren *et al.* 1999). During major climatic episodes of

medieval warming (900 - 1300 AD) and Little Ice Age cooling (1300 – 1800 AD), correlations between the data sets were much higher (Tyson *et al.* 2002).

Over the summer rainfall areas of southern Africa, droughts are induced by El Niño and wet conditions by La Niña (Mason and Lindesay 1993). In Kenya, the opposite patterns occur (Ogallo 2000). When observing the two data sets, it is evident that major events in the Makapansgat δ^{18} O record appear to be inversely correlated with levels of Lake Naivasha for the last 1100 years (see Figure 4.2).

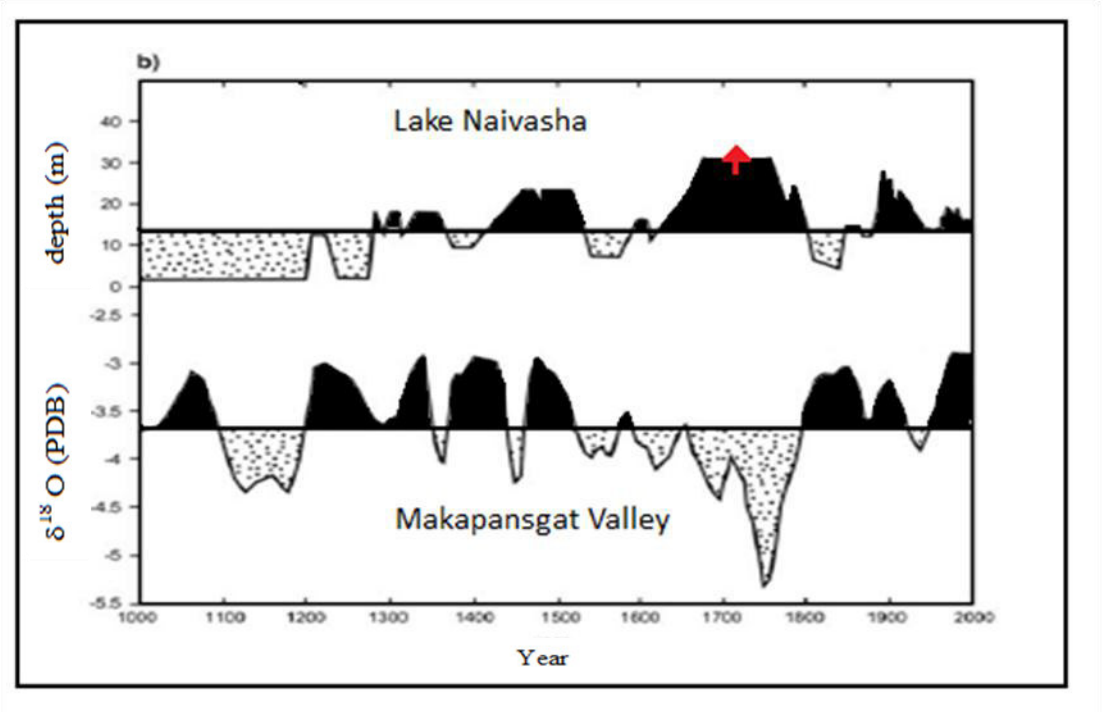


Figure 4.2: Correlation between lake levels in East Africa and speleothems in southern Africa, based on Tyson *et al.* 2002.

Further evidence that the climates of East and South Africa have varied inversely on inter-annual and ENSO (El Niño-Southern Oscillation) time scales can be seen clearly during the period of meteorological record (Tyson *et al.* 2002).

4.2.2 Speleothems

There are two detailed climate series from speleothems that are available for the Limpopo Province, both of which have been derived from the precisely dated stalagmites taken from the Cold Air Cave in the Makapansgat Valley. The first is

a stable oxygen isotope record which yields information about the regional pattern of relative changes in temperature and precipitation as mentioned above, and the second is a temperature reconstruction, based on the correlation between colour changes in the annual growth layers of stalagmites and regional annual maximum temperatures, which yields information about local temperatures (Holmgren *et al.* 2001: 49).

Stalagmite colouring is valuable to paleoclimatic reconstructions because changes in visible or luminescent colour banding of speleothems are caused by a number of factors, such as variations in amount, concentration or type of organic matter, changes in porosity and differences in crystallography (Holmgren *et al.* 2001: 49). On closer inspection the Makapansgat stalagmite indicates that the close correlation between recent regional temperature variations and stalagmite colour banding offers a way to examine past temperature proxies. There have been several studies that show a correlation between annual stalagmite thickness and mean annual precipitation (Holmgren *et al.* 2001). It is evident that the climate has fluctuated from warmer wetter periods to colder drier ones in approximately 80 year intervals (Holmgren and Öberg 2006: 186). The fluctuations between a warmer wetter climate and a colder drier climate can be alleged to have a quasi-periodicity of approximately 80 years (Tyson 2002) with the shift between the two being relatively abrupt (Holmgren and Oberg 2005).

The above studies suggest the occurrence of two major cool periods, the most recent of which occurred from 1500 AD to 1800 AD during the Little Ice Age (occurring AD 1300 – 1850), the second occurred from 800 to 200 BC representing the neoglacial period (Holmgren *et al.* 2001). Pronounced warm periods occurred during medieval times at around AD 900, when the highest annual maximum temperatures reached 2.5 °C above those of the present, and again in the late-fifteenth century, when the positive anomaly exceeded 3 °C (Holmgren *et al.* 2001: 50).

Holmgren and Öberg (2005) argue that relating the period of agricultural development to the regional climate record derived from stalagmites could

conclude that it was during times of climate shifts that societal expansion occurred and that there is a direct correlation between climate change and societal development. Holmgren and Öberg created a chart which expresses the above point clearly (see Figure 4.3).

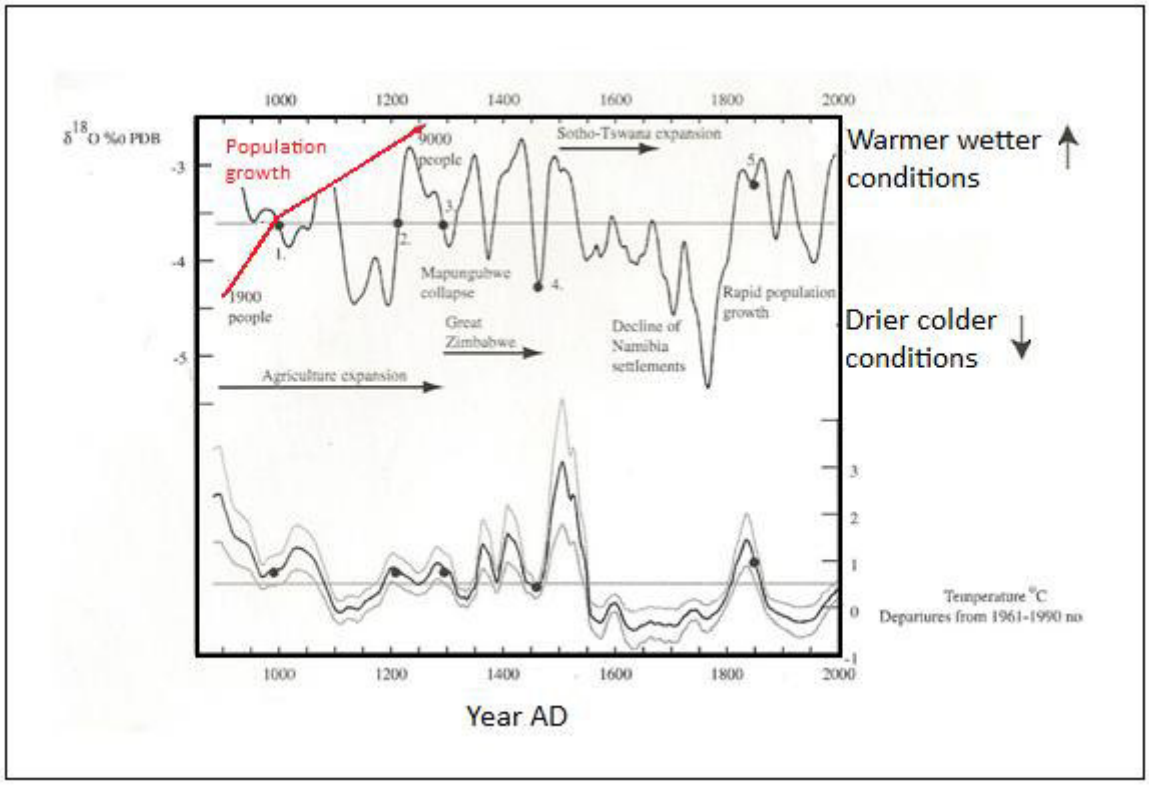


Figure 4.3: Climate time series are derived from analyses of stalagmites from Cold Air Cave together with historical information. The top series show $\delta^{18}O$ variations reflecting relative changes in temperature and moisture and the bottom series shows temperature changes in °C anomalies from 1961-1990. Based on Holmgren and Oberg (2005: 188).

The above clearly indicates that societies are affected by changes in climate patterns. There are of course other factors that add to the collapse of societies, for example, Huffman (1996) argues that the collapse of Mapungubwe was a result of a combination of population growth reaching unstable limits and drier climatic conditions. The first Sotho-Tswana settlements in eastern Botswana also correlate with a warmer wetter peak in climate between 1475 and 1525. Based on the above

evidence, it becomes clear that all societies have been affected to some extent by climate variations. The LFC in Mpumalanga are therefore no exception.

So far, the researcher has demonstrated that there is a strong correlation between the climatic variations derived from stalagmites and societal development. There are, however, additional factors that can be taken into account to strengthen the above hypothesis. Therefore, the next data under discussion is that of dendrochronology or dendroclimatology.

4.2.3 Dendrochronology

Dendroclimatology is another valuable method of determining past climatic conditions. Shifts in the trees $\delta^{13}C$ composition and wood anatomy resemble indications of climate change observed in regional paleoclimatic studies (Norström *et al.* 2005). Dendroclimatology measures different properties of annual tree rings in order to extract paleoclimate information with yearly resolutions (Norström *et al.* 2005). The second technique used in dendroclimatology is that of studying the chemical properties of the stable carbon, oxygen and hydrogen isotopes in tree rings (Norström *et al.* 2005). This method is based on fractionations of the stable isotopes ^{13}C and ^{12}C during photosynthetic transpiration and carbon fixation (Norström *et al.* 2005). Depleted $\delta^{13}C$ values will represent wetter conditions and increased $\delta^{13}C$ values will represent drier conditions. Examples of such methods are found in the research conducted on the *Widdringtonia cedarbergenisis* (cedar), *Podocarpus falcatus* (yellowwood) and *Breonadia salicina* (Transvaal teak) trees in Southern Africa. These records reveal similarities with the previously discussed variations in annual rainfall in the Mpumalanga region (Visagie 1985, Tyson 1991 and Norström *et al.* 2005).

Visagie (1985) conducted an analysis on a 376-year-old tree-ring series for *Widdringtonia cedarbergenisis* in the South Western Cape. The analysis included selecting eleven overlapping 125-year segments of the *Widderingtonia* data and commencing each segment 25 years later than the preceding one. This demonstrated that the 18-year oscillation phase (mentioned by Tyson above) has been stable over the 376-year period (Visagie 1985). This excludes the exception

to the phase shift in the early 1900s, however, shows that the oscillation itself has been in existence for at least the past four decades.

Tree-ring series for *Podocarpus falcatus* (yellowwood) trees in the north-eastern Transvaal and Natal, and for *Widdringtonia cedarbergensis* (cedar) trees in the South Western Cape also show the effect of the Little Ice Age. In observing the summer rainfall region of South Africa, from the fourteenth century until the mid seventeenth century it is clear that below normal tree-ring growth conditions occurred in response to the lower temperatures that prevailed during this colder period (Tyson 1991).

During the seventeenth and eighteenth centuries, above normal tree-ring growth was observed in the above mentioned trees. This occurred around 1630 in Natal (*Podocarpus falcatus)* and 1670 in the South-Western Cape *(Widdringtonia cedarbergensis*) (Tyson 1991). Enhanced growth occurred in the northern and eastern parts of Southern Africa from 1760 to 1860 (Tyson 1991). Clear regional differences are apparent at times in the tree-ring series; for example, the extended period of retarded growth in northern and eastern areas of South Africa during the period from 1860 to 1915 coincides with a period of above normal growth conditions from 1874 to 1902 in the South-Western Cape (Tyson 1991).

Tree-ring data series from South Africa are minimal; however, the said data corresponds directly with the climate observations mentioned above (Tyson *et al.* 2002). Strong growth in the *Podocarpus falcatus* trees of KwaZulu-Natal corresponds with droughts that occurred around 1550 – 1600 and 1800 – 1850 AD in the Naivasha Lake record (Hall 1976). Retarded tree growth in the late thirteenth century, mid sixteenth century and late nineteenth century corresponds with higher lake levels (Tyson *et al.* 2002). When observing the tree-ring record of *Widdringtonia cedarbergensis,* which grows in the winter rainfall region of South Africa, and the lake records, it is evident that these two data series are more concomitant with each other. The same can be argued about the climate variability of present-day South African winter-rainfall regions that was determined from the meteorological record (Mason and Lindsay 1993).

As mentioned above, a further tree-ring study was conducted by Norström *et al.* (2005) on two *Breonadia salicina* trees from the Limpopo Province. Data series from the trees span from 1375-1995 and 1447-1994 respectively. The trees recorded the occurrence of drier phases in the early 1400s, mid 1500s, 1700s and early 1900s followed by wetter conditions in the late 1400s and in the 1600s (Norström *et al.* 2005).

Greater detailed observation in this study indicates that both trees (M1 and M2) display depleted $\delta^{13}C$ values at AD 1475, followed by an increase in values until the mid 1500s. Depleted $\delta^{13}C$ values occur again during the 1600s in both records, followed by another increase starting in about 1700 and peaking at about 1730 for M1 and 1790 for M2 (Norström *et al.* 2005). Norström *et al.* (2005) hypothesise from their results that overall, the $\delta^{13}C$ record indicates that major wet spells occurred during the period of AD 1475, on several occasions between 1600 and 1700 and also around 1875. Major droughts occurred in the years prior to 1475 as well as around 1540, 1575, 1720 and 1780 (Norström *et al.* 2005: 167). The vessel diameter and frequency data from M2 placed dry spells at AD 1400, 1450, 1530, 1650, 1775 and 1850 (Norström *et al.* 2005).

When observing the results over the period of recorded climate history (1904 to the present) an interesting correlation occurs. During this time, M1 and M2 show higher $\delta^{13}C$ values during the early and late 1900s while more negative values are observed during the mid 1900s (Norström *et al.* 2005). What is even more interesting about this observation in particular, with reference to the present research, is that both trees correlated trends showing that the variations in $\delta^{13}C$ composition are influenced by a common source, although the trees grew at different localities.

Exploring the correlations between $\delta^{13}C$ variations and the regional precipitation index and mean annual rainfall record (in this case Polokwane as it was the closest weather station) further, it is observed that the $\delta^{13}C$ record covering the last century indicates that the highest values occur during the early 1900s and the most negative $\delta^{13}C$ values occur between 1960 and 1980. The rainfall data show that

the early 1900s had several extreme dry years, especially 1904, 1918 and 1934. The rainfall during the second half of the century was less variable with a higher annual mean and three extremely wet years in 1955, 1958 and 1964 (see Figure 4.4) below (Norström *et al.* 2005). These results suggest a stomatal response to water stress in *Breonadia salicina trees,* which is generally regulated by soil water availability and influenced by rainfall (Norström *et al.* 2005).

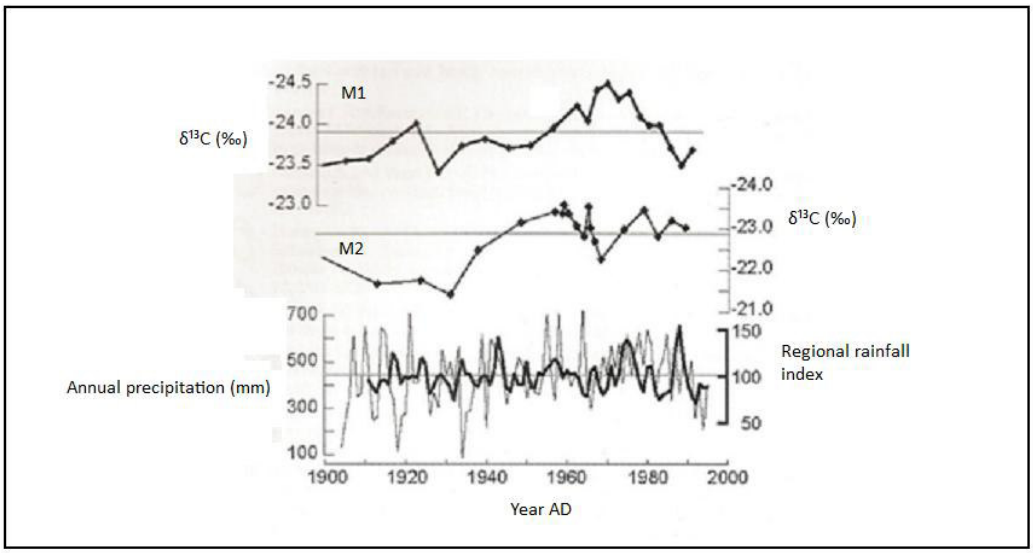


Figure 4.4: Properties of M1 and M2 plotted together with rainfall variations at Polokwane weather station and a regional rainfall index. Based on Norström *et al.* 2005: 167.

The different dating methods correlate. The *Breonadia salicina* correlates to speleothem isotope records from Makapansgat. This can be observed in the mid 1400s when the *Breonadia salicina* record indicates enriched $\delta^{13}C$ values followed by depleted $\delta^{13}C$ values at around 1500 and the speleothem records show a change from cold, dry conditions to warmer wetter ones (Norsrtöm *et al.* 2005).

The records from these data sets are characterised by high amplitude and rapid, decadal- to century-scale responses in hydrological systems (Tyson *et al.* 2002). These results clearly had implications for the economies of African farming communities (Tyson *et al.* 2002). Southern African oral traditions and archaeological evidence suggest that climate shifts provided advantages for the

agropastoralists during periods of climatic amelioration, or induced constraints on regional economies during periods of deterioration (Tyson *et al.* 2002).

4.3 Climatic Effects on Societies during the Late Farming Communities

The development of the first large, socially stratified centres of power and trade in the Shashi-Limpopo River Basin area are coincident with the medieval warming and wetter conditions (Huffman 1996). Agricultural expansion can be noted in this region during the period 850 -1290 AD (Leslie and Maggs 2000).

Observations of the history of Southern African farming communities reveal that large centres of power and trade commenced around AD 900 when climatic conditions were favourable. These centres shifted over small distances of a few kilometres, from a site called Shroda to site K2 at AD 1030, and from K2 to Mapungubwe at AD 1220 (Holmgren and Öberg 2006: 189). Huffman (2000) observed population growth from AD 900 – 1200 and concluded that the sudden collapse of the capital at Mapungubwe at AD 1290 was likely a result of deterioration in the climatic conditions. The combination of a high population and dry conditions, resulting in failed crops, being the primary cause of collapse (Holmgren and Öberg 2006). The Mapungubwe collapse coincides with the ending of the medieval warm period, which is now firmly dated in southern Africa by the Makapansgat stalagmite chronology. This strongly suggests that deteriorating climate was an important contributory factor in the decline of Mapungubwe (Tyson 2002). Other factors that confirm this possibility is shifts in the production and trade of gold and other items (Maggs 1984). Climatic re-organisation in this case coincides with climatic instability and shifts.

It must be noted however that climate is not the only determining factor that influences site settlement. The above statements mention strong correlations between large scale climate shifts and societal rises and collapses, however Smith *et al.* (2007) have conducted further research on the climate variability in the Shashi-Limpopo River Basin and refined the above statements. The previously

defined Medieval Warm Epoch of AD 900 – 1300 was subdivided into three variable climatic phases in which three settlement periods within the Shashi-Limpopo River Basin correlate. These included a dry phase between AD 880 – 1030 in which initial settlement began, a wet phase from AD 1030 - 1415 alongside a growth in population and agro pastoral production which led up to and continued beyond the abandonment of Mapungubwe at AD 1290, followed by a small-scale settlement between AD 1310 - 1415, and lastly, a dry phase post AD 1450 with a resettlement of the area (Smith *et al.* 2007).

The above results indicate that it is not 100 % correct to assume that wet and warm conditions equate with agropastoral success and cold and dry conditions with agropastoral failure (Smith *et al.* 2007). It is prudent therefore to observe different factors when determining the cause behind societal success and destruction. Such factors include an anthropological approach in determining the ability of a society to manipulate its environment positively as well as the benefits of social and trade networking for each specific group. Climate will affect the environment directly; it is the relationship between the environment and each individual society that is far more complex.

Great Zimbabwe is situated towards the east and along the southeast escarpment, where the amount of rain is generally more favourable to farming communities as it benefits agricultural production (Holmgren and Öberg 2006: 189). Population growth occurred between AD 1400 – 1420 when conditions were starting to get warmer and wetter which would have aided in agricultural production. It is believed that communities expanded from Zimbabwe into parts of the Kalahari and agriculture, gold and ivory trade were valuable attributes to the contribution of wealth accumulation in growing centres (Parsons 1993). Based on this account, it is possible to conclude that favourable temperatures often result in increased affluence in societies. This in turn may result in an increase in trade and other social networking which may further benefit the society and as a result aid in preventing complete societal collapse during unfavourable temperatures.

Expansion of the farming communities into the previously unoccupied Highveld grasslands began in the sixteenth century. In examining all the above data, it is evident that during this time the temperature peaked at its highest. The Makapansgat speleothems showed an average increase of 3 °C higher than present conditions and the *Breonadia salicina* trees showed a phase of strong growth between 1440 and 1520. The LFC expansion then accelerated after approximately 1640 AD during an interlude of slight amelioration in Little Ice Age conditions (Tyson 2002). Between these two phases, the *Breonadia salicina* and the *Podocarpus falcatus* trees indicate that a severe drought phase was experienced between about 1520 and 1560, otherwise generally warmer, wetter conditions were experienced leading up to the acceleration point of population increase on the escarpment. The adoption of maize as a crop allowed for the expansion of habitable areas as it could withstand shorter growing seasons and colder conditions (Maggs 1984). Following the cessation of the Little Ice Age, it appears that in many cases the change in climatic conditions was further followed by periods of prosperity or famine (Maggs 1984). This depended on the social networking ability of a society and its ability to trade in order to avoid collapse. Below (Table 4.1) is an outline of climatic changes in Southern Africa.

Table 4.1 Broad outline of climatic changes over the last 1000 years. After Tyson *et al.* 2000.

	Temperature	Available Moisture
1800	warm	wet
1750	average	slightly dry
1700	cool	very dry
1650	average	average
1600	cool	dry
1550	cool	above average
1500	cool	slightly dry
1450	cool	average
1400	average	above average
1350	cool	average
1300	high	above average
1250	high	above average
1200	average	dry
1150	warm	wet
1100	warm	wet
1050	high	slightly dry
1000	average	wet

4.4 Conclusion

By analysing and contrasting the climatic variation and the patterns that occur within the meteorological record with the speleothem and dendrochronological data for the same time period it is evident that an obvious and significant correlation occurs. It can thus be concluded that the data acquired for the period before the meteorological record is valid. Therefore, it is feasible that the major wet and dry spells presented above had a direct effect on the LFC of the Mpumalanga escarpment. It must, however, be noted that the Mpumalanga escarpment has its own unique climate, and although these general climate reconstructions can be applied as a guide for climate patterns throughout the area, this should be performed with caution. Current climate data of the escarpment and areas to the east and west are observed to note differences in micro climate. The data correlated in this chapter are also used to establish the links of the archaeological chain that intricately bind society to climate, vegetation and disease.

Chapter Five

The Role of Disease in a Site Location

5.1 Introduction

There are a number of diseases that have swept over the north-eastern part of South Africa during the past 500 years. This chapter will observe only malaria and nagana or sleeping sickness (caused by the tsetse fly) as these were the most severe and probably the most influential at the time. The distribution and environmental conditions that cause malaria and nagana/sleeping sickness to prevail in and around Mpumalanga are observed.

Not much data relating to disease distribution before 1900 exists, but it is possible to observe where some of the infected areas were and what general malaria traits existed over the last century from the limited records that are available. A comparison between the distribution of diseases and the climate data maps reveals the interactive trends that exist between the two as well as the disease hot spots. Existing climate data of the past 500 years can thus be employed to assume that the peaks and troughs of temperature will correlate directly with disease distribution.

Research on malaria in the Northern Transvaal has been conducted by Rees (1992). She used a wide collection of resources relating to malaria in the area, including the records of the Native Affairs Department, reports and accounts of missionaries at Elim Hospital, reports of the Contagious Disease Commission of 1906 and the annual reports of the Swiss missionaries. Rees also mentions the difficulty with obtaining any specific and useable information on malaria before 1906.

5.2 European Reports of Disease

Europeans began settling in the higher parts of the Eastern Transvaal in the mid-1800s and it is from their accounts that information about disease in the area can

be garnered. They avoided the lower elevation areas of what is now Mpumalanga, in the north and east, as these areas were difficult to access and lay within the tsetse and malaria belts (Packard 2001). Boers who settled in the northern and eastern lowland areas of the Transvaal in the 1840s were reported to have suffered from fever deaths and were forced to move to higher areas (Packard 2001). This provides evidence of the distribution of disease in the area. The LFC would have been subjected to the same environmental conditions and diseases, thus resulting in their choice of location.

The trade routes were regarded as extremely dangerous when considering the risk of deadly diseases. A trek group led by Louis Trichardt to Lourenço Marques in 1837 ended in the deaths of most of the settlers due to fever (Packard 2001). This was due to both malaria and nagana as discussed below.

Boers in the Eastern Transvaal (Mpumalanga) in general wanted to trade with the Portuguese at Delagoa Bay as it was markedly closer than the British ports of Durban or Port Elizabeth. However, the Mpumalanga trade routes to Mozambique were hazardous for the settlers and their livestock as the routes passed through belts infested with tsetse fly, thereby resulting in the loss of herds, a valuable trade commodity. The traders themselves were at high risk of contracting malaria (Delius and Hay 2009). These reports of the difficulties faced by the Boers when living in the area affirm that the area is susceptible to diseases and therefore would have influenced the LFC in the same area over the last 500 years.

5.3 Malaria

Packard claims that the role of malaria in the development of pre-colonial societies in the Lowveld is unclear (2001: 595). According to oral sources consulted by Packard, malaria was a new disease when it was first reported in the region in the 1890s. However, the Europeans who travelled in the area during the middle of the nineteenth century state that malaria was present in the Lowveld at that time and probably occurred there for decades previously (Packard 2001). This

is the most widely accepted notion and can be held true due to accounts of "fever" earlier in the 1800s, such as those reported by Louis Trichardt.

In 1843, the European settlers tried to occupy the Ohrigstad valley. In the first summer after their arrival a few settlers died from fever and over the following two years fever deaths increased dramatically, so much so that in 1848 the settlers abandoned the valley and moved to the Lydenburg area (Packard 2001). Settlers who attempted to establish communities at Schoemansdal in Limpopo were also affected by fever and the community was severely weakened. Although Lydenburg was not fever free in the 1840s, the number of fever deaths was much lower than in the Lowveld regions (Packard 2001).

During the 1910s the Barberton and Nelspruit areas, where settlers had begun agricultural endeavours along the river valleys, were reported to have cases of malaria (Packard 2001). During this time, the Lowveld area gained the reputation of being a "white man's grave", further showing the extent of malaria in the area.

Malaria endemics in the agricultural sector were observed to be at a high during 1920 and 1923 and again in the 1930s and 1940s (Packard 2001) (see Figure 5.1). Table 5.1 below presents malaria reports for the wider region:

5.3.1 A Brief Description of Malaria

Malaria is transmitted by the *Anophelene* mosquito. There are three main malaria transmitting mosquito subspecies in southern Africa. *An. funestus* which breeds in streams and is most abundant after rainy seasons; *An. gambiae* which has larval stages and is found in open sunlit pools, varying from freshwater to high salinity; and *An. Arabiensis,* which occurs in the dry areas of tropical Africa and is the main vector in the Mpumalanga Province. A vector is a bearer or host of a disease that transmits the pathogen to another species or organism (Gullan and Cranston 2005). This last subspecies is less anthropophilic (associated with humans) and more exophilic (outdoor loving) (De Meillon 1931, 1934, Govere 2000). The parasite protists that cause malaria are sporozoans belonging to the genus *Plasmodium. P. Falciparum.* These are the main sources of malaria in southern

Africa and are limited in their distribution by a minimum 20 °C isotherm (Gullan and Cranston 2005).

Table 5.1

Year	Malaria Reports
1905	Severe Malaria epidemic (*Anopheles gambiae)* occurred in Durban during summer (Hill and Haydon 1905).
1910	Outbreak in northern KwaZulu-Natal (Le Sueur *et al.* 1993).
1915	Worst ever outbreak reported in the Northern Transvaal (Rees 1992).
1920	Malaria epidemic in KwaZulu Natal radiating from St. Lucia (Govere 2000) and severe in Northern Transvaal (Rees 1992).
1922	Mild outbreak in Northern Transvaal (Rees 1992).
1926	Heavy outbreak at Umfolozi Co-operative sugar mill following importation of labourers (Swellengrebel 1931).
1928	Severe outbreak in KwaZulu Natal, Northern Province and Mpumalanga (Swellengrebel 1931, Rees 1992).
1932	One of the worst epidemics on record occurred in KwaZulu Natal (Govere 2000) but mild in Northern Transvaal.
1935	Extensive epidemic occurred stretching from Limpopo River south to Pongola (Govere 2000).
1937	Outbreak in the northern part of the country, extending as far south as Pretoria and west to Rustenburg (Govere 2000).
1967	Severe outbreak following heavy rains after six years of drought (De Meillon 1986).

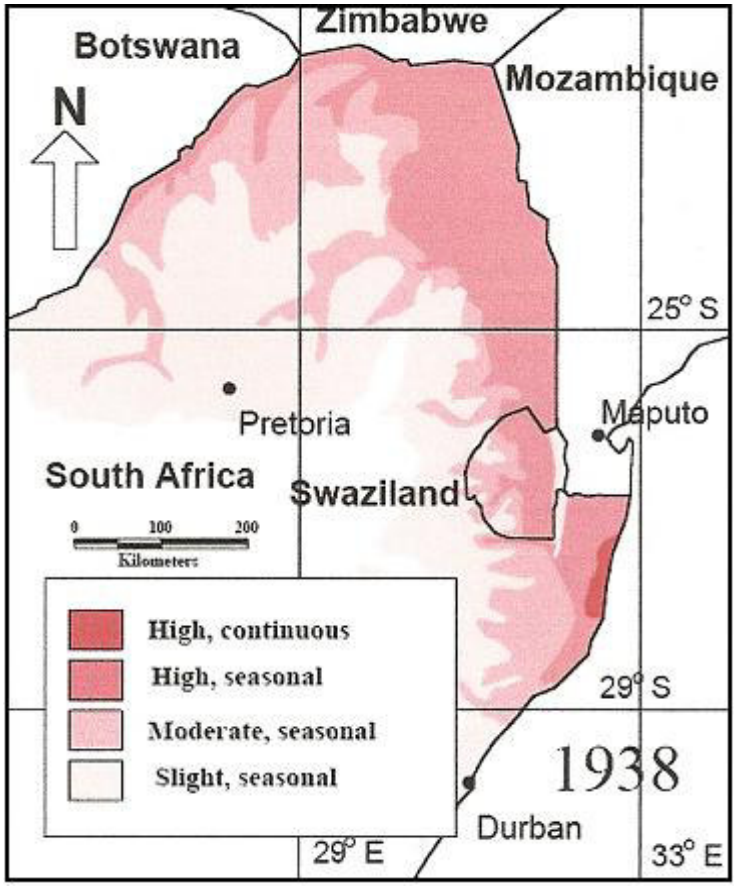


Figure 5.1: Malaria distribution before prevention control (1938) (After Le Sueur *et al.* 1993).

The most important factors that govern malaria epidemiology, prevalence and transmission are season, rainfall, humidity, temperature changes and altitude (Govere 2000, Martin and Lefebvre 1995, Strebel *et al.* 1988). By applying current knowledge of the conditions and rules necessary for malaria transmission to the past 500 years and by using historical climate data the effects of malaria on the LFC can be determined.

Temperature affects the survival of parasites during their life cycle in the *Anopheles* vector. The shortest development cycle takes place during temperatures ranging between 27 °C and 31°C, while lower temperatures lengthen the cycle. The minimum duration of the cycle doubles with temperatures below 19 °C for *P. falciparum* (Martin and Lefebvre 1995), which will result in less breeding and therefore less transmission. Temperature affects the vectoral capacity of the

Anopheles equally*;* its favourable temperatures being between 22 °C and 30 °C, whereas higher temperatures will shorten the aquatic life cycle from 20 to 7 days. Rainfall can either provide more breeding places or destroy them by washing out breeding sites (Martin and Lefebvre 1995). To survive, *Anopheles* mosquitoes need a minimum level of between 50 % 60 % relative humidity. Higher levels of humidity will lengthen their life span, enabling them to infect more people (Martin and Lefebvre 1995).

Due to the local climate, the number of malaria transmissions follow a distinctly seasonal pattern as vector mosquitoes need a minimum of 50 % 60 % Relative Humidity (RH) and temperatures between 22 °C and 30 °C for ideal malaria transmission conditions (Govere 2000). On the Highveld, lower temperatures during winter inhibit parasite development. During July to September the average temperatures are low and the dry conditions restrict mosquito biting activity and breeding success, thereby reducing the number of malaria cases (Govere 2000). High temperatures with dry conditions are equally unfavourable for mosquito survival and breeding success which will therefore result in low levels of transmission. The transmission of malaria peaks during the period from January to May owing to the favourable state of ground cover in the Lowveld and the rain during this period creates puddles which result in more breeding sites. Mosquitoes favour high humidity for their survival; however, these conditions need to continue for twelve consecutive days for the malaria parasite to develop to the stage where it can start transmitting. Therefore, mosquito breeding and transmission levels can only reach their ultimate capacity during extended periods of high relative humidity, such as in the summer months (Govere 2000).

Altitude also has a significant impact on malaria. The prevalence of malaria in the Lowveld decreases from east to west in direct relation to the higher altitude. The highest prevalence is in the east, at an altitude below 600 m in elevation, and then decreases towards the west, which is at an altitude above 600 m in elevation (Govere 2000). The said author describes malaria as mesoendemic and unstable below 600 m in the Lowveld region and absent in the Highveld regions above

600 m. Only in seasons particularly favouring malaria transmission has there been any evidence of malaria above 600 m ASL.

5.4 Distribution of the Tsetse Fly

There is limited information available on the role of nagana prior to European settlement. In 1923 Fuller conducted an historical review of the tsetse fly distribution in the Transvaal since 1836. In his research Fuller (1923) found that both the Voortrekkers and the English hunters encountered tsetse flies on crossing the Limpopo River on their way north past the junction with the Marico River. Fuller (1923) mentions that Louis Trichardt was one of the few settlers who recorded his encounters with the tsetse fly; however he did not specifically indicate the location. In studying the diary of Trichardt, Fuller found that in 1837 Trichardt and his company were dissuaded by the locals from moving east from the Zoutpansberg district to trade with the Portuguese on account of the prevalence of tsetse fly on the Massouw (Klein Letaba) River. Trichardt also mentions encounters with the tsetse fly on a tributary of the Zand River beyond the Zoutpan and along the Olifants River. Further entries in Trichardt's journal mention that the local population along the foothills of the mountains in the region where the Blyde River enters the Olifants River were unable to keep cattle due to the abundance of tsetse fly in the area (Fuller 1923).

Fynney (1878) conducted research on the geographical and economic features of the former Transvaal in 1878. He asserts that many parts of the former Transvaal district and the Waterberg were infested with tsetse fly; however, he concluded that "many parts which six years ago were known as fly country, are now entirely free, and therefore it may be fairly hoped that the extinction of this pest is only a matter of time" (Fynney 1878: 21).

Fuller mentions that Andreas Duvenage, who had been living in the area around 1871, reported to know a safe track through the tsetse fly infested areas between Blaauwberg and Zoutpansberg. Up to the year 1897 tsetse fly belts occurred from north to south between the Drakensberg on the west and the Lebombo on the east.

These areas are also believed to have been affected severely by the appearance of rinderpest which killed the tsetse host animals (Fuller 1923). Figure 5.2 below presents a map (Fuller 1923) showing the distribution of the tsetse or Nagana Zone in the former Transvaal and the effects of rinderpest. From this historical map it is evident that the entire escarpment where the terraced sites used to be are free of tsetse fly, and this was due to a second limiting factor on tsetse flies, namely altitude, which is discussed below.

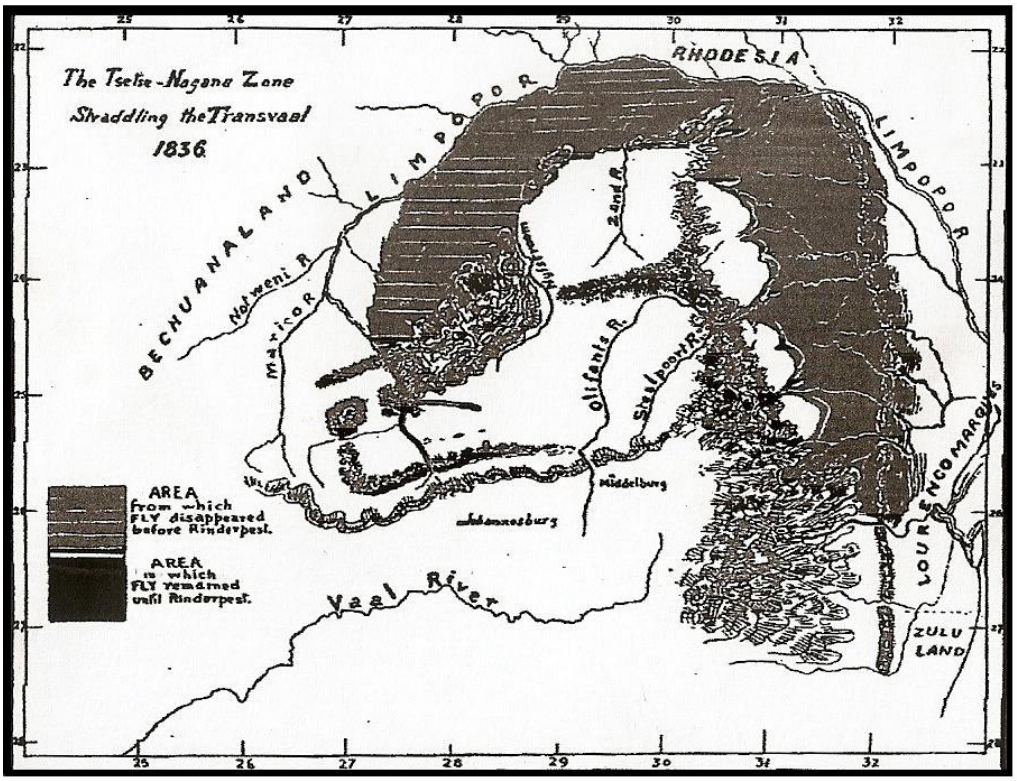


Figure 5.2: The Nagana Zone in the Transvaal, after Fuller 1923.

By the 1890s the Swazi settlements had extended north of the current Swaziland border and westward along the Crocodile River (Packard 2001). These areas, in particular the lower parts of the region including the flats of the Komati Ward, were previously largely avoided in general and therefore remained uninhabited, due to the presence of tsetse flies and trypanosomiasis. Most settlements were located in river valleys associated with major rivers such as the Crocodile, the Komati and the Lomati as they provided easy access to water for cattle and rich alluvial soils for agriculture (Packard 2001).

According to Wint (2008), the southernmost dispersion of tsetse flies did not extend beyond the Umbeluzi River, east of the Lebombo mountain range. Close examination reveals that the definite historical distributions also extended to the Mozambican coast, although the distribution of flies did not include a narrow strip along the Lebombo Range (Wint 2008); this is also probably due to the effects of altitude.

Glasgow (1963) notes that the early European travellers to Africa soon learnt to recognise certain types of vegetation as tsetse fly belts, which needed to be avoided. They also understood that within a circumscribed area one could identify certain types of vegetation with certain species of fly. Tsetse flies require specific vegetation as discussed below.

5.4.1 A Brief Description of Tsetse

The tsetse fly which occurs in South Africa belongs to the group *Glossina morsitans.* Its distribution is indicated by the term "fly-belt" as this species is usually confined to quite definite tracts which are often of limited extent (Austen 1911). Environmental components that are essential to the survival of *G. morsitans* include extensive plant cover; this can be in the form of trees with thick undergrowth, open thickets or scattered shady trees. *G. morsitans,* like all other species of tsetse fly, are never found on the open sunlit veld (Austen 1911). The general distribution of *G. morsitans* appears to occur on river banks and in riverine thickets along a water course (Austen 1911, Glasgow 1963). *G. morsitans* has been found out of sight of water in open grassland, but in close proximity as they cannot survive without water (Austen 1911, Glasgow 1963).

Temperature also affects the development of the fly. *Glossina* favours a temperature range of approximately 22°C to 24°C. Temperatures from above 33 °C and below 14 °C prevent the puparia from completing their development. Relative humidity can vary; however, RH below 40 % causes heavy mortality during pupation (Austen 1911).

The effect of altitude on the fly has also created some debate as it appears that the fly is seldom found above an altitude of 3000ft (914.4 m) in southern Africa;

however, it has been found between 5000ft and 5500ft (1524-1676.4 m) in Zimbabwe and the Congo on rare occasions (Austen 1911). Glasgow (1963) also points out that certain generalisations can be drawn when discerning the location of tsetse flies. These include that tsetse flies can only occur below their altitude limit which is a maximum of 6000ft (1828.8 m) at the equator and which decreases as the latitude increases. Secondly, that all tsetse flies live in some kind of woodlands and that any species of *Glossina* can be destroyed by replacing woodlands with grass (no higher than a man's waist). Tsetse flies are reliant on woodlands as they require shade for their puparia and therefore for the adult, a complete absence of trees would result in death by insolation.

Tsetse fly distribution is also closely associated with the course of the rivers as well as the distribution of wildlife and domestic livestock. Climate affects the distribution of wildlife and during a drought less game will occur. This in turn will affect tsetse fly distribution because if there are no hosts, the tsetse fly cannot survive.

5.5 Impact on LFC

Without records of the distribution of malaria and nagana it is difficult to determine the relationships between the LFC and these diseases. Packard (2001) theorises that the LFC had possibly adapted to the presence of malaria by building their homesteads on higher ground, thereby avoiding malaria breeding areas, as well as generally abandoning the locations that were affected by fever. This would have drastically reduced the impact of these diseases. A second possibility suggested by Packard is that the local populations could have developed an immunity to malaria, considering their long history of occupation in the area (Packard 2001). With nagana in general it can be assumed that the high altitude, dense population or high cultivation would limit the range of the tsetse fly (Wint 2008). These are significant points when attempting to better understand the relationship between the LFC and diseases as the terraced sites appear to be out of the range of the tsetse fly. This relationship may be better observed in the creation of a detailed map of the area, this is presented in chapter 7.

It appears that the LFC terraced sites on the Mpumalanga escarpment are situated in areas that would have been free of both diseases. This conclusion can be drawn due to two factors. The first being the evidence provided by the early records of where the diseases existed. The second being the analysis of the environmental conditions that were required by the disease carrying hosts. The tsetse fly needs woodland areas, which are found at a lower elevation than the majority of the terraced areas. Furthermore, woodlands are not suitable for the cultivation of crops and accordingly, the areas that are cultivated become unsuitable for the tsetse fly. Malaria should not occur 600 m above mean sea level as the malaria pathogen cannot survive in this altitude; however climatic differences may slightly affect this range but not to a large extent. Incorporating all this information into a GIS will help to visualise these past conditions and advance an understanding of the LFC interaction with their environment.

Chapter Six

Methodology

The research utilises Geographic Information Systems (GIS) to integrate various data over an area of the Mpumalanga Escarpment. This collection of information can be used to draw conclusions as to the likely motivation for the location of stone walled sites. The GIS software packages employed for this research include Google Earth 6.1.0, Quantum GIS 1.8.0 (QGIS) and ArcGIS version 10.1

6.1 Data Collection

In order to determine possible reasons for the location of stone walled sites a number of factors need to be taken into consideration and information about each factor needs to be gathered. These factors include the following:

Table 6.1

Data Required	Description	Data Sources
Defined research area	The exact area of concern	Topographic maps
Site locations	Longitude, latitude and altitude of each site located	Google Earth
Vegetation and soil	The ability of the land to produce crops and grazing for livestock	ESRI shape files
Geology	Applies to land utilisation and possible mining potential	ESRI shape files. Detailed geologic maps
Access to water	Water is a valuable asset for the human and animal population	ESRI shape files.
Climate	Highly significant in site location, observation of current and paleo-climates	ESRI shape files. South African Weather Service. Paleo-climate research.
Disease	Affecting human and livestock populations	SRTM 90m DEM acquired from the Climate Research Group (CRG) at the University of the Witwatersrand for the entire South African region. Fuller (1923), Sandeman (1975).
Trade	To what extent it influenced site location	De Vaal (1984)
Digital Elevation Data (DEM)	This data is used for a variety of processes	SRTM 90m resolution acquired from the Climate Research Group (CRG) at the University of the Witwatersrand. ASTER DEM (30m resolution) acquired on line (http:\\reverb.echo.nasa.gov)

Each point is discussed in greater detail below. This includes how the data was sourced, the process of incorporating it into a GIS and a description of the GIS applications and procedures that were used. The projection that was used is GCS WGS84 (EPSG 4326).

6.2 Data Preparation

6.2.1 Research Area

The literature pertaining to the Iron Age repeatedly mentions the high density of sites occurring between Lydenburg and Carolina and therefore this area constituted an important part of the search area. As the terraced sites occur only on the escarpment this area was selected. In order to search this extensive area the parameters needed to be defined in order to create a structural layout. This step is essential to ensure that the entire selected area was searched for all possible sites and that no areas would be overlooked.

For the purpose of this thesis two areas were observed. The first area is that of the entire escarpment. In this case, sites were observed on a general level. This process was necessary in order to observe general patterns of distribution of archaeological sites. The second area is much smaller. This area was selected based on previous work conducted by Evers (1975) and to compare previous research with the current research in order to observe whether Google Earth presented the same clusters of sites as those that Evers (1975) presented. In the case of the latter, a new typology was created based on the Google Earth observation of sites.

A polygon was placed over both areas of concern in order to create a perimeter boundary. The first area was selected through visual analysis of a topographic map. This was accomplished by using a topographic map of the area and visually selecting the area of higher altitude (see Figure 6.1). The second area was selected by importing a scanned image of the distribution map of Iron Age sites that Evers (1975) drew in

the immediate vicinity of Lydenburg. The semi transparent image was subsequently stretched over the area of Lydenburg, essentially matching features on the Evers (1975) map with the features on the satellite image accessed from Google Earth. Once the map was placed correctly, a polygon was placed around the selected area (see Figure 6.2).

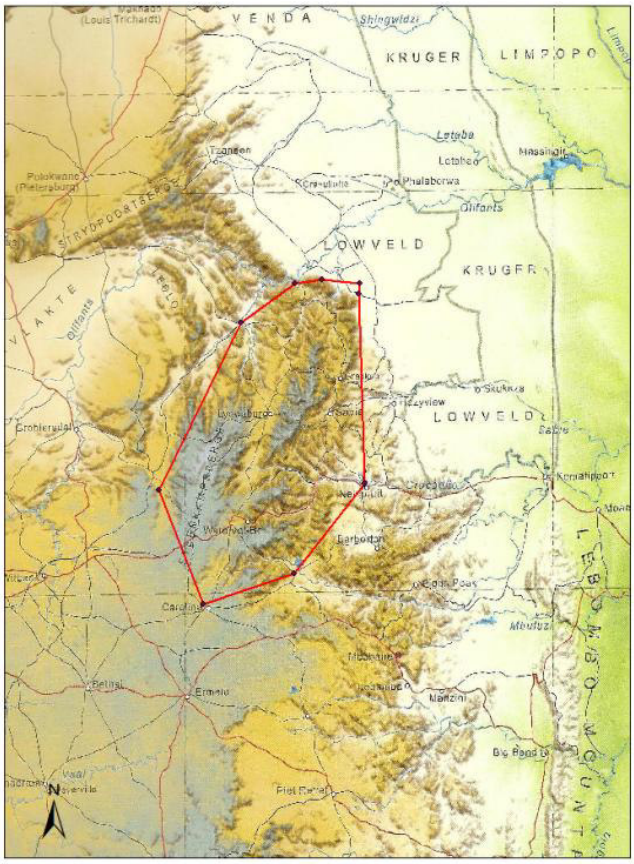


Figure 6.1: The Mpumalanga escarpment with a polygon defining the research area

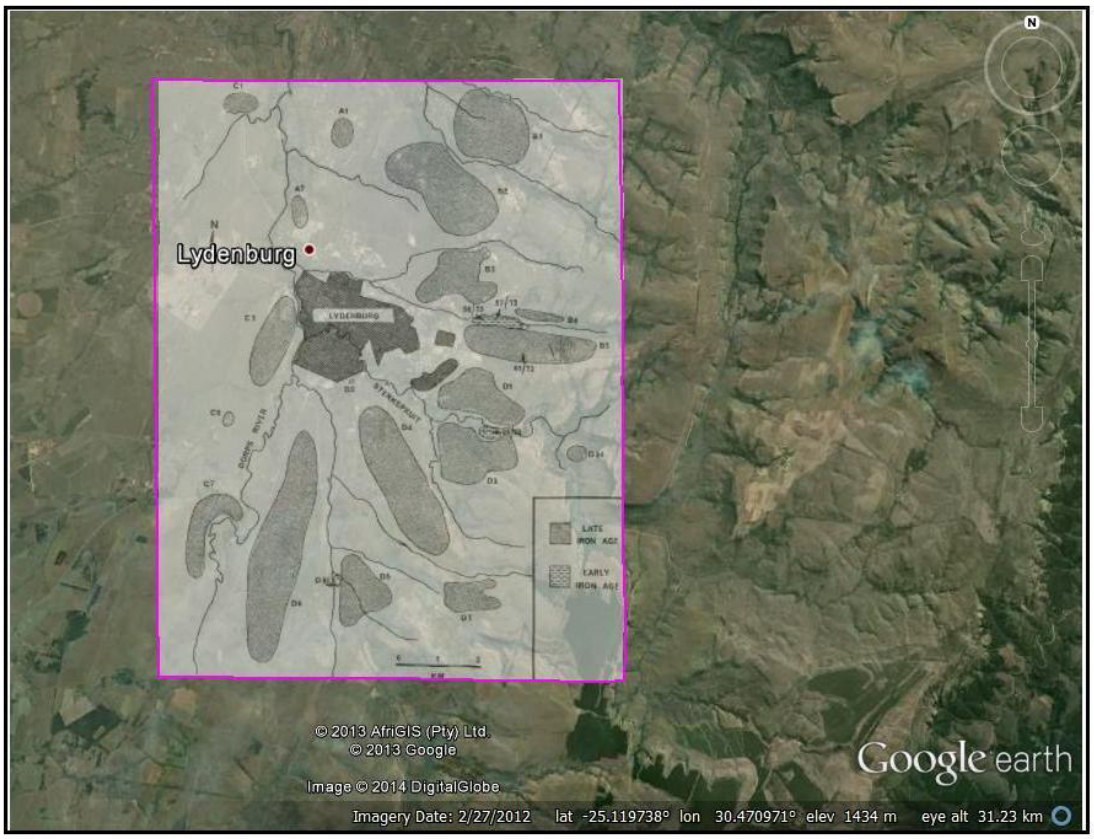


Figure 6.2: Evers (1975:77) Distribution of Iron Age sites in the immediate vicinity of Lydenburg, with polygon defining research area (Google Earth maps).

6.2.2 Locating Stonewalled Sites

Google Earth has extensive satellite imagery of the entire globe. The Mpumalanga escarpment has a reliable spatial resolution which allows for a visual examination of stonewalled sites. As Google Earth was the software used to locate the sites, the polygons defining both selected areas were constructed within it.

The second step for the larger area was to divide this massive area (1676 Km²) into subsections that would be easier to search intensively. The area was divided into 11 subsections. The polygon method was employed (see Figure 6.3).

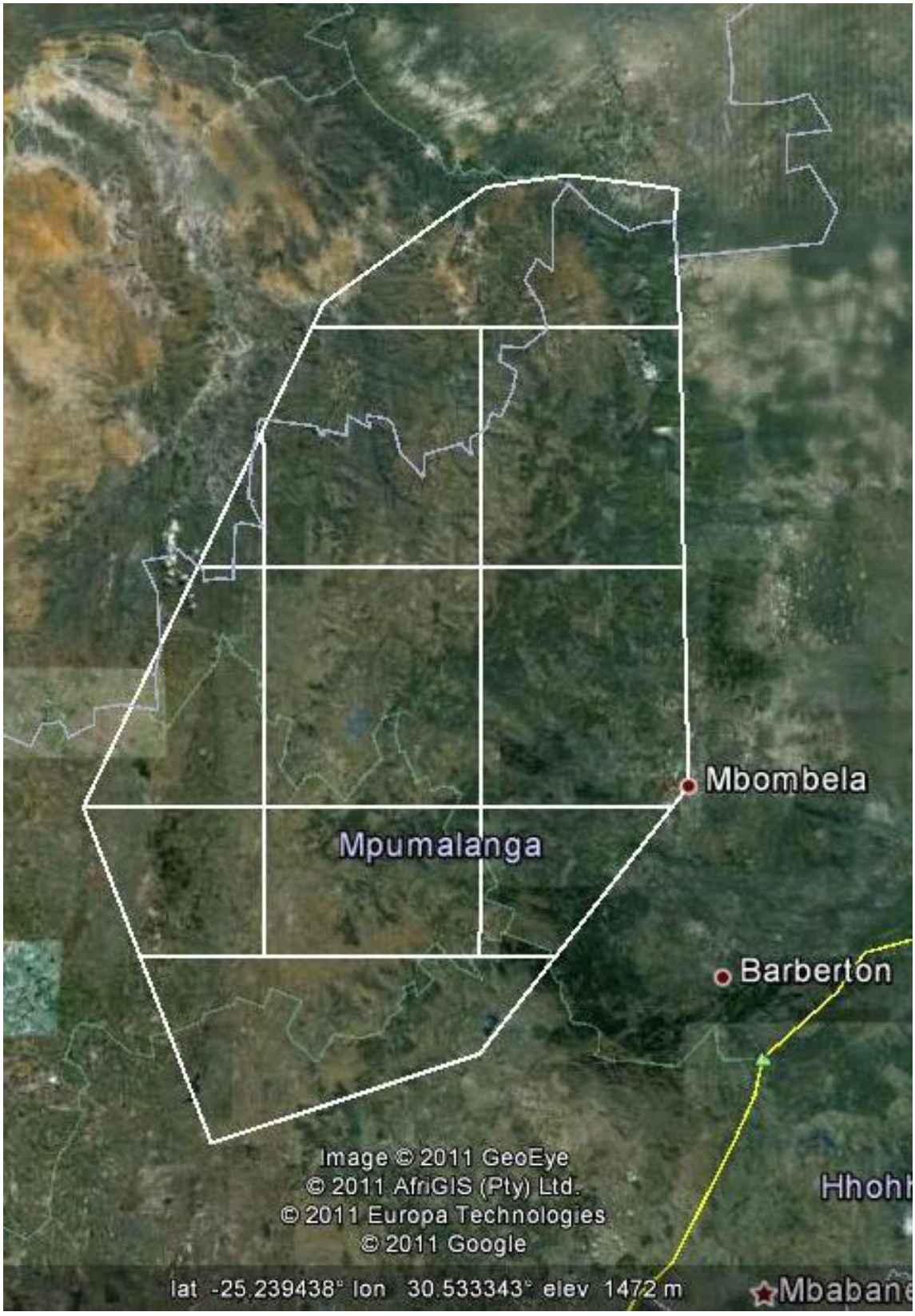


Figure 6.3: Google Earth image, showing the 11 subsections within the polygon.

Each subsection was divided within the whole with the use of Google Earth's "grid". This sequence of grid lines aids in searching for sites the grid lines allows one to follow the horizontal lines through each subsection. By placing "placemarks" at the start and end of each horizontal line within each subsection a record can be kept regarding which areas have been searched (see Figure 6.4). Folders were created for each subsection's placemarks in order to facilitate organisation at a later stage as a large number of placemarks were used.



Figure 6.4: Google Earth image with grid lines present at a spatial resolution of 278m. Yellow "placemarks" represent the start of the search on that specific grid line which would occur at the left side of one of the 11 subsections within the research area polygon..

When any group of sites was located they were marked separately. A folder was created for the occurrences of terraced site locations per subsection and another folder was created for all other sites per subsection. Each point was given a numeric label. It is important to note that sites were not recorded by marking each individual structure; rather, each cluster was marked. Different placemarks were used for terraced and non-terraced sites (see Figure 6.5).

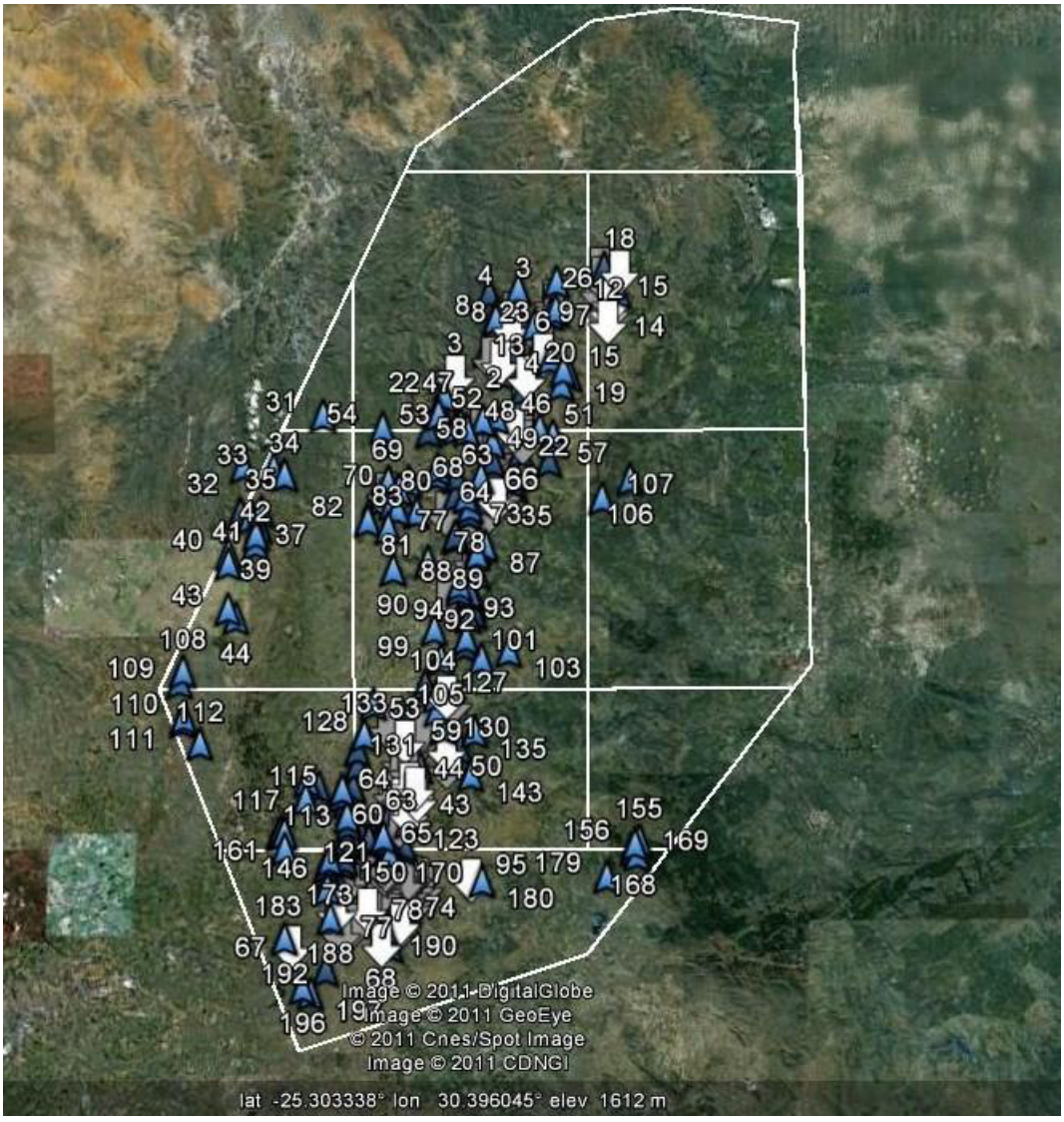


Figure 6.5: Google Earth image of the research area showing placemarks representing the position of terraced sites (white arrows) and all other site clusters (blue arrows) with their numeric values

Once all the site locations had been recorded in Google earth, the Latitude, Longitude and altitude of each location were recorded in a Microsoft Excel spreadsheet.

The above process was employed for the terraced sites as well as the non-terraced sites that were located. In this case, the levels of complexity of the non-terraced sites were also included in the spread sheet. Three types of descriptions (simple, complex and very complex) in accordance with those of Evers (1975) and terraced sites were included. While this typology was used to observe the larger area, a different typology was used for the smaller area as discussed in greater detail below. This process will aid in the analysis of distribution patterns.

Once all the sites were recorded in this manner, the document was saved as a Text (Tab delimited) document. This process was necessary if the sites are to be imported into ArcMap or QGIS.

The smaller area of concern was observed in greater detail. As mentioned above, the grid system was used to navigate across the area in an organised manner in order to locate any sites. In this case however every single unit that was located was recorded.

Each single unit was digitised and a polygon was created around it, which aided in observing trends in the size of the area of each unit and trends in distribution patterns. A total of 871 sites were located and 345 areas of terracing. Every unit was observed carefully and a new typology of sites was created according to the features that each unit possessed. The terracing around these sites was recorded with the placemarks plotted systematically throughout the area of terracing. Two types of were observed. The running lines of walls (Figure 6.15) and shorter clusters of walls (Figure 6.16) also described by Type F (see Figure 6.11). This step aided in the observation of site locations and their types in relation to the presence of terraces.

The types that were created are:

- Type A: Single circular structure
- Type B: Circular structure with inner and outer walls

- Type C: Circular structure with any number of structures within the outer circular wall that is greater than one
- Type D: Flower shaped structure with no outer perimeter wall
- Type E: Circular structure with “pockets” of smaller structures attached within or alongside the perimeter wall
- Type F: Circular structure with complex arrangement within the perimeter walls (Possible enclosed terracing)
- Type G: Three concentric walls
- Type H: Random anomalies, possible Boer war adaptations to structures
- Type I: Circular outer wall with random display of smaller circular structures.



Figure 6.6: Type A



Figure 6.7: Type B



Figure 6.8: Type C



Figure 6.9: Type D



Figure 6.10: Type E



Figure 6.11: Type F



Figure 6.12: Type G



Figure 6.13: Type H



Figure 6.14: Type I



Figure 6.15: Terracing type A



Figure 6.16: Terracing type B

6.2.2.1 Placing site data into ArcMap and QGIS

The point site locations were imported into ArcMap and QGIS from the text documents that were created. The sites are displayed as point layer files. The polygon files were saved as KML files and imported into ArcMap as shape files.

6.2.2.2 Site analysis

Once the sites were recorded in the area defined by Evers (1975) they were further analysed. First the area of the individual sites was observed to gain an understanding of the size range of the sites. Second the site types and their distribution in relation to the terraces was analysed. In this case a 150 m buffer was created around the terraced sites to observe which site type occur in close range of the two types of terracing. Finally, a cluster analysis was performed in order to test if sites are distributed randomly, regularly or clustered. The cluster analysis selected was the kernel density analysis.

6.2.3 Vegetation and Soil Maps

The subsequent layers added to the map were those of vegetation soil potential, soil depth and clay composition in the area. The said maps were imported as vector shape files into QGIS. The attribute tables of the above mentioned and of site-types were combined in order to observe which type of sites are located on what soil or vegetation type and to observe any possible trends.

6.2.4 Geology Maps

Geology maps were used to determine potential for agriculture as well as potential for mining valuable minerals in the area. The ESRI shape file was imported into QGIS. Attribute tables were joined in the same manner as mentioned above. The second series of maps were three separate maps of the escarpment area. These maps were used as they are slightly more detailed than the former. These three areas included 2430

Pilgrim's Rest, 2530 Barberton and 2630 Mbabane. These were georeferenced on receipt.

6.2.5 Climate

Climate is exceptionally difficult for archaeologists to map as the complexities of climate are not fully understood. Climate exerts a significant impact on site location as it influences a variety of environmental factors such as vegetation and disease. For the purpose of this research only very general climate conditions will be observed.

In order to map climate in the Mpumalanga escarpment area several ESRI climate shape files were imported into QGIS. The shape files attribute tables were joined in order to obtain one attribute table with all relevant climate information. This attribute table was subsequently added to the attribute table of all the stone-walled sites in order to observe the general climate trends around each of the structures.

The second attempt to map climate was by comparing an extreme wet year on record with an extreme dry year on record, that is, 2000 and 1992 respectively. Station data for the following weather stations around Mpumalanga were requested from the South African Weather Service.

These stations were selected on account of their being spread out across the Mpumalanga area and that more than just rainfall data were recorded. These include maximum and minimum temperatures, maximum and minimum rainfall and relative humidity. However, not all the stations were able to provide data for the year 1992.

The data acquired was plotted into ArcMap in the same manner as the site coordinates. Excel spreadsheets were created for weather station locations, maximum temperature yearly average 1992 and 2000, minimum temperature yearly average 1992 and 2000, rainfall yearly average 1992 and 2000 and relative humidity yearly average 1992 and 2000. As with the site coordinates, these spreadsheets were all saved as text documents and subsequently imported into ArcMap.

Table 6.2 Requested stations around Mpumalanga

Station Name	Province	Latitude	Longitude	Height
OUDESTAD	MPUMALANGA	-25.18	29.33	953
LYDENBURG	MPUMALANGA	-25.11	30.48	1,433
BETHAL	MPUMALANGA	-26.46	29.46	1,650
GRASKOP AWS	MPUMALANGA	-24.93	30.85	1,436
KOMATIDRAAI	MPUMALANGA	-25.52	31.9	183
ERMELO WO	MPUMALANGA	-26.5	29.98	1,774
CAROLINA	MPUMALANGA	-26.07	30.12	1,700
WITBANK	MPUMALANGA	-25.84	29.19	1,555
BELFAST	MPUMALANGA	-25.69	30.03	1,879
KRUGER MPUMALANGA INT. AIR.	MPUMALANGA	-25.39	31.1	865
MACHADODORP AWS	MPUMALANGA	-25.72	30.23	1,652
DELMAS VLAKPLAAS	MPUMALANGA	-26.24	28.78	1,593
GROOTVLEI	MPUMALANGA	-26.8	28.52	1,530
WITBANK STREHLA	MPUMALANGA	-26.21	28.91	1,573

Finally, climate data were used in order to observe differences in rainfall and temperature between the escarpment and the areas to the east and west. The stations that were selected were those which had recorded history for a longer term (Table 6.3 and 6.4). These include:

Table 6.3 Requested climate stations which have long term recorded history

Station Name	Province	Latitude	Longitude	Height
MIDDELBURG (w)	MPUMALANGA	-25.77	29.47	1,447
SKUKUZA (e)	MPUMALANGA	-24.98	31.6	263
OHRIGSTAD POL (esc)	MPUMALANGA	-24.75	30.55	1,166
MARBLE HALL (w)	MPUMALANGA	-24.98	29.28	915
TALAMATI (e)	MPUMALANGA	-24.55	31.55	358
NELSPRUIT (esc)	MPUMALANGA	-25.5	30.92	883
CAROLINA (esc)	MPUMALANGA	-26.07	30.12	1,700

Table 6.4 Rainfall, maximum temperature and minimum temperature of the selected stations

Stations east of the escarpment	RF Ave 1993-2010 mm/year	Max temp Ave 1993-2010 °C	Min temp Ave 1993-2010 °C
Talamati	448	29.39820125	14.35541248
Skukuza	328.5	no data	no data
Escarpment			
Origstad	473.4	no data	no data
Nelspruit	606.2	24.54690151	13.54305376
Carolina	660.6	22.16954657	8.556004902
Stations west of escarpment			
Marble Hall	481.3	28.64066925	14.12579316
Middleburg	500.8	no data	no data

Paleo data of the Mpumalanga area over the last five hundred years is a necessary factor to observe in order to gain a better understanding of the history of the area. There is at present no precise paleo-climate data for Mpumalanga specifically. Paleo-data from speleothems and tree rings elsewhere in South Africa are used. Chapter Four discusses the said data in detail. Dates and climate averages determined from paleo-data were collected and used alongside this data with the current trends as displayed above. The paleo-data (Table 6.5) are presented below:

Table 6.5 Paleo-climate data

Source	Warm wet phases	Dry cold phases
speleothems	late 15thC +3°C than present	
tree rings	17th and 18th C	14thC - mid 17thC
tree rings	1760-1780's	1860-1915
tree rings Limpopo	late 1400's	early 1400's
tree rings Limpopo	several occasions during 1600's	mid 1500's
tree rings Limpopo	1475-mid 1500's	mid 1700's
tree rings Limpopo	1700-1730's	early 1900's
tree rings Limpopo	1875	1475

tree rings Limpopo		1540
tree rings Limpopo		1575
tree rings Limpopo		1720
tree rings Limpopo		1850
tree rings Limpopo		1400
tree rings Limpopo		1450
tree rings Limpopo		1530
tree rings Limpopo		1650
tree rings Limpopo		1775
tree rings Limpopo		1850

6.2.6 Disease

As mentioned in Chapter Five, Malaria and Nagana are the two endemic diseases that this research has taken into account as influential factors on site location. With an understanding of the basic optimal conditions required for these diseases to thrive, it is possible to map their potential locations on the landscape.

6.2.6.1 Malaria

In order to map the locations where malaria is prevalent a Digital Elevation Model (DEM) is required. The SRTM 90m Resolution DEM was used in this case. Four SRTM 90m DEM images make up the region and these were loaded into ArcMap.

The next step is to make visible the areas of optimal altitude for malaria (600m above sea level (ASL)). The DEM data is imported a second time for manipulation. The data is re-imported for every new layer that is added. A classified image is thus created. The preferred altitude was accorded a 10m buffer on either side, therefore an area situated between 590 m and 610 m ASL was selected.

This altitude barrier however may not apply for the whole of South Africa. As a result, only the Mpumalanga escarpment and the area extending to the eastern coast line are taken into account. The other factor to consider is that 600m ASL is the present maximum altitude for malaria to exist, and climate change will affect this barrier.

Layers were created extending the barrier assuming that warmer wetter conditions could extend the altitude barrier for malaria to exist. Hence, 700m ASL, 800m ASL and the extreme 1200m ASL boundaries were created. These layers were defined in terms of two classes, namely all areas lower than the desired altitude and everything above the desired altitude. The reason for extending the layers only for assumed warmer wetter conditions is because these would increase the altitude of malaria distribution whereas cooler conditions would decrease the distribution. As the sites are situated at high altitude, cooler conditions are of no concern.

6.2.6.2 Nagana

In the same process as for Malaria a classified image was created. This time only two classes were defined at 0m - 920m ASL and 920-max ASL. As with Malaria an additional layer was created for warmer wetter conditions; this layer of the altitude of 1200m was considered to be an extreme extension of the tsetse belt. However, the vegetation would probably not be favourable at these altitudes and furthermore, Tsetse flies prefer cooler conditions.

Two other maps that were located showing traveller records of areas where the tsetse fly is prevalent (Fuller 1923), as mentioned in Chapter Five, and a second map (Sandeman 1975) were scanned and imported into ArcMap. The images were georeferenced assigned the coordinate system WGS84 (EPSG 4326).

Once both maps had been added as a layer, a polygon was drawn around the tsetse belt and a file with a new shape was created which portrays only the tsetse belt in order to use for further analysis.

6.2.7 Access to Water

This aspect is important to consider as water is essential to both human and animal survival. The ESRI shaped file of rivers in the area was loaded into QGIS. Once the data were imported a 1km buffer was added to the rivers. This process is carried out in

order to observe how many of the sites fall into a 1km range of water access. A shape file of natural features in the area was also used.

6.2.8 Trade

The last factor to be incorporated into the GIS analysis is that of trade. There is not yet any definite connection between site location and trade. It is unclear if the one influenced the development of the other or if they simply benefited from each other independently.

De Vaal (1984) provides a map portraying the trade routes through the area (see Figure 6.17). Although the quality is not very clear, the image was imported into ArcMap and georeferenced. A new shape file was created and the trade routes were digitised. This layer file was used to analyse the trade routes.

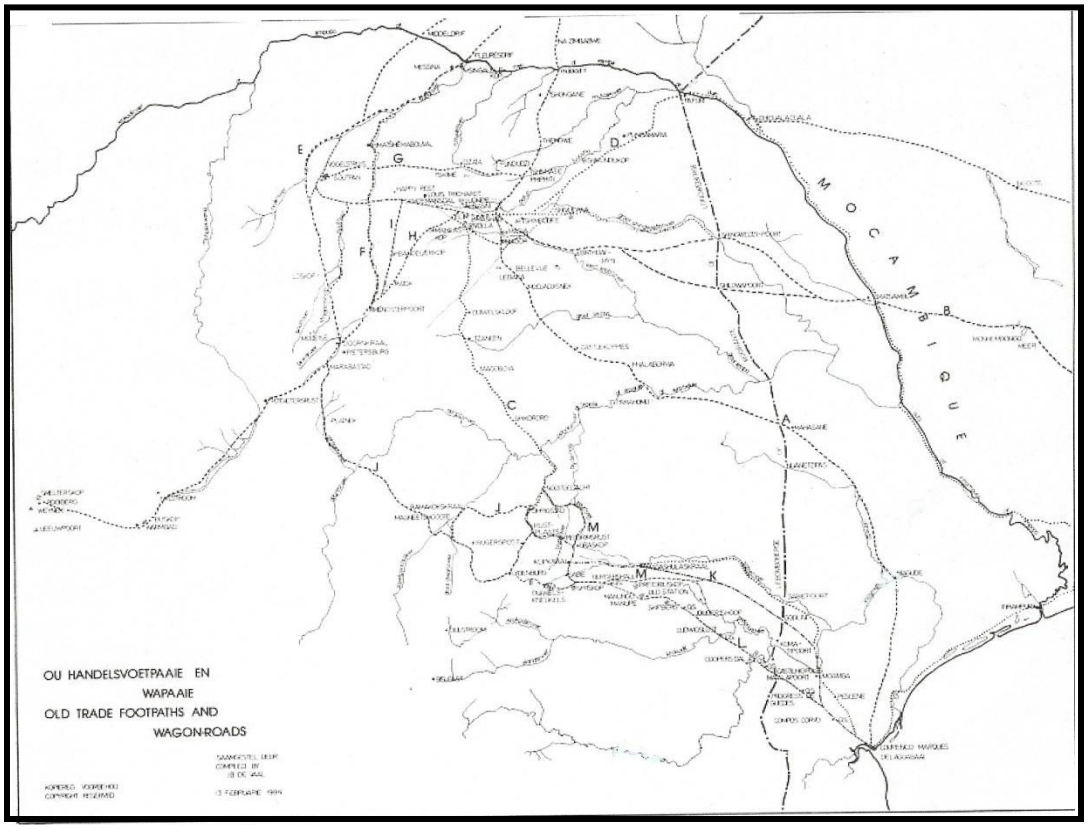


Figure 6.17: De Vaal (1984:6) Trade routes

6.3 Data Analysis using the created layers to determine site location

The next step was to overlay the different layers of information created to identify the reasons behind the location of the sites. This is performed by overlaying different factors simultaneously and observing if there is any pattern or common occurrence. Site location cannot be compared with any single factor. Multiple factors need to be integrated.

6.3.1 Agricultural potential

The ability of the land to produce sufficient food, or even surplus, is a vital aspect of site location for the LFC. However, certain LFCs could have existed in areas with poor agriculture if they had enjoyed a trade network which provided the necessary food. The first factor to take into account is an investigation into the capacity for agriculture on the Mpumalanga escarpment

Agriculture depends on a variety of factors:

- Soil type and geology
- Temperature
- Rainfall

} Determined in part by

- Altitude

Overlaying the above factors with the site locations will determine the viability of agricultural sustainability in the area. If the LFCs were farming maize, sorghum, beans or cucurbits, specific conditions are required.

a) Site maps are overlaid on soil type maps and geology maps in order to assess if these requirements are met.
b) Site maps are overlaid with vegetation maps to determine if the current vegetation could give more information about choice in site location.

c) The foodstuffs are dependent on a 21° C - 25°C average temperature, therefore the current weather data is overlaid to observe whether the wetter or drier years are more favourable to agriculture.
d) The sites are placed over the river buffer shape file to observe the proximity of the site to water.

6.3.2 Mining

The factor of mining may also have exerted some influence on the choice of site location. It is possible that metals may have been the attractive element. In order to determine if this is possible, the sites are overlaid on the geological maps.

6.3.3 Disease

Disease is dependent on:

- Altitude
- Temperature
- Rainfall
- Relative Humidity
- Vegetation.

a) The sites are overlaid on the created nagana and malaria maps mentioned above.
b) Each of the different altitude possibilities is used.
c) The climate data is subsequently added to these maps to see if a trend occurs.
d) The nagana map is overlaid on the vegetation data as nagana relies so heavily upon it.
e) The two nagana maps were overlaid on each other in order to observe if there was a change in the distribution of the diseases between 1836 and 1879.

6.3.4 Trade

The last possible influence on site location that this research looks into is that of trade. Trade most certainly occurred in the interior of the country; however, the extent to which it influenced the Mpumalanga terraced sites is unclear. The site maps were overlaid on the above mentioned route maps.

6.3.5 Least-Cost Paths

Terrain will affect the movement through a landscape. Using the DEM data it is possible to calculate possible routes through the landscape using the least cost tool in ArcMap. Three departure points were selected for the larger area in order to observe general possible movement in the region. These include departure from Delagoa Bay, Swaziland and Pretoria. The destination points varied throughout the area where the sites are positioned. The resulting routes that were calculated were compared with the trade routes according to De Vaal (1984). Similarly, least cost paths were constructed for the smaller area of concern. In this case two departure points were selected: Pretoria as a random point to observe if the route converges with De Vaal's route, and Louis Trichardt to observe if the least cost path will follow the trade route of De Vaal's description. In the case of the latter, a weighted overlay was used. DEM data was weighted with river locations and vegetation types. This process took place with the consideration of the tsetse distribution. As tsetse occurs in particular vegetation types and in river catchment areas, these areas would constitute a higher risk and therefore would have been avoided. This step was carried out because topography is not a primary determinant of route choices. The weights that were accorded were 50 % for slope terrain, 25 % for vegetation and 25 % for rivers.

6.3.6 Viewshed Analysis

Another factor that could make the escarpment a desirable location is the wide range of view that an elevated position could provide. This would be useful in a variety of ways including a defensive strategy or control over trade routes. Three viewshed analyses were conducted for the entire settled region. This was conducted by first creating three polyline shapefiles that run through the areas of site distribution (see Figure 6.18). The viewshed tool in the spatial analyst toolbox in ArcMap was used to calculate these data for each of the three polylines. The input DEM was the ASTER 90m DEM. An observer height of 1.7m above the surface was specified.

A second set of viewsheds was conducted for the smaller area of concern based on clusters of areas discussed below. In this case four viewshed analyses were peformed.

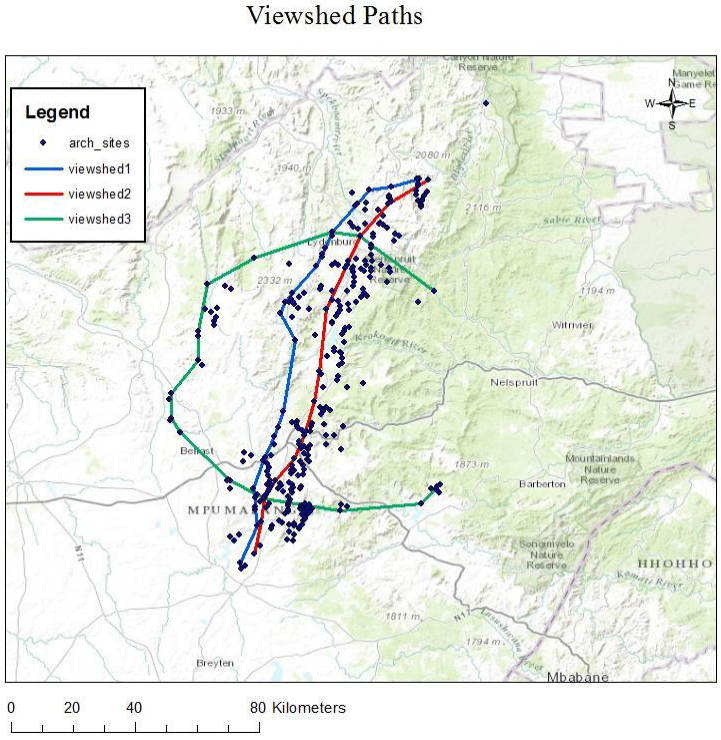


Figure 6.18: Polylines running through site locations.

6.3.7 Aspect

Aspect is the cardinal direction of the slant of the landscape on which structures are built. When concerning the stone walled sites, this is a valuable landscape feature to observe because it could be possible that particular aspects were chosen in order to maximise solar radiation. If the terraced sites are orientated towards a northerly aspect, this would offer evidence of advanced agricultural techniques as this aspect would provide additional warmth to the sites. Aspect data were acquired from the ASTER 90m DEM, using the aspect tool in ArcMap. The aspect data for each site were obtained by using the extract multivalues to points tool in the spatial analysis toolbox. The data were observed and plotted on a graph for further analysis.

6.3.8 Altitude

The ASTER DEM tiles of the area of concern were merged using the mosiac to new raster tool in ArcMap. The site-types were observed in relation to altitude by placing them on the DEM. The tool to extract multivalues to points in ArcMap was used to gather the altitude data for each site. This process is employed to determine whether if there is a trend in the site-type and altitude.

6.3.9 Slope

The ASTER DEM tiles of the area of concern were merged using the mosiac to new raster tool in ArcMap. Use of the new DEM created the slope tool was used to create a computer generated slope image. Sites were observed in relation to their slope.

6.4 Summary

In order to determine plausible reasons behind the location of the sites much information needs to be assessed and utilised. The data mentioned above will aid in further understanding the Mpumalanga sites as discussed in the following chapter.

Chapter Seven

Results

Based on the analysis of Chapter Six it becomes possible to determine in part, the environmental and political implications that would have exerted an influence on site location. Data were acquired from a variety of sources in order to better understand the conditions surrounding the Mpumalanga escarpment over the last 500 years. The data were incorporated into a GIS as explained in Chapter Six. This chapter examines the results of what the different created layers present.

The following five factors have been taken into consideration as likely key components in the selection of site locations by LFC along the Mpumalanga escarpment:

- Agricultural potential
- Access to surface level minerals suitable for mining
- Prevalence of disease
- Connection with trade routes
- Landscape features.

Equipped with multiple Geographic Information System layers, each factor will now be explored as to its relevance and extent of influence on site selection.

7.1 Agricultural Potential

Agricultural potential refers mainly to the ability of the LFC to produce maize, sorghum, cucurbits and legumes on the Mpumalanga escarpment. The ability to sustain cattle in this area is also observed. As discussed in the previous chapter, the site maps were overlaid with geology, soil, vegetation, access to water, climate and aspect maps in order to establish how suitable the land surrounding the sites was for cultivation and grazing given that conditions were similar to that of the present day.

7.1.1 Soils

The first factor under investigation was the capacity of the land to sustain agricultural production. Maize, sorghum, legumes and cucurbits were the most likely crops to have been produced in the area and all share similar optimal environmental conditions for growth (Smith 2005, Hadfield 2001, http://www.fao.org). These ideal conditions are shallow well-drained moderately fertile soils, rainfall at an average of 500 mm per growing season and average temperatures of between 20 °C and 27 °C as mentioned in Chapter Three. Soil depth, soil potential and clay content were observed to determine agricultural potential.

Clay content

On observing the content of clay present around the sites, it is evident that the majority of the sites occur where the content is between 15 % and 35 %. Clay components in soil provide many plant essential nutrients; however, they decrease drainage capacity. A clay content of about 15 % to 35 % in the soil is beneficial as this will provide nutrients and will not affect soil drainage (see figures 7.1, 7.2, 7.3 and 7.4).

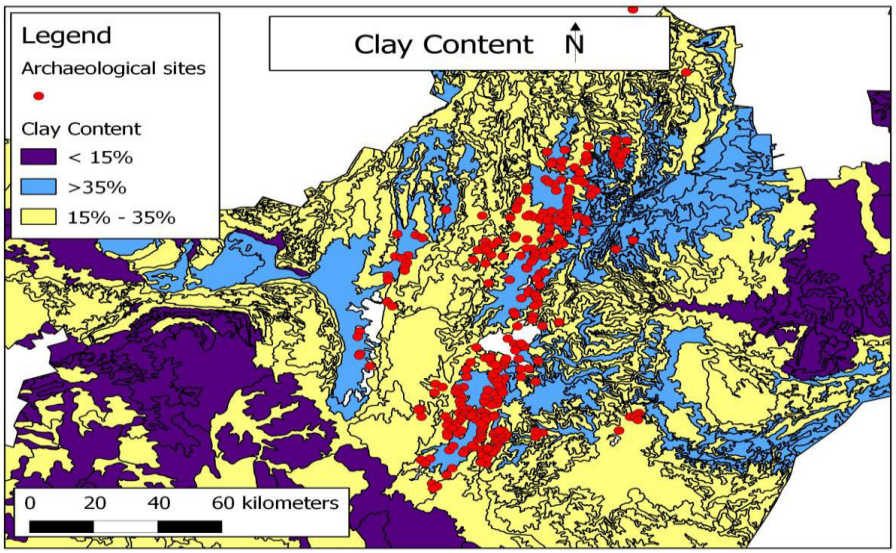


Figure 7.1: Sites over clay content in the Mpumalanga Region

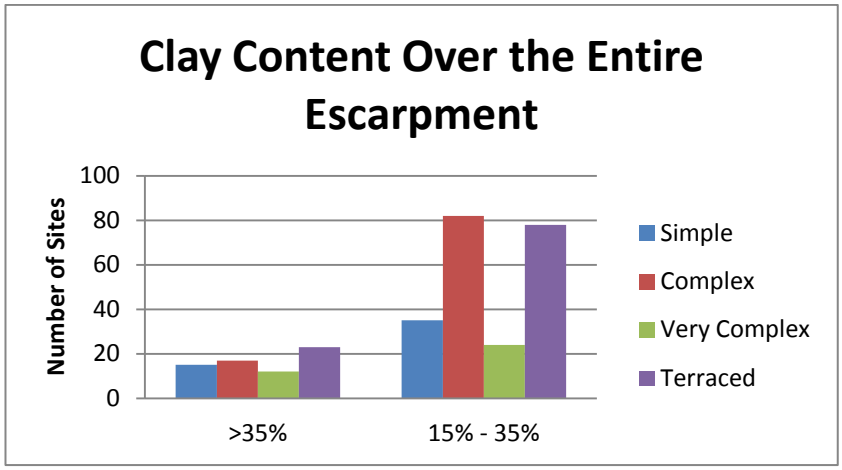


Figure 7.2: Majority of sites occur in the 15%-35% clay content range

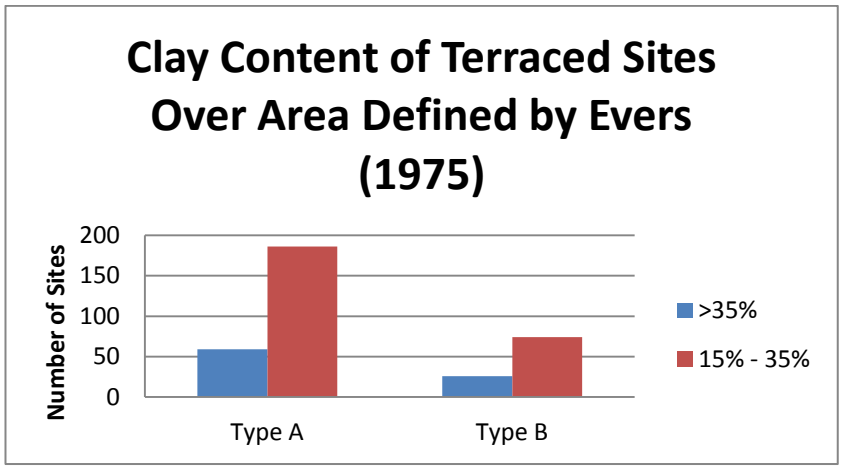


Figure 7.3: Majority of sites occur in the 15%-35% clay content range

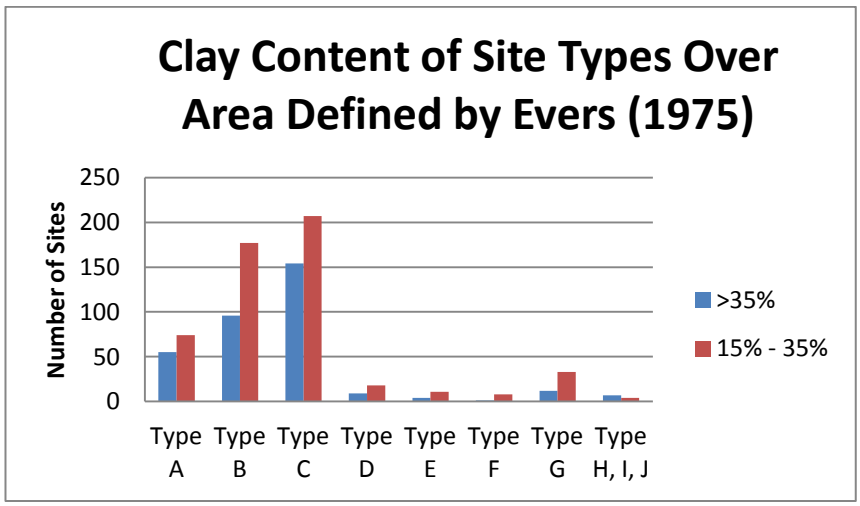


Figure 7.4: Majority of sites occur in the 15%-35% clay content range

Soil Depth

Sites are mostly established on soils with depths of less than 450 mm, with fewer sites on soil depths of 450 mm and 750 mm and almost no sites on soil depths of more than 750 mm. As the soil requirements for the above mentioned plants are shallow soils, the range of soil depth on which the sites are located will be adequate for agricultural production (see figures 7.5, 7.6, 7.7 and 7.8).

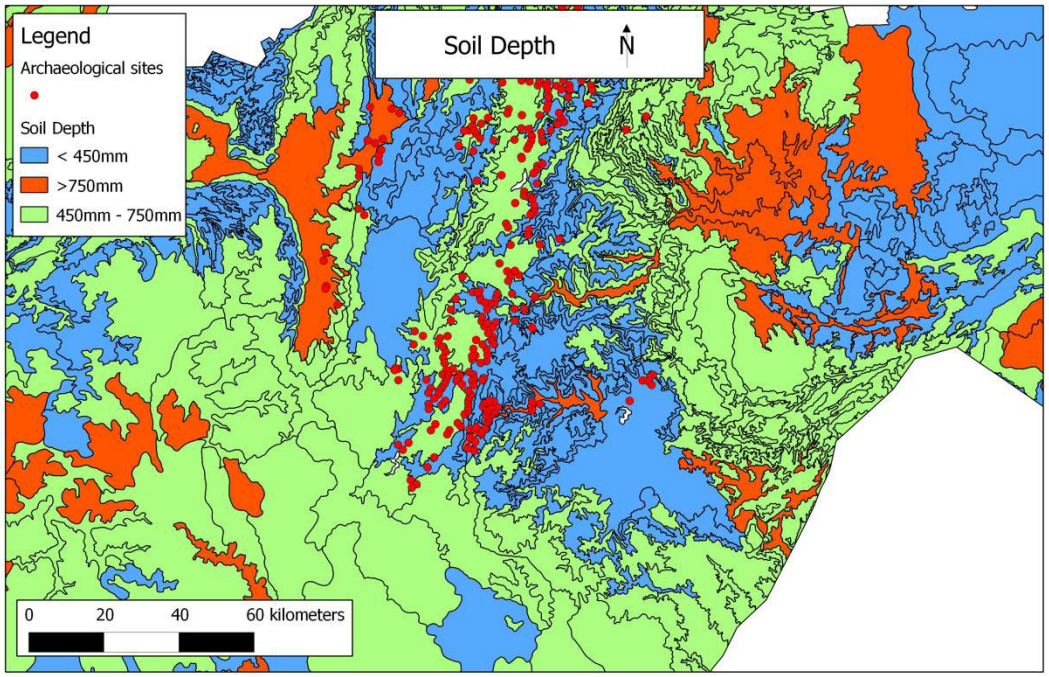


Figure 7.5: Sites over soil depth in the Mpumalanga Region

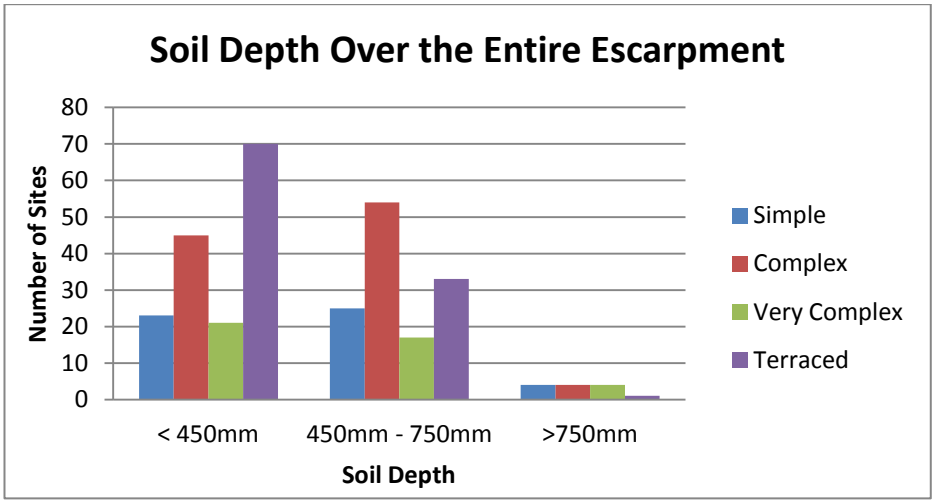


Figure 7.6: Sites range over soils with a depth of <450-750mm

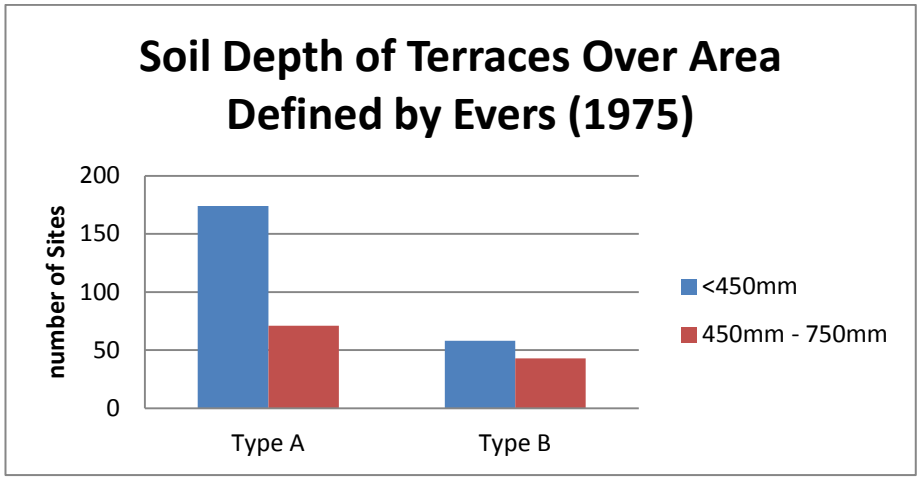


Figure 7.7: Sites range over soils with a depth of <450-750mm

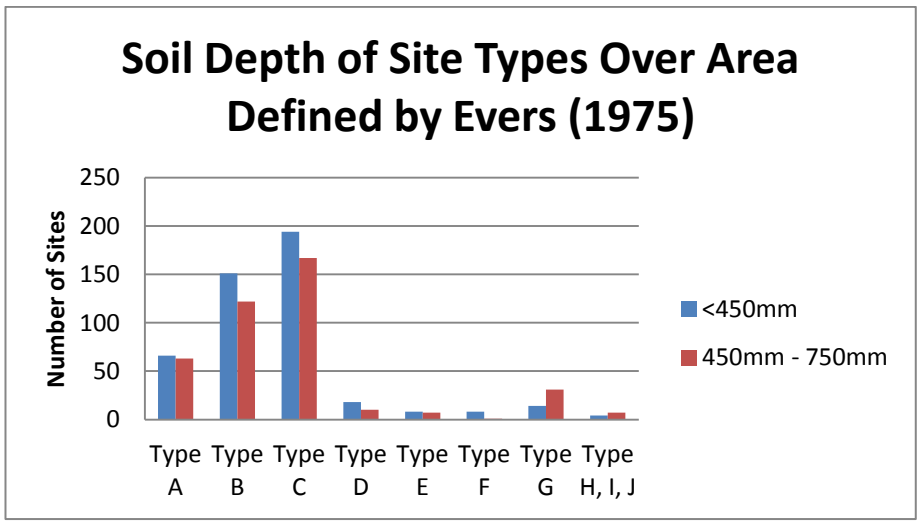


Figure 7.8: Sites range over soils with a depth of <450-750mm

Soil Potential

The majority of the sites fall into one of two ranges. These include soils not suitable for arable agriculture but suitable for forestry or grazing where climate permits, and soils of intermediate suitability for arable agriculture where climate permits. The distribution of these sites occurs throughout the escarpment region. These results provide evidence that agriculture and grazing of cattle were both probable on the Mpumalanga escarpment region (see figures 7.9, 7.10, 7.11 and 7.12).

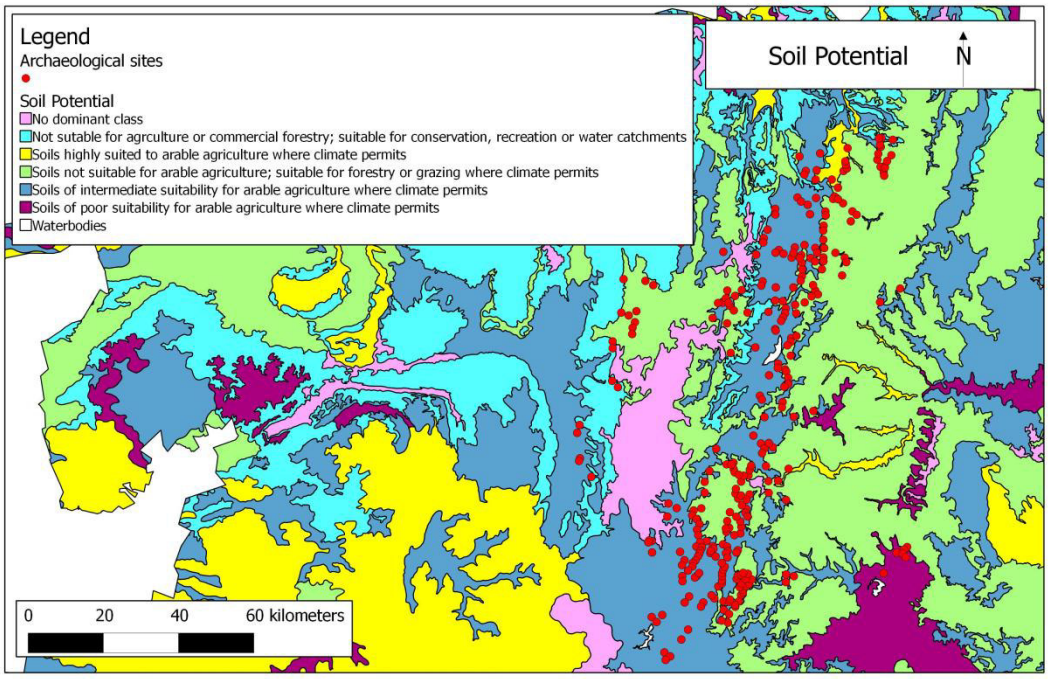


Figure 7.9: Soil potential of the areas on which the sites occur

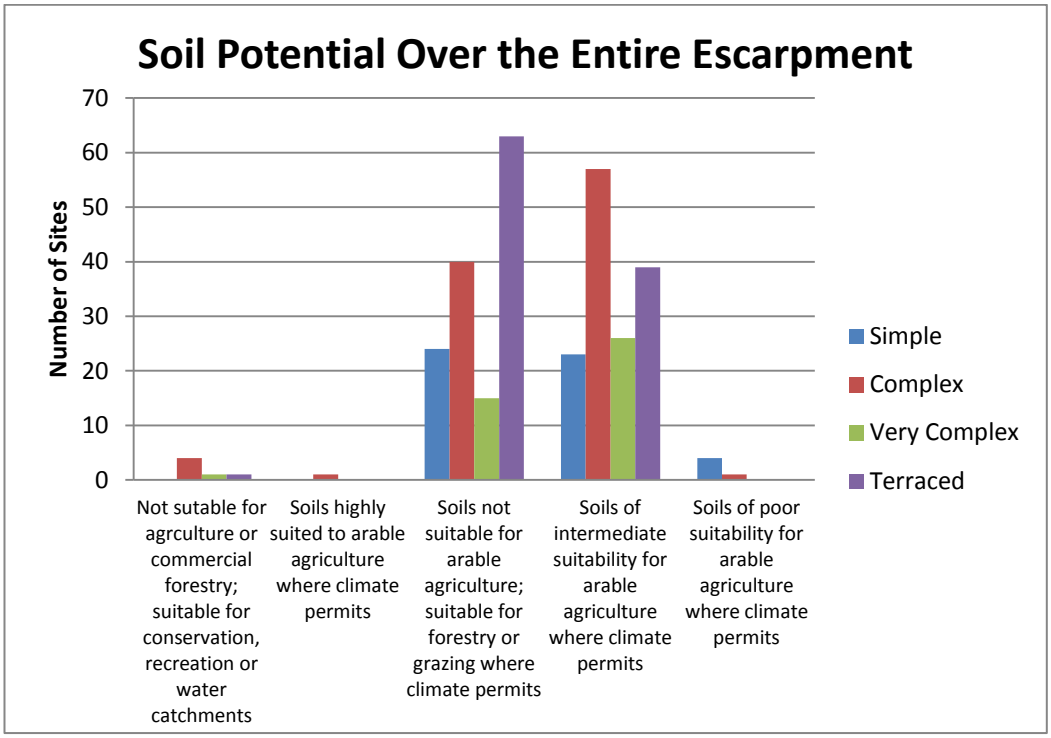


Figure 7.10: Majority of sites occur on soils suitable for agriculture or grazing

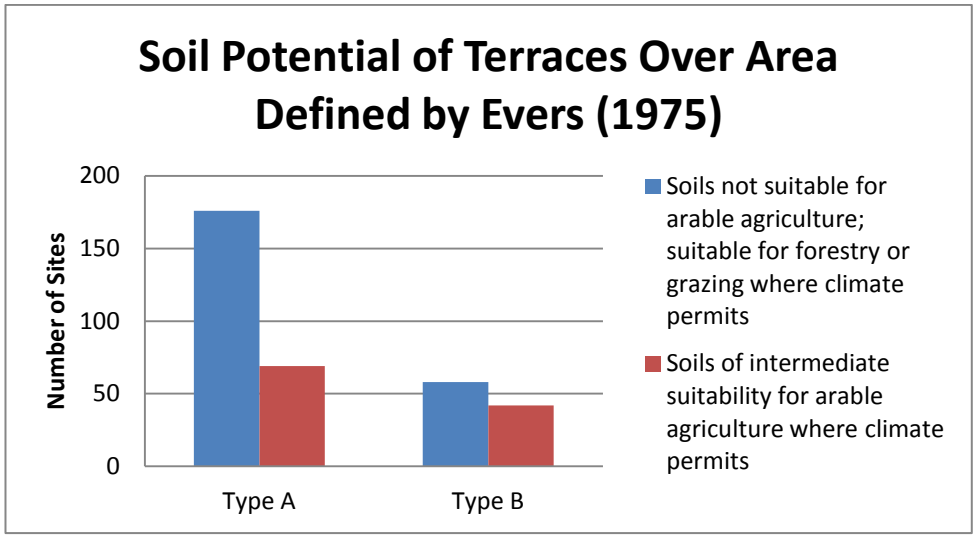


Figure 7.11: Majority of sites occur on soils suitable for agriculture or grazing

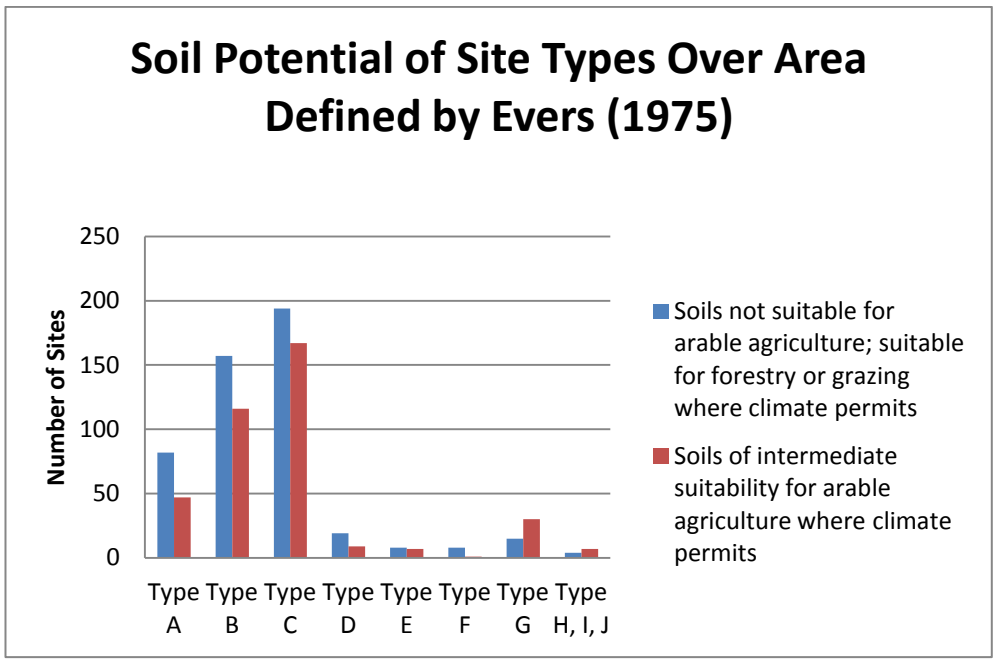


Figure 7.12: Majority of sites occur on soils suitable for agriculture or grazing

7.1.2 Grazing potential

Although this research is focused mainly on terracing, the potential to sustain large amounts of cattle on the Mpumalanga escarpment is also noted as cattle play a significant role in LFC economic and political systems.

Observations of the clay content, soil depth and soil potential suggests that the soils on the escarpment provide the necessary requirements for agriculture and grazing.

7.1.3 Access to Water

Site access to water is exceptionally important as water is essential to both human and livestock survival. The 1 km buffer zone around the rivers map showed very few of the sites within a 1 km radius (see figures 7.13 and 7.14). Proximity to natural features such as waterfalls was also observed (Figure 7.15). Only nine sites were in close range. It must be noted, however, that rain water and non-perennial water sources would have been utilised.

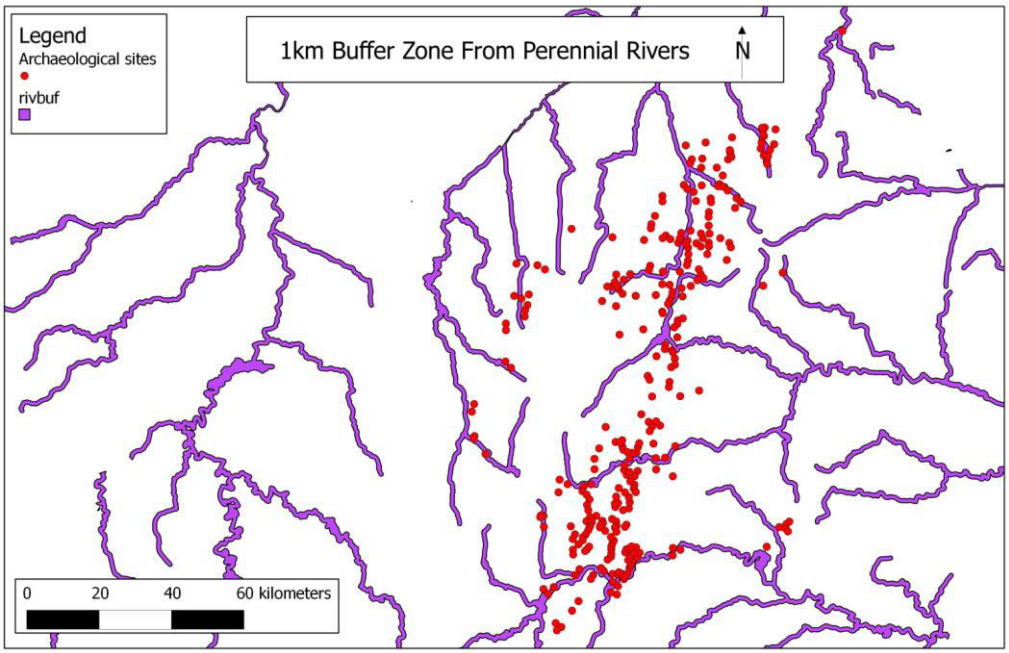


Figure 7.13: Sites located within a 1 km buffer zone of rivers

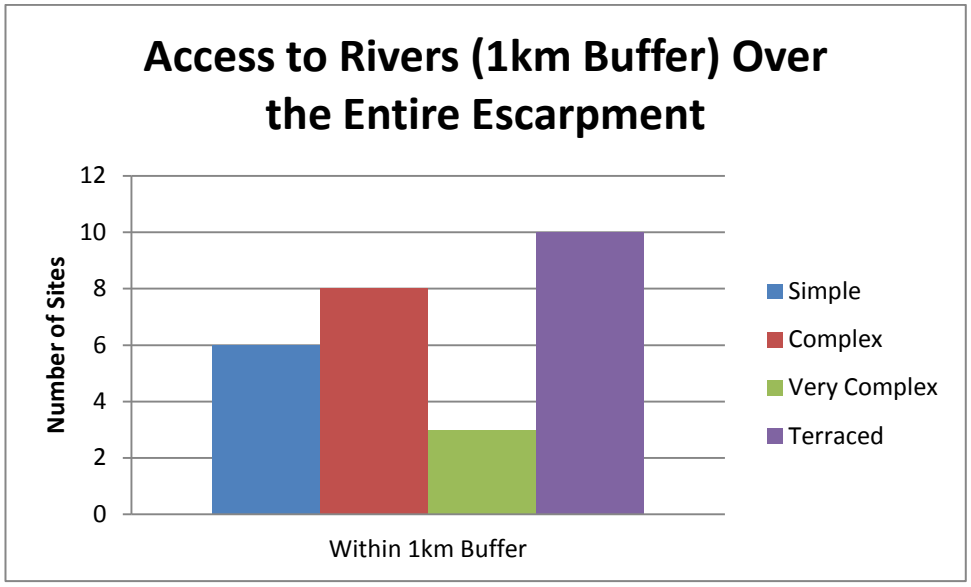


Figure 7.14: Number of sites that fall into a 1 km buffer zone around rivers

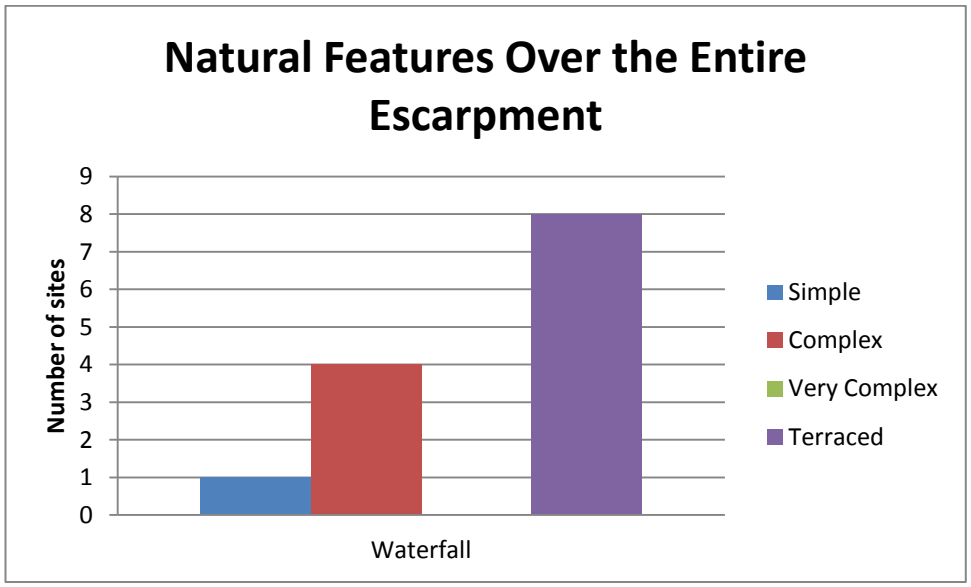


Figure 7.15: Number of sites in proximity to waterfalls

7.1.4 Aspect

The orientation of sites on different aspects was observed. From figures 7.16, 7.17, 7.18 and 7.19 it is evident that a trend existed where sites were situated in a southwest to northwest orientation with more sites occurring on western slopes. However, in general sites occurred sporadically across the region not favouring a specific orientation. Analysis of the terraced sites in relation to their orientation presents a trend to occur between south and north-western slopes. It is possible that sites were located more frequently on western slopes to avoid the impact of westerly winds; however, this aspect will need to be researched in greater detail in order to draw any definite conclusions.

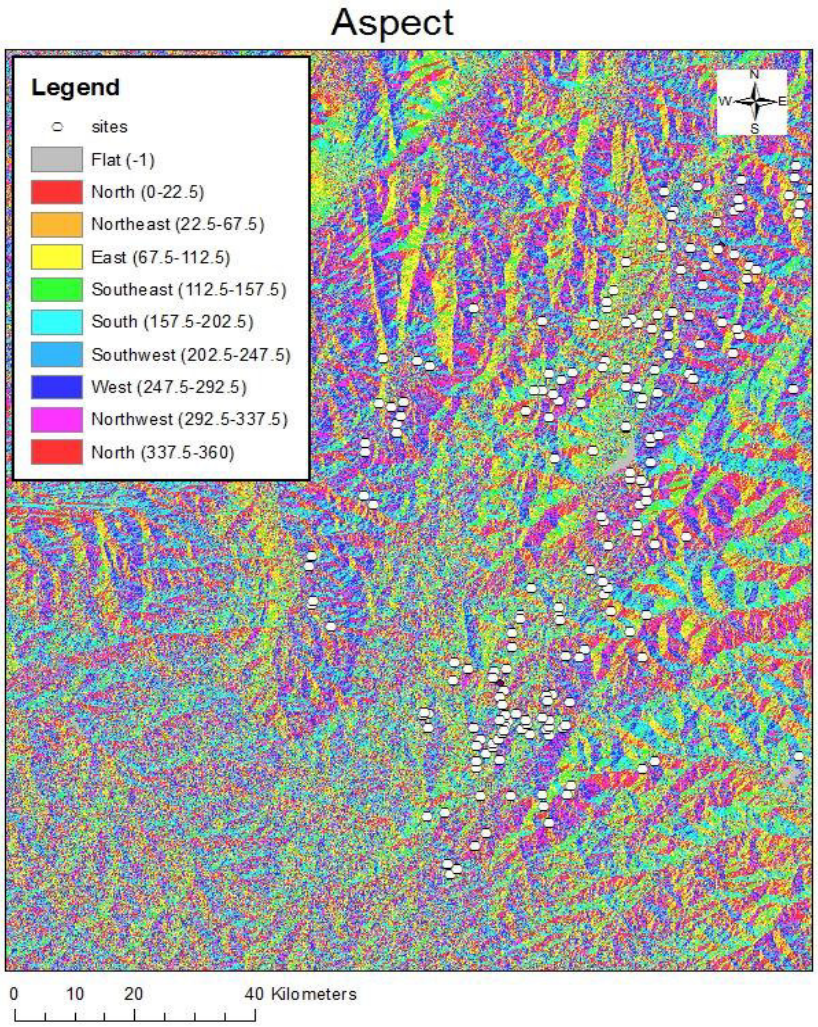


Figure 7.16: Sites distributed unevenly on different aspects over the escarpment

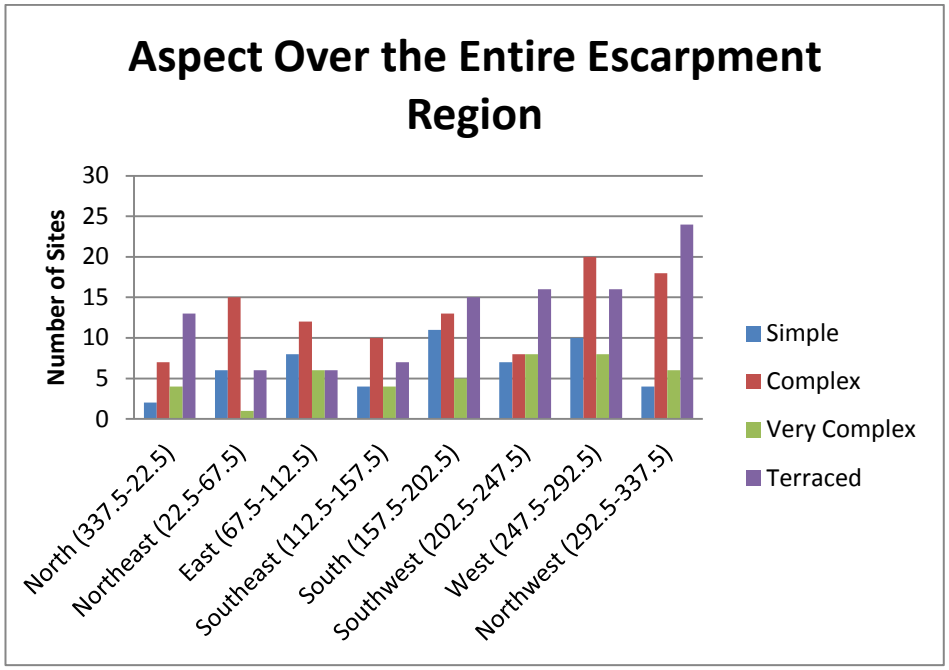


Figure 7.17: Number of sites on different aspects

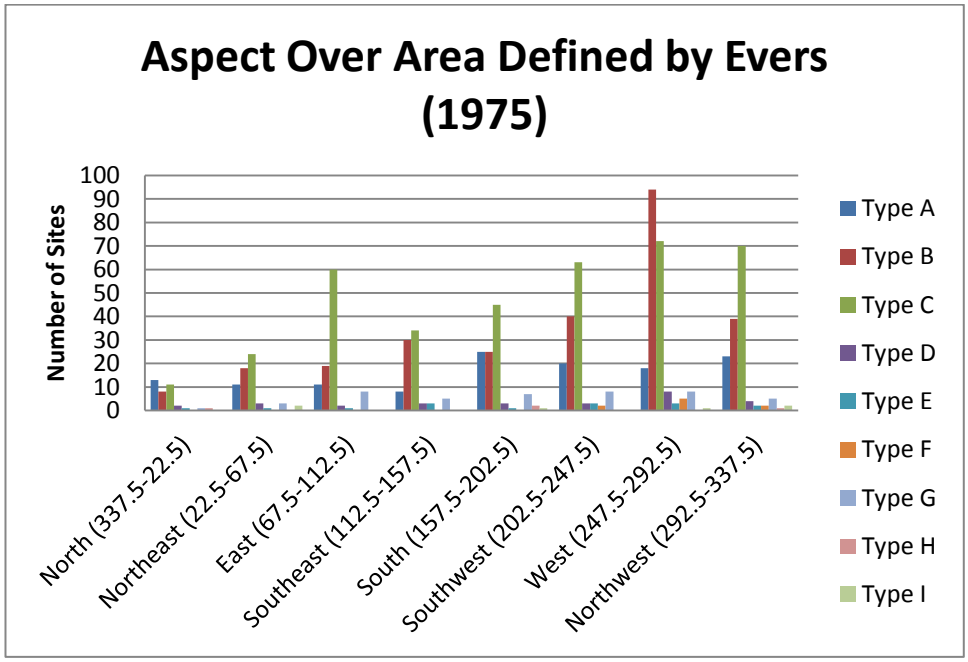


Figure 7.18: Number of sites types on different aspects

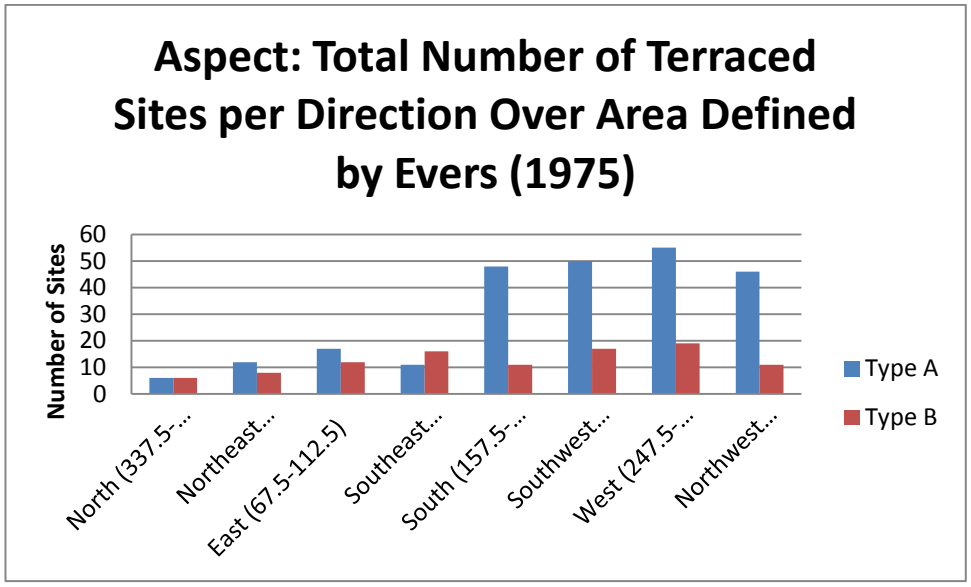


Figure 7.19: Number of terraced sites on different aspects

7.1.5 Geology

In regard to the geology of the area, it is evident that the sites fall predominantly over shale with a few sites falling over andesite and arenite (see figures 7.20, 7.21, 7.22 and 7.23). It is further evident that the sites predominantly follow the shale and arenite thus avoiding other geologic types on the landscape (Figure 7.20.) Shale areas represent well drained soils. And as Chapter Three mentioned, well drained soils result in leaching of other nutrients. In the case of Mpumalanga, leaching will minimise harmful magnesium levels which stunt plant growth. Andesite is a fine-grained intermediate rock (Cairncross 2004) whereas arenite is a form of sedimentary rock. It is likely that these areas may have been selected in order to use the rock for building stone walls and terraces. Type A terraces which exhibit extensive lengths definitely favour the arenite areas, which emphasises the use of this rock for extensive walling.

The geology of the area is thus favourable to site location in regard to agriculture and the building of terraces and stone walls.

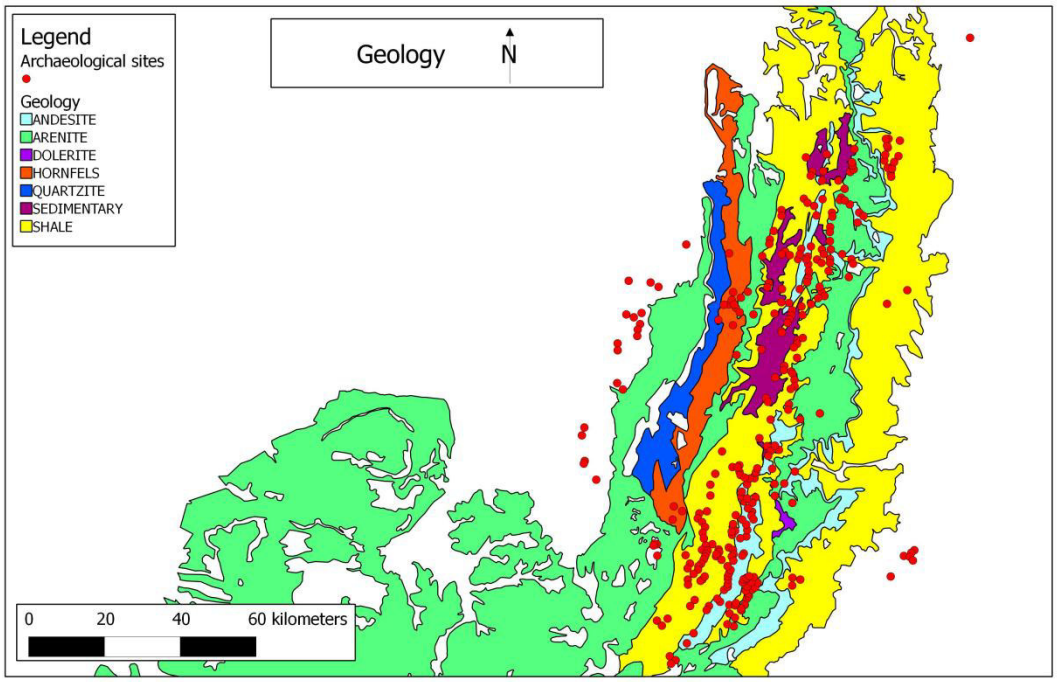


Figure 7.20: Sites exhibiting the geology of the Mpumalanga region

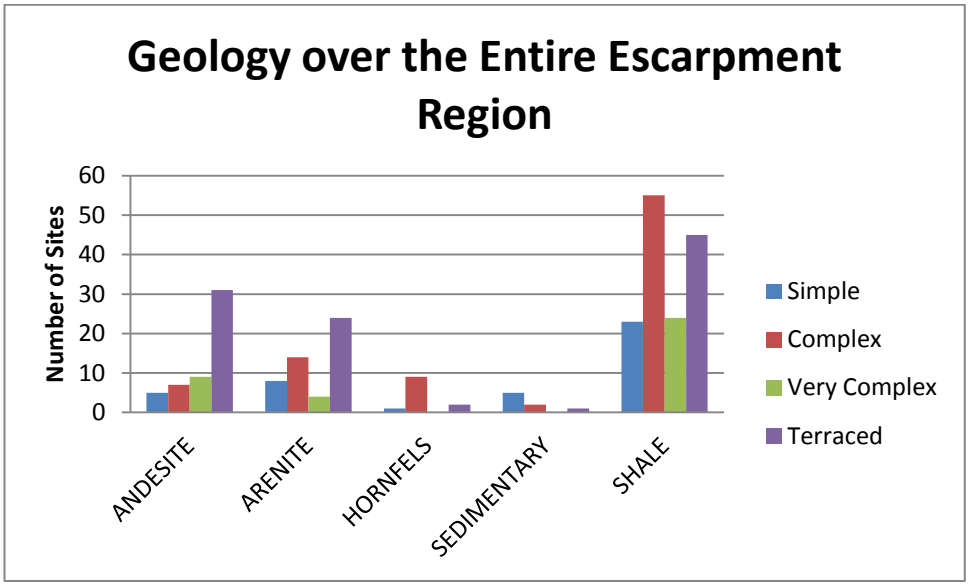


Figure 7.21: Number of sites situated on various minerals

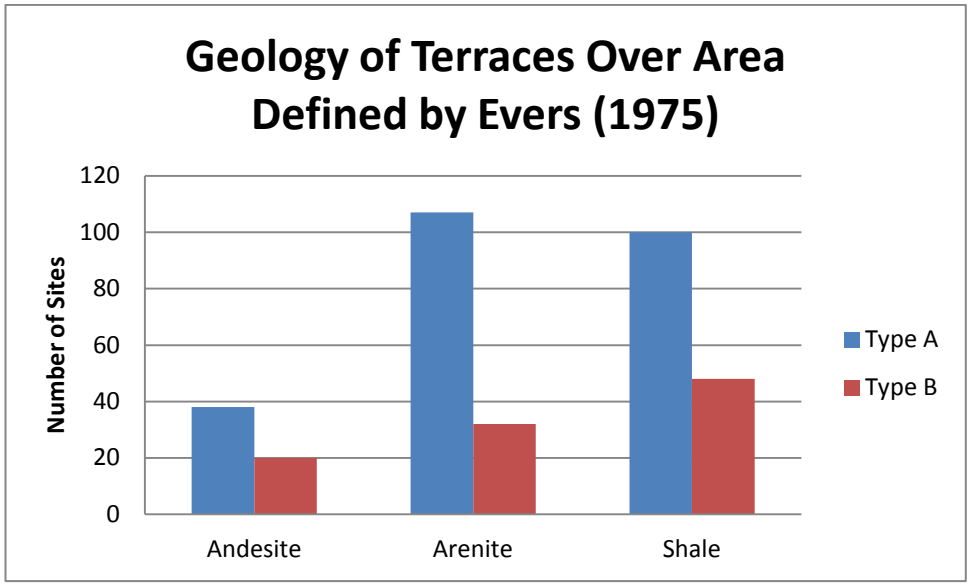


Figure 7.22: Number of terraced sites situated on various minerals

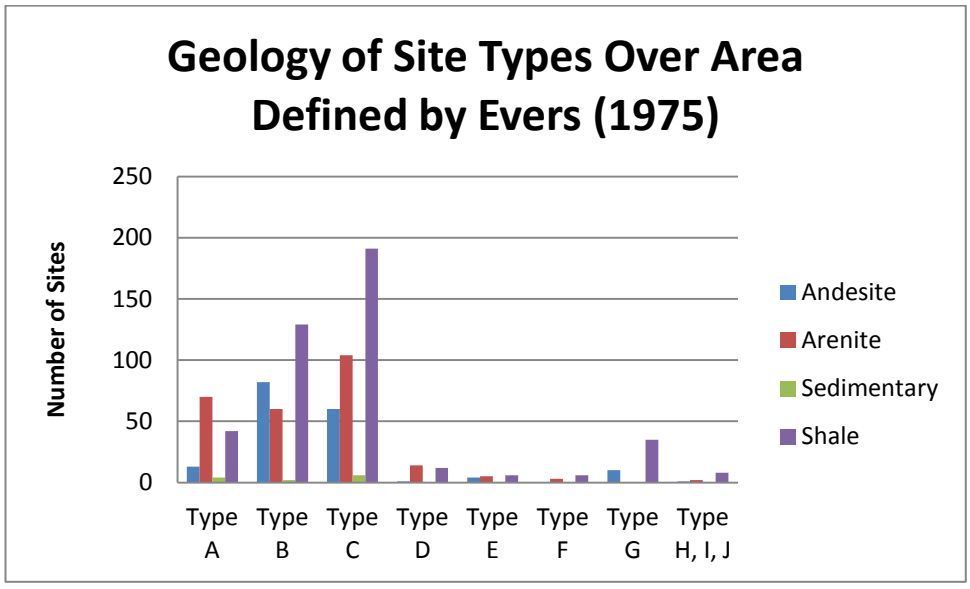


Figure 7.23: Number of sites situated on various minerals

7.1.6 Climatic Influence on Agricultural Potential

7.1.6.1 Data from the South African Weather Service

Climate is a vital component to be considered in establishing the extent of agricultural sustainability in the research area. As mentioned in Chapter Six, data from an exceptionally dry year and data from and exceptionally wet year were used to observe the same area under different climatic conditions and to determine whether or not the ability to produce maize, sorghum, beans or legumes, and cucurbits is viable under different conditions (Figures 7.25 and 7.26).

The results reveal that even in a particularly dry year the average rainfall total over the research area is over 500 mm and will meet the minimum requirement for maize, sorghum, beans or legumes and cucurbits to survive. Both the maps show that the escarpment area, where the terraced sites are located, has significantly higher amounts of rainfall than the lower areas. This is an important advantage of settling on the escarpment and a key element in the location of the sites, as it allows for agricultural exploitation since the rainfall amount is adequate during both dry and wet periods.

The escarpment has a higher rainfall amount with its average at 580 mm/year average over the 17-year period compared to 388 mm/year average to the east and 491 mm/year average to the west of the escarpment. The above suggests that over the past 17 years the escarpment has had a climate that could sustain agriculture.

When comparing the above data with paleo-data (Tables 4.1 and 6.5), it is evident that there were time frames in the past 500 years where the agricultural potential would have been better than that at present and times when the climate would not have been suitable for agriculture. During the period of approximately 1440 to 1520 the general increase of temperature would have had an effect on the escarpment settlements and probably been favourable for agriculture, whereas the periods between 1540 and 1575, and 1730 and 1725 were cooler over Southern Africa and possibly would have made agriculture an impractical practice on the escarpment during such times.

7.1.6.2 Alternative current rainfall maps

A third map of the general average rainfall in the area is also provided (see Figure 7.27). This is to further show that the sites were located largely in the present 600 mm to 800 mm annual rainfall zone (see Figure 7.24).

As the rainfall maps demonstrate, the area of the escarpment where the terraced sites were located has a higher amount of rainfall than the surrounding areas as mentioned above. Although the rainfall amount is higher in this area, it is not excessively so in creating unfavourable conditions for agriculture as the maize, sorghum, beans and cucurbits would not have thrived in areas with rainfall amounts of over 800 mm.

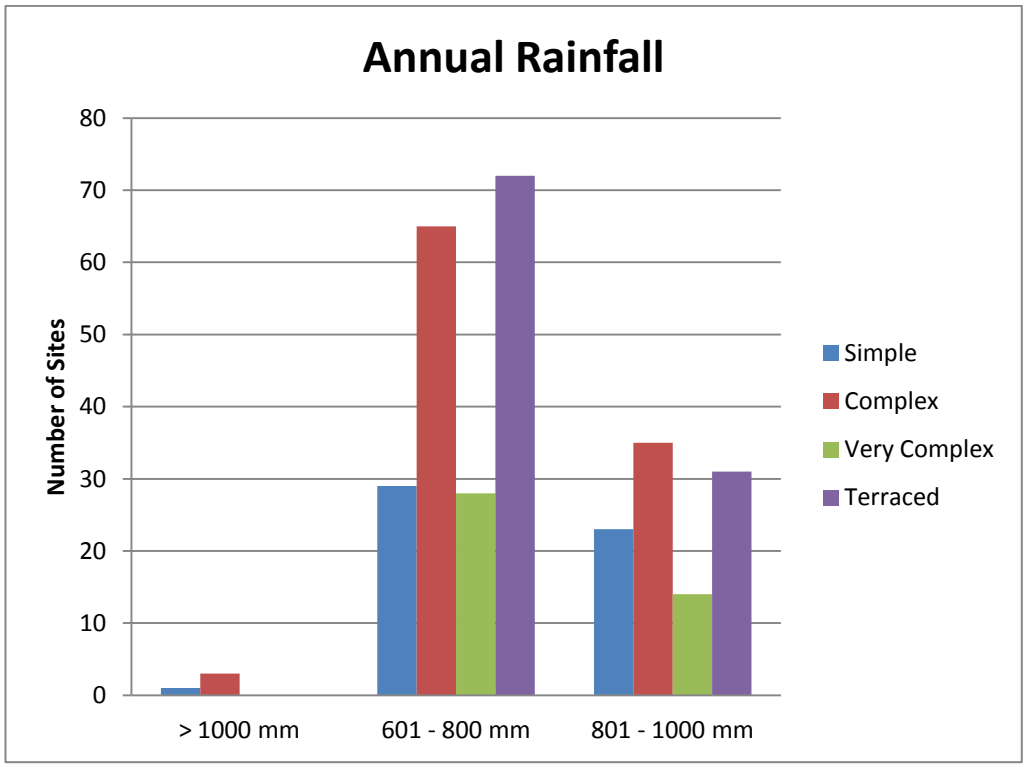


Figure 7.24: Annual rainfall received at site locations

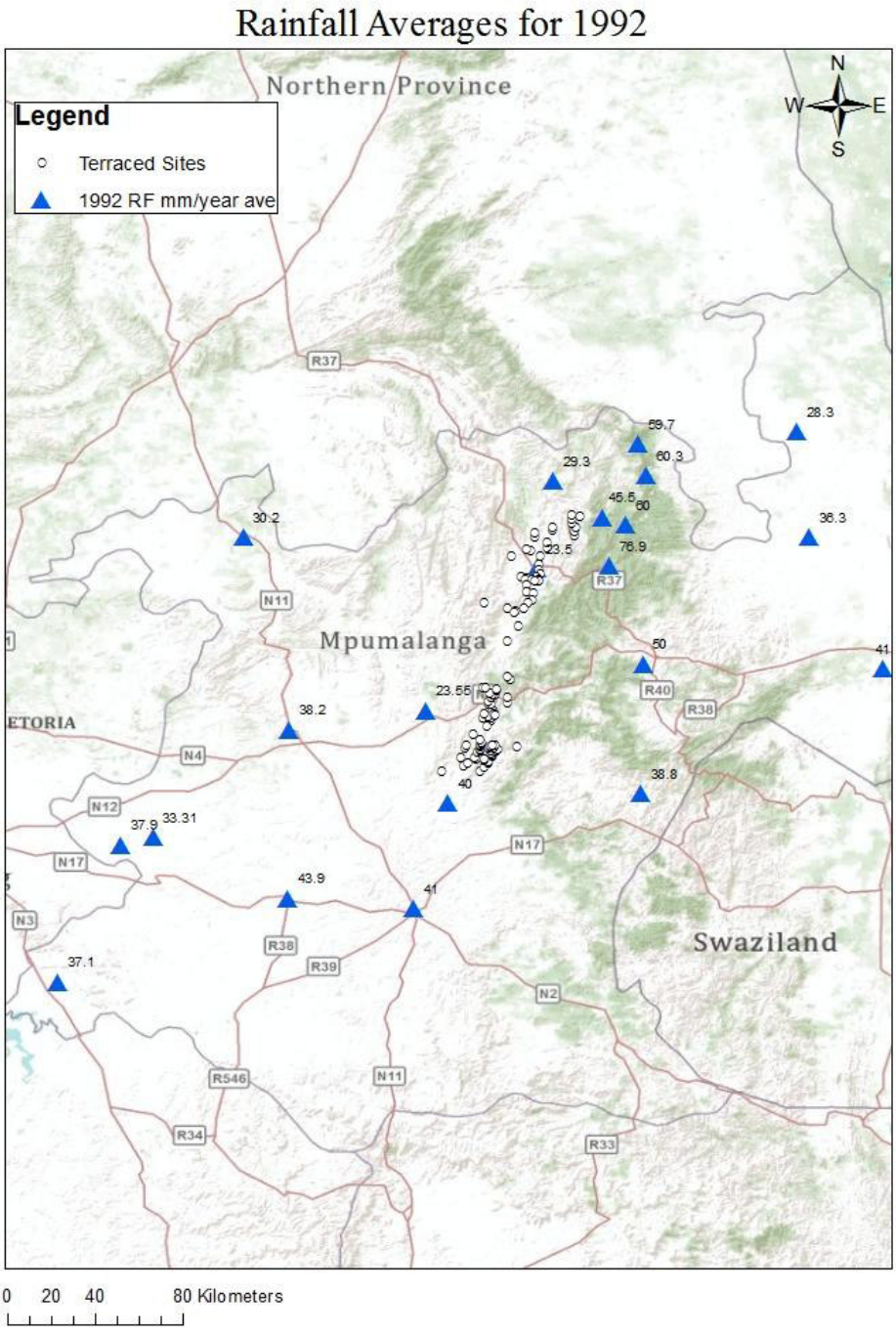


Figure 7.25: Rainfall averages for 1992. Data plotted from station records received from SAWS. Note that the escarpment area has higher amounts of rainfall

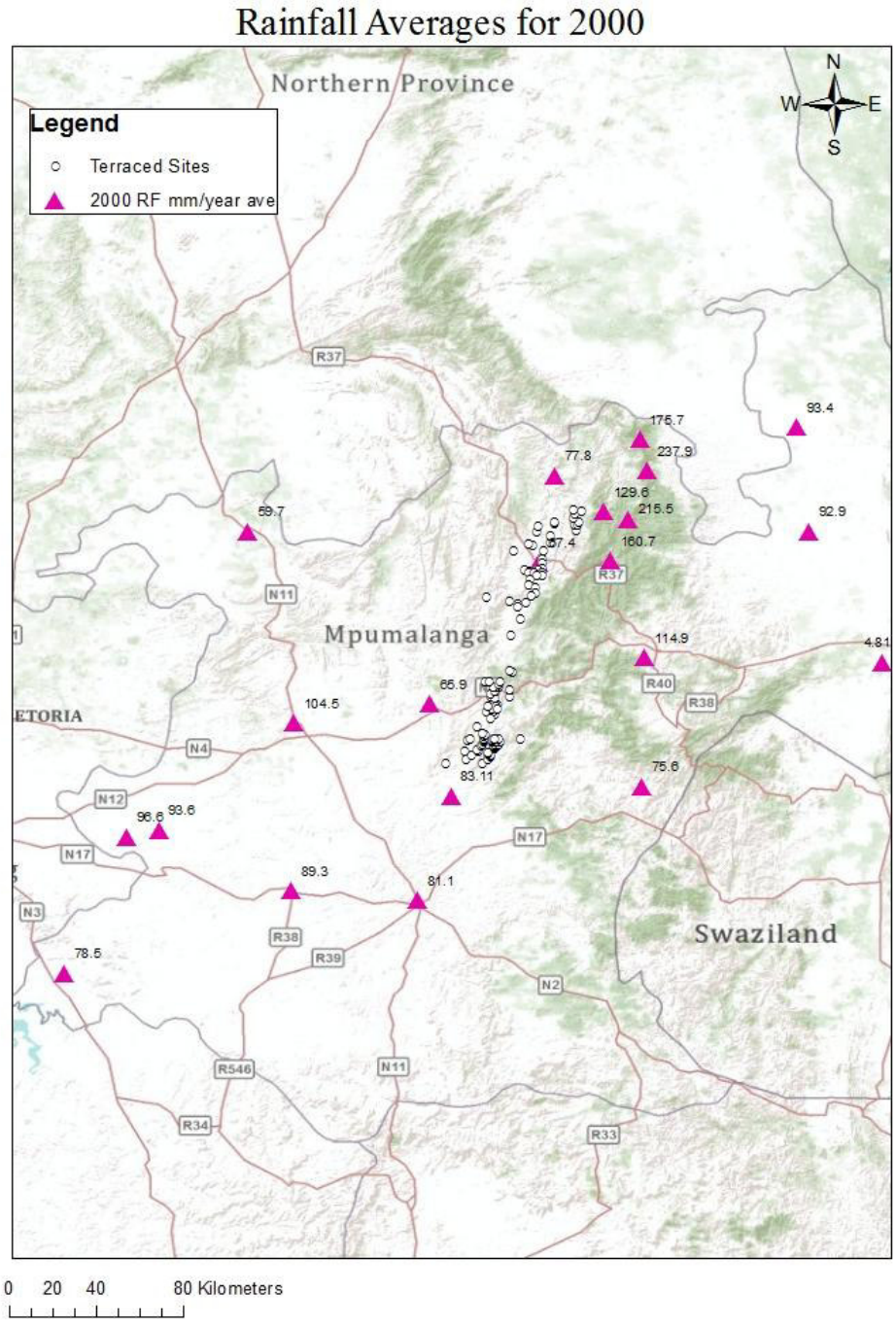


Figure 7.26: Rainfall averages for 2000. Data plotted from station records received from SAWS. Note that the amounts of rainfall are far higher compared to 1992. Although the pattern of the escarpment having higher amounts of rainfall compared to the lower areas remains

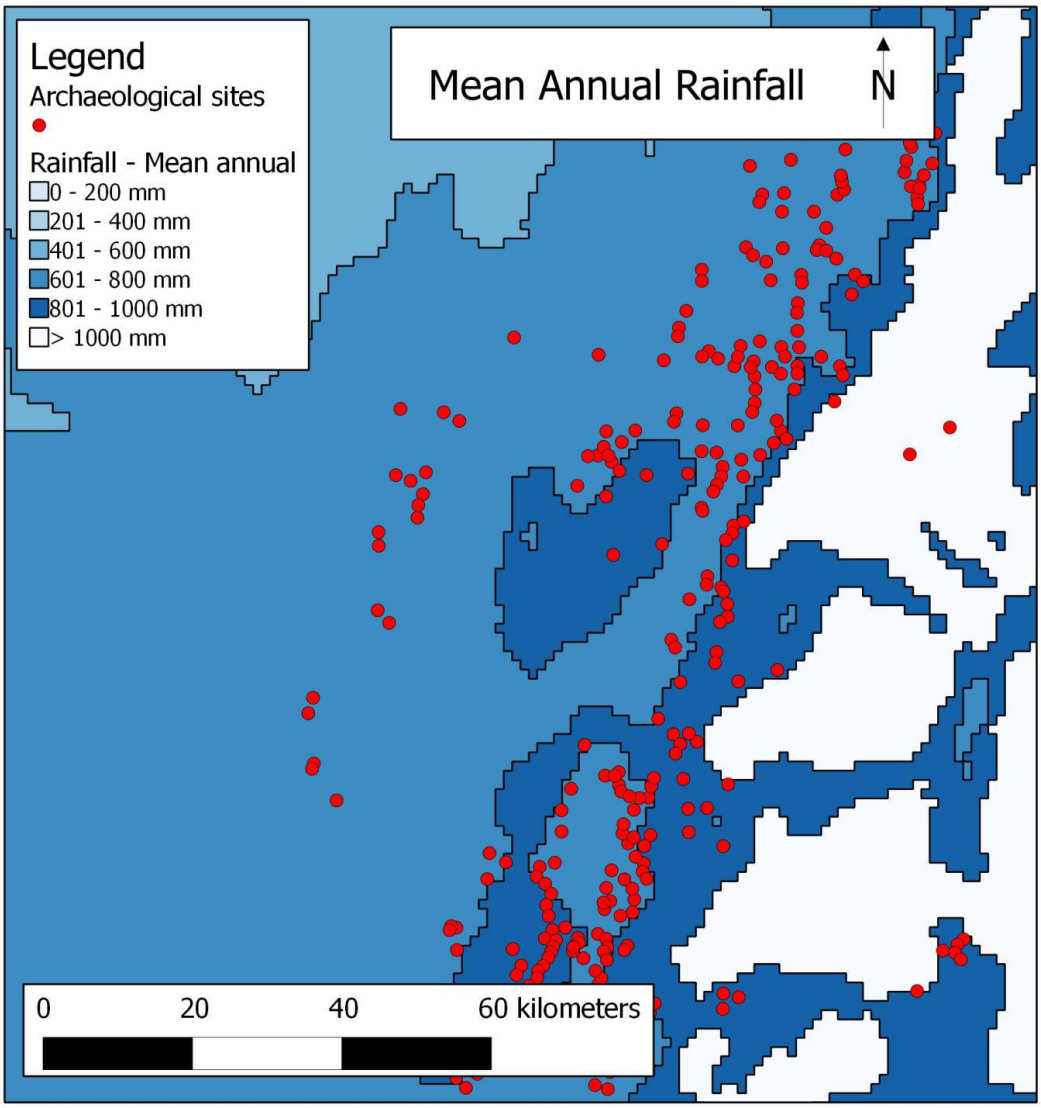


Figure 7.27: Average rainfall over the research area. The sites were located mainly in one rainfall zone, in this case the 600 mm to 800 mm zone. This zone has sufficient rainfall for agricultural production of maize, beans and squash

7.1.6.3 Temperature

The final climatic requirement for successful agriculture is an appropriate temperature variation band. Again the years 1992 and 2000 were used to contrast the wet and dry patterns discussed above (Figures 7.28 and 7.29).

For the dry year of 1992 the minimum average was 11.75 °C and the maximum average 23.95 °C and for the wet year of 2000 the minimum average temperature was 9.48 °C and the maximum average 21.24 °C. These results show that the temperature requirements are slightly low for successful agricultural production at present conditions, however it is possible. As mentioned in Chapter Three, a variety of maize can survive lower temperatures so it is possible that such strains of maize were being utilised.

Chapter Three further mentions that the periods of warm wet phases were determined to be warmer than the current climate conditions and the dry cool phases were similar to present conditions. Therefore, if the conditions were slightly warmer than present conditions, the area would be ideal for the production of maize, sorghum, beans or legumes, and cucurbits during these warmer phases.

Overall we can conclude that the production of the above mentioned plants was not only possible but probably highly successful along the escarpment during the warmer seasons and periods. The fact that the rainfall pattern, temperature spread and soil composition allowed for harvesting means that there was probably a surplus of food during warm wet phases and during summer months.

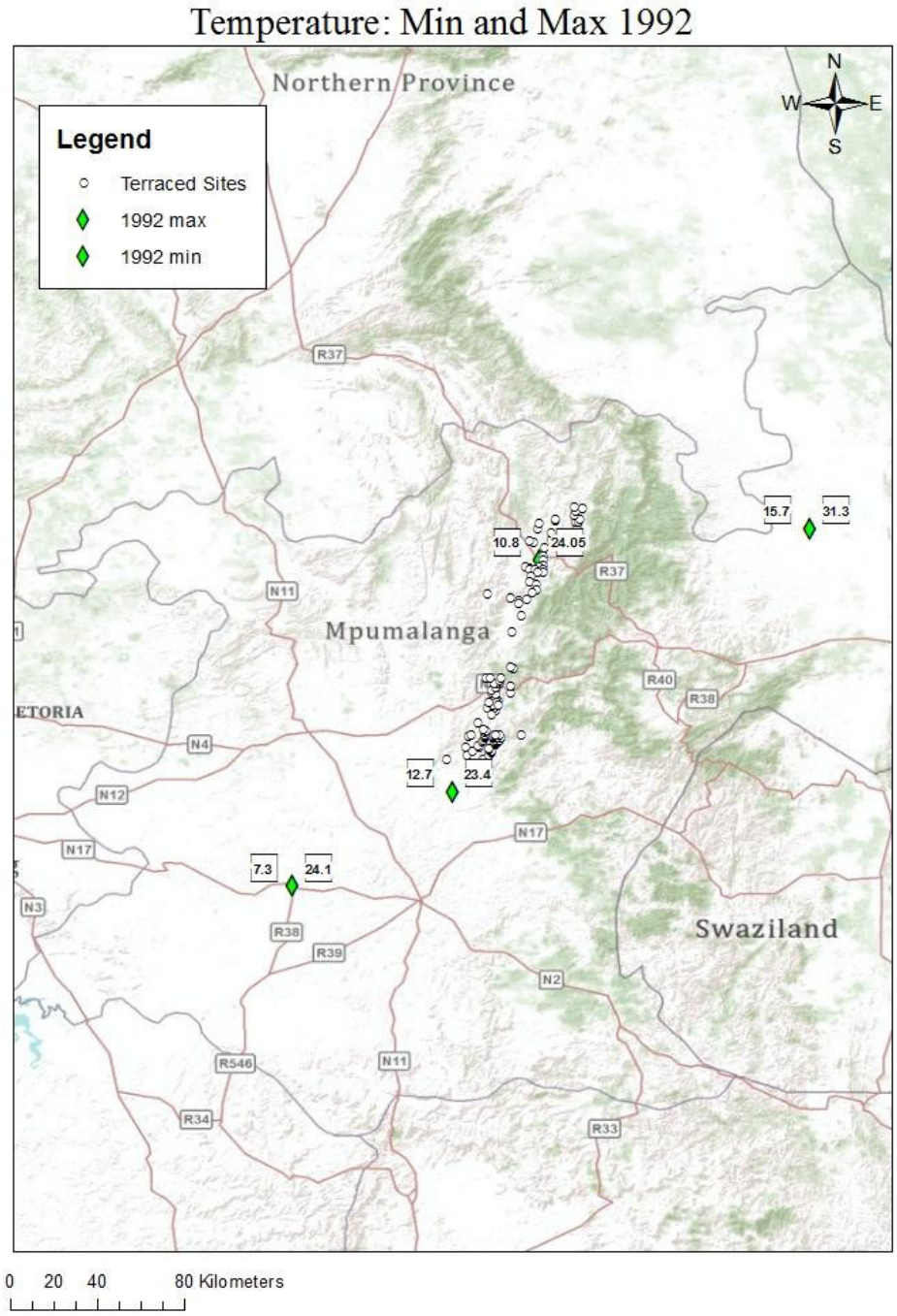


Figure 7.28: Minimum and Maximum temperatures for 1992. Although the temperatures are lower at this altitude they still fall within the required band for the production of maize, beans and squash

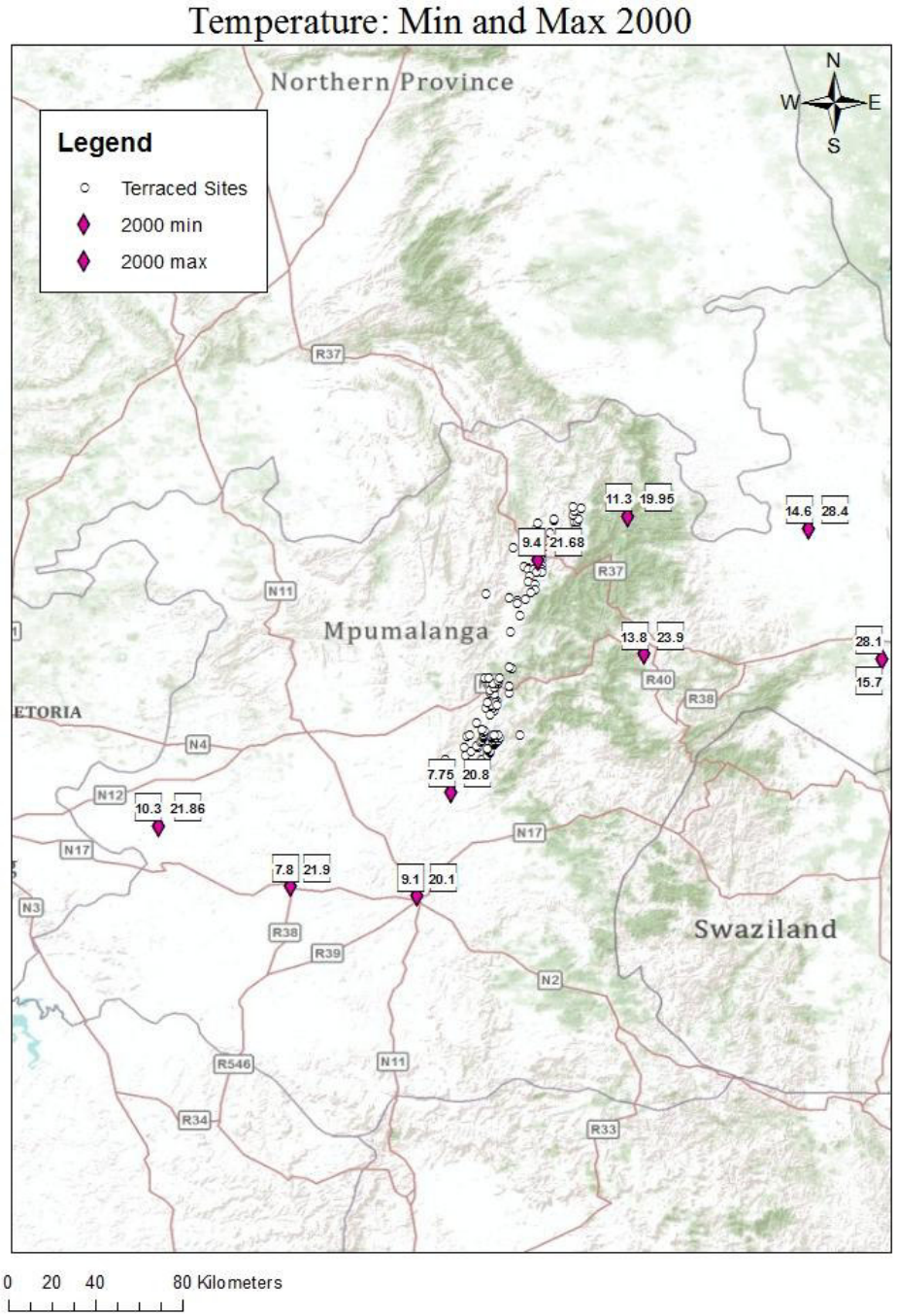


Figure 7.29: Maximum and minimum temperatures for 2000. Although the temperatures are lower at this altitude they still fall within the required temperature band for the production of beans and cucurbits

7.2 Mining

7.2.1 Significance of access to surface level minerals suitable for Mining

The availability of a range a minerals may also have attracted the LFC to settle in the area. Figure 7.31 presents a detailed geological map with the LFC sites of the escarpment region overlaid. This is to observe the distance of the minerals from the complex settlement as a whole.

Mining of minerals would have had a profound impact on the LFC economic systems as such specialist items could be traded for food stuffs during times of famine or simply to increase wealth.

The results indicate that the sites are indeed close to a variety of minerals. These include iron, lead, gold, copper, bismuth and chrysotile asbestos. Not all of these minerals are significant; the minerals to consider are mainly iron, gold and copper. Figure 7.30 shows the mineral legend on the geological maps.



Figure 7.30: Geological legend, Department of Mineral and Energy Affairs

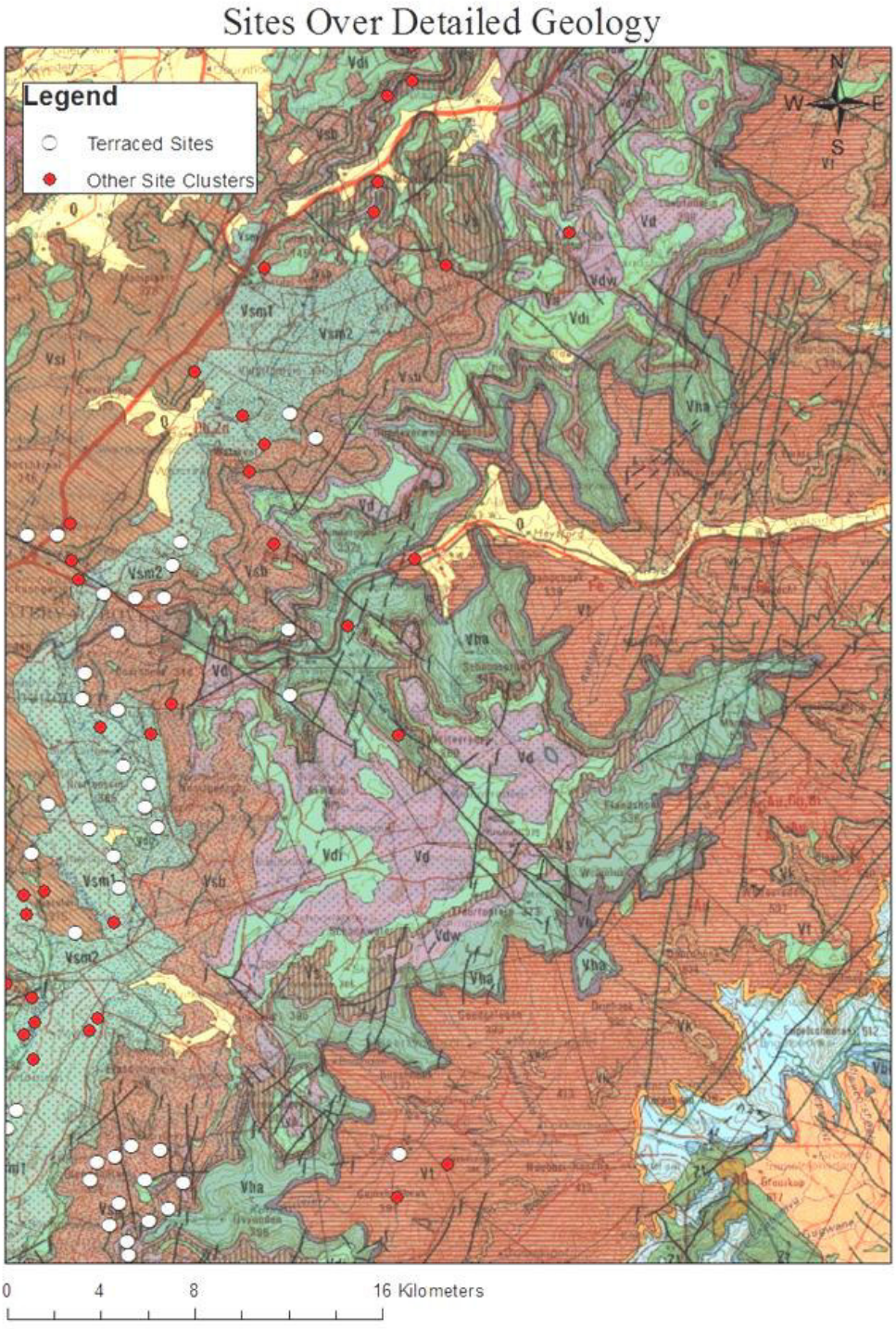


Figure 7.31: Detailed geological survey map with all the sites. The mineral components are marked in red

7.3 Prevalence of Disease

To what extent disease influenced LFC site distribution along the escarpment is also a vital aspect to consider. Several maps were produced showing the distribution of malaria and nagana in relation to the sites.

7.3.1 Distribution of Malaria

The present-day extent of malaria on the Highveld was observed using altitude as a limiting factor (see Figure 7.32). This image shows the 600 m ASL limit described by Govere (2000), which indicates that the sites are found beyond the range of malaria. Temperature change will, however, also influence the elevation limit of malarial distribution. Therefore, considering changes in climate increase, further maps were created and these included a limiting elevation of 700 m ASL, 800 m ASL and an extreme example of 1200 m ASL. (see Figure 7.32). The results reveal that even with the extreme extension in elevation, and considering a drastic increase in its prevalence under such climatic conditions, the sites were always clear of malaria.

The affect that elevation has on temperature also needs to be considered as an increase in elevation results in a decrease of temperature and therefore a decrease in malaria transmission.

Lastly, maps were produced showing the Relative Humidity (RH) of 1992 and 2000 (Figures 7.33 and 7.34). This was carried out to observe whether RH during dry and wet periods could significantly influence the extent of malaria. Malaria requires an absolute minimum of 50 % RH, although higher levels are preferred. The RH maps indicate a more than adequate RH for malaria in the area during both dry and wet years. As illustrated in the temperature maps, the temperature along the escarpment is low, which is unfavourable for mosquitoes as they prefer a temperature band of 27 °C to 31°C.

Therefore regardless of climatic variation the LFC sites located along the escarpment would have remained malaria free throughout the year.

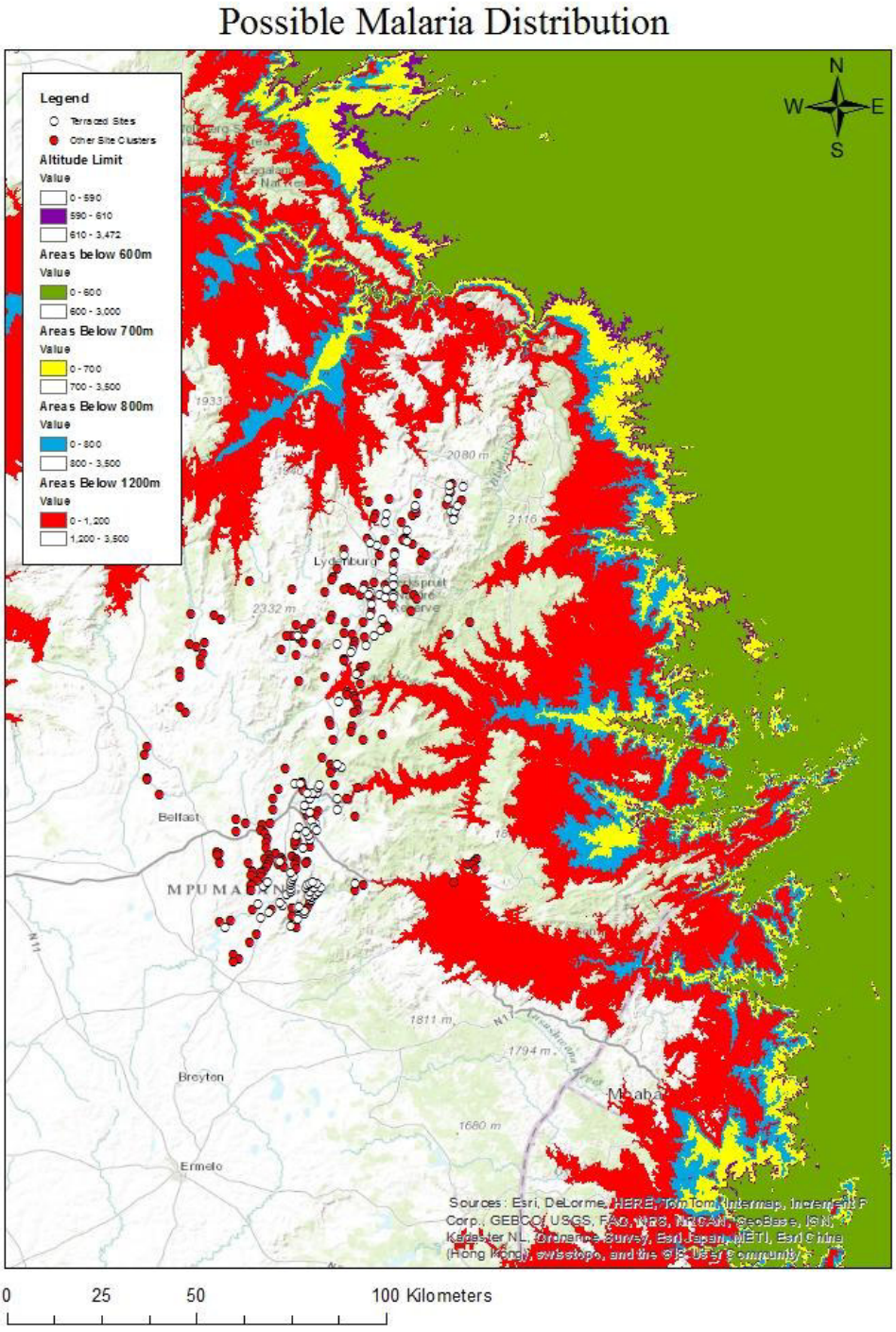


Figure 7.32: Showing different extents of malaria distribution by considering climate changes from present conditions

1992 Relative Humidity And Malaria Distribution below 600m asl

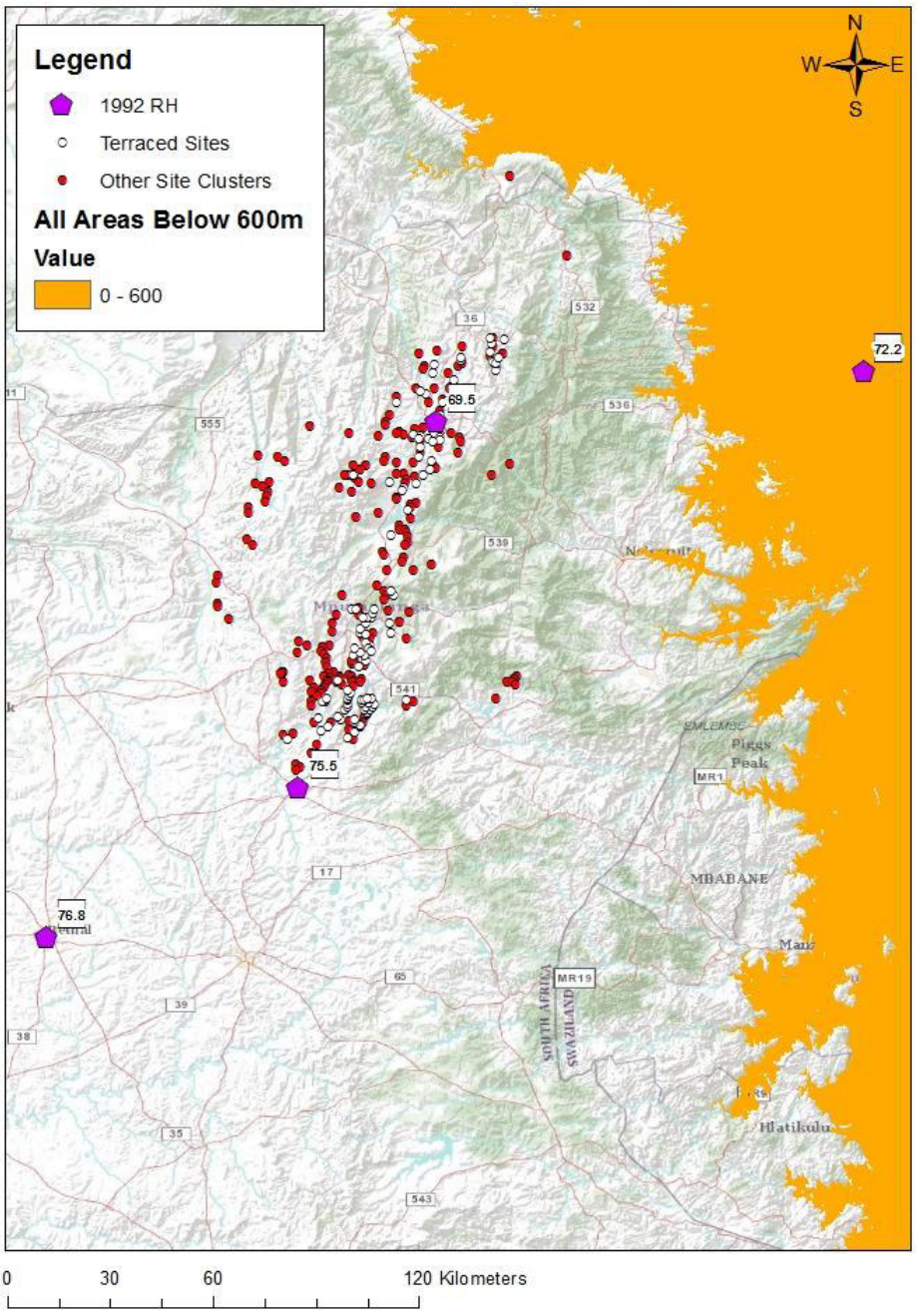


Figure 7.33: Portraying RH in the area for 1992. The dry years would have had a high enough RH to sustain malaria; however, elevation is a greater limiting factor as it affects temperature

2000 Relative Humidity And Malaria Distribution below 600m asl

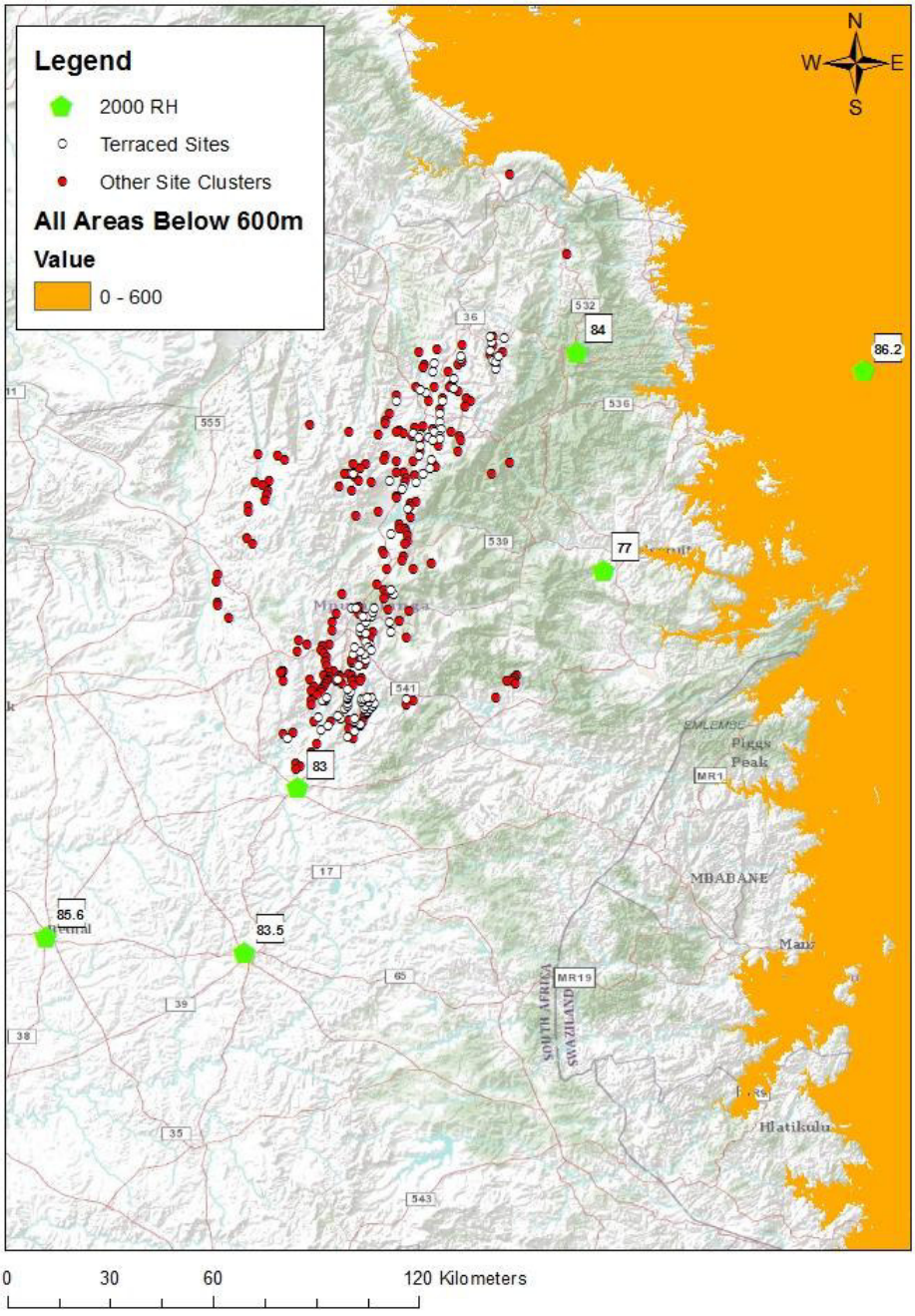


Figure 7.34: Portraying RH in the area for 2000. The wet years would have experienced a sufficiently high RH to sustain malaria; however, elevation is a greater limiting factor as it affects temperature

7.3.2 Distribution of Nagana

As with malaria, nagana is limited in its range by elevation as above certain elevations the temperature is too low for tsetse flies to survive. The tsetse fly elevation limit is 920 m ASL. A map was produced showing all the areas below this limit where tsetse flies could exist (see Figure 7.25). An extreme example of 1200 m ASL was also then produced assuming warmer conditions (see Figure 7.25).

The second factor that has a large impact on tsetse fly distribution is vegetation as the tsetse fly is reliant on relatively dense woodland areas (see Chapter Three). Figures 7.36 and 7.37 indicate the presence of tsetse fly prevalence over the vegetation and biomes of the region. The fly avoids vegetation types of the north-eastern Mountain Sourveld, Bankenveld or Highveld Grassland, and the Lowveld Sour Bushveld, which are all dominated by grassland species. When observing the biome map, this is evident as the grassland biome is avoided. The area that the tsetse fly inhabits is the Lowveld and the Mixed Bushveld. The Sour Lowveld contains trees and shrub layers along with tall dense grass while the Mixed Bushveld contains short Bushveld to open tree Savanna, both of which are suitable for tsetse flies.

Lastly, shape files derived from the two historical maps that show the distribution of Nagana in the area were used. The two historical depictions of the tsetse were subsequently placed over each other to observe any change in distribution over the period of 43 years (see Figure 7.38). The results of this map reveal that the tsetse fly belt extended further north of the Limpopo River between 1836 and 1875.

The overall results indicate that tsetse flies avoid the Highveld grassland areas and remain below its limiting altitude. The terraced sites as well as all the other sites were located at a safe distance away from tsetse flies.

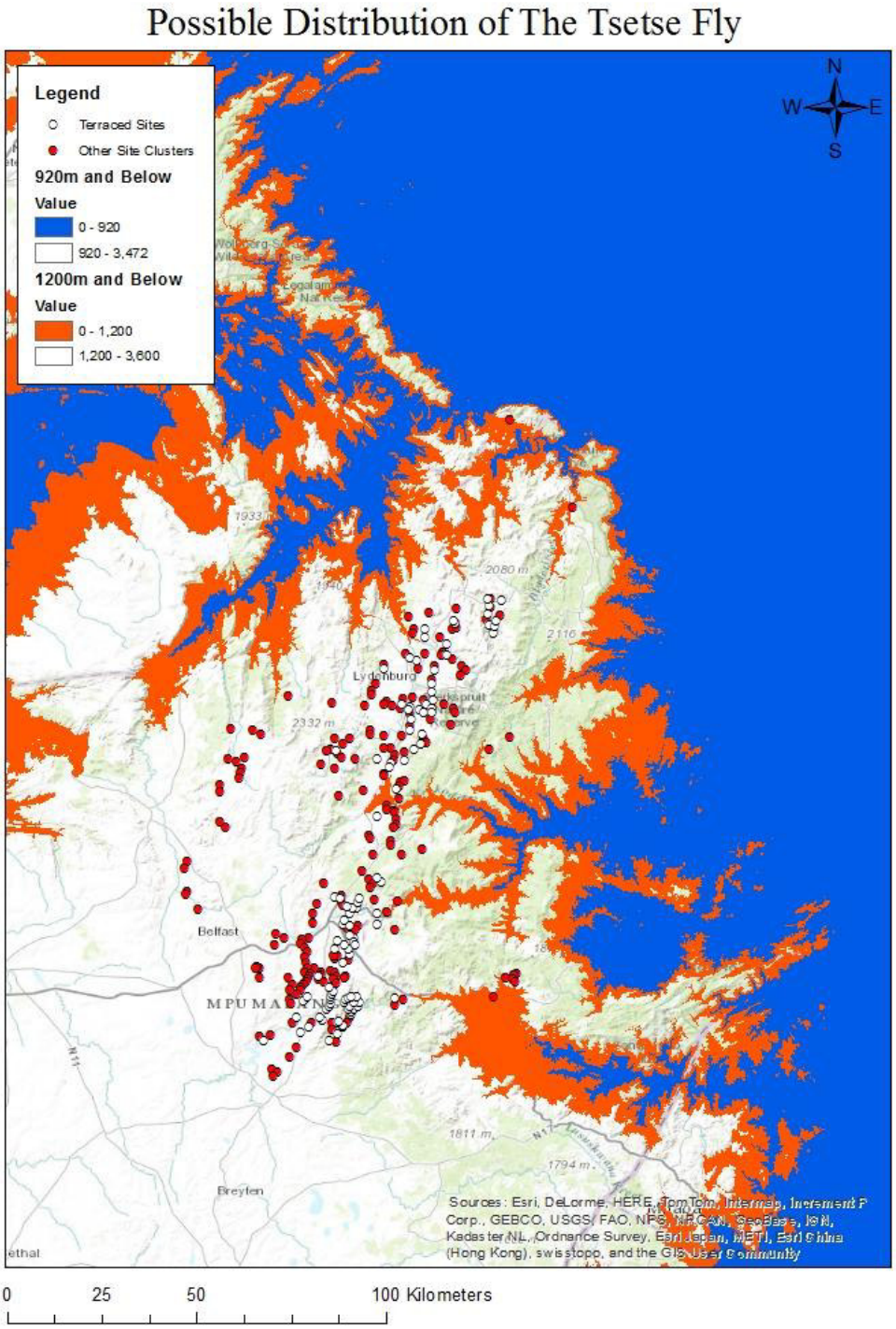


Figure 7.35: Showing the 920 m ASL elevation limit on tsetse and an extended elevation of 1200 m ASL considering the climate change. The terraced sites as well as all the other sites are located at a safe distance from the disease, being only mildly affected at the fringes of the 1200 m ASL limit

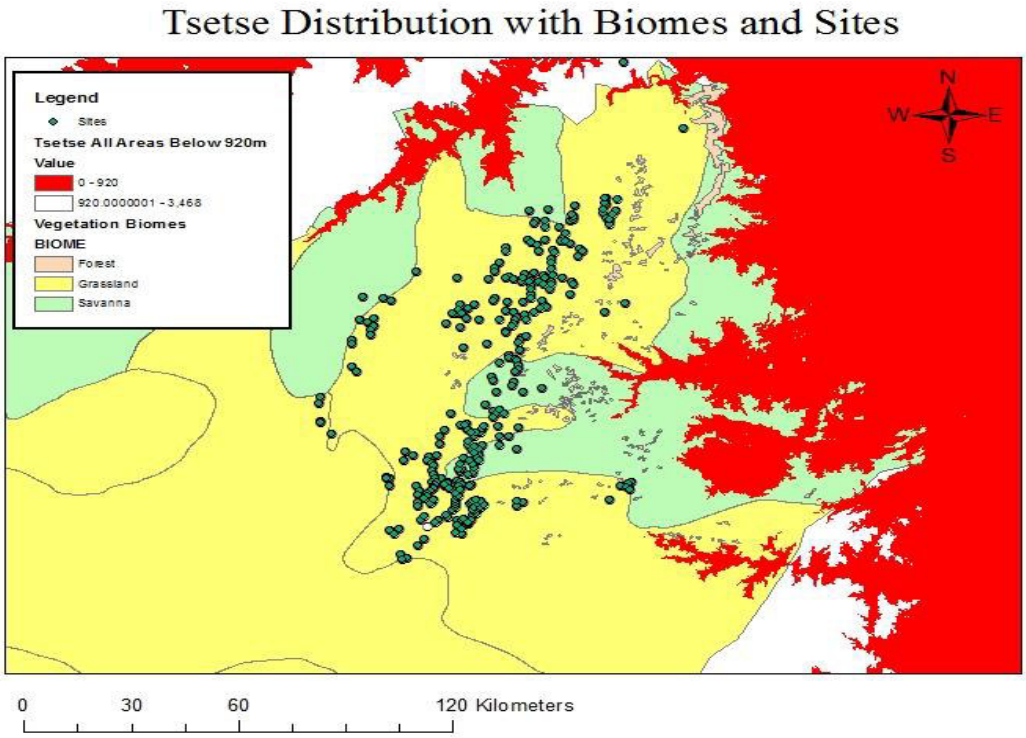


Figure 7.36: Tsetse distribution over biomes

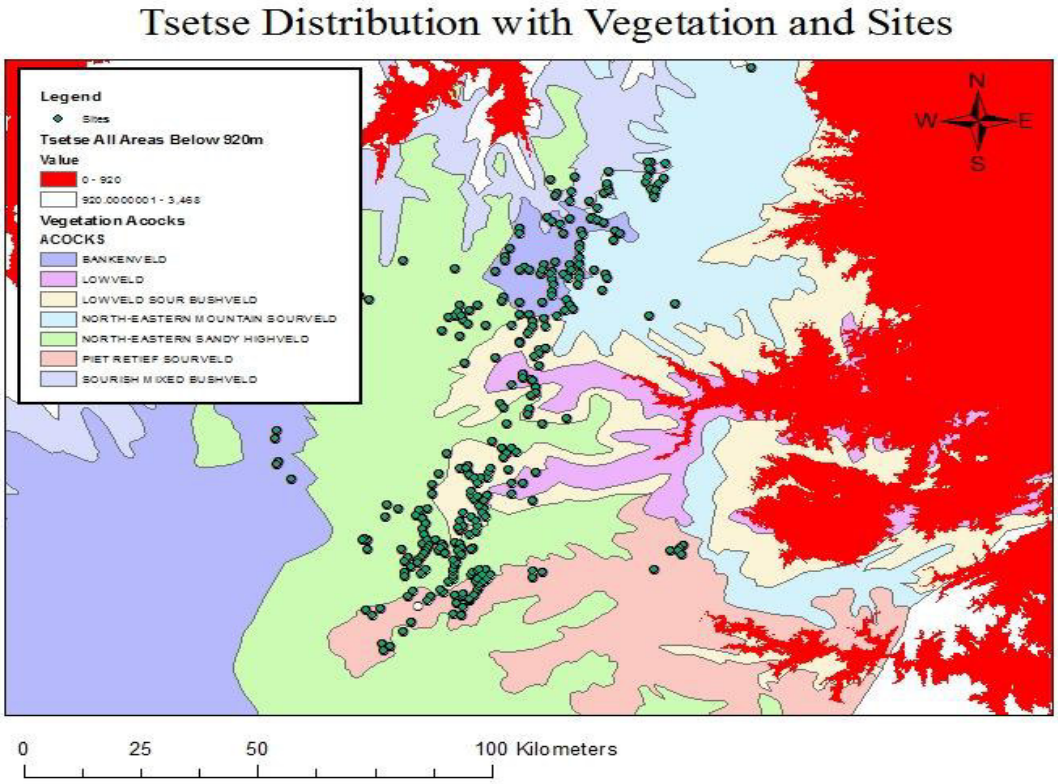


Figure 7.37: Tsetse distribution over vegetation

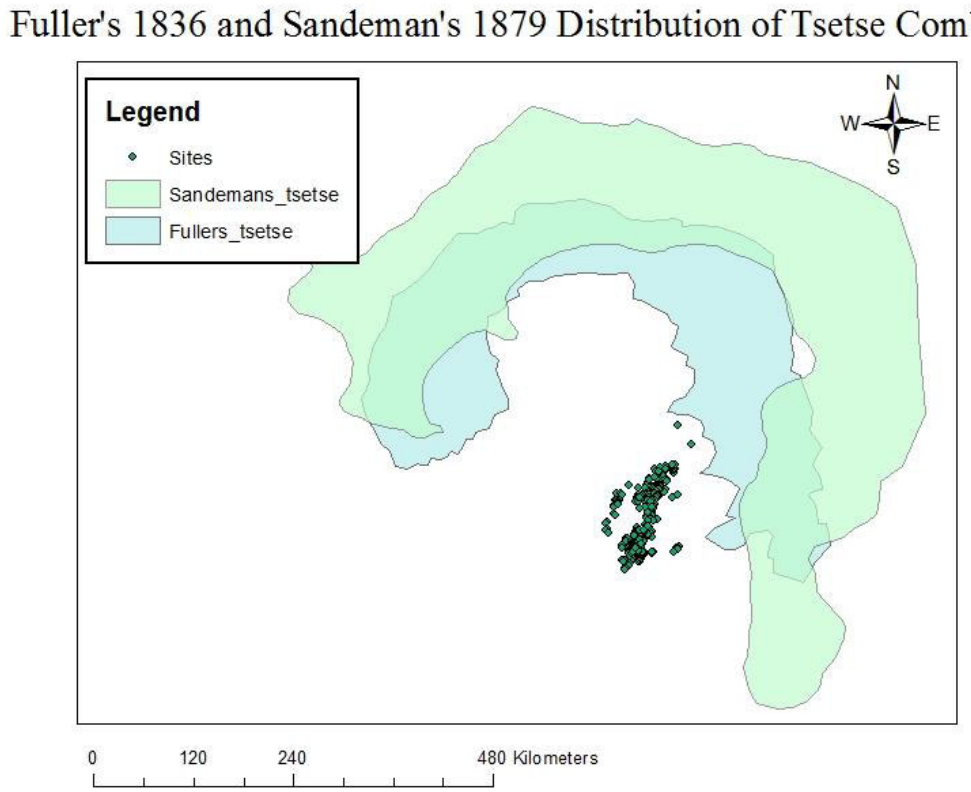


Figure 7.38: Historical tsetse belts compared

7.4 The Influence of Trade

7.4.1 De Vaal's 1984 trade routes

The next factor to be investigated is whether any of the sites were located near trade routes. The shape file of trade routes recorded by De Vaal (1984) were placed with the site locations. By comparing site distribution with trade routes it is evident that the sites are located on or close to trade routes (see Figure 7.39).

Trade would have started on the escarpment around the 1500s after the escarpment area was occupied. This would have occurred between the LFC internally and between the LFC and the Portuguese. Later the trade developed between the LFC and the Boers, Dutch and English. It is noted in Chapter Three that the Mpumalanga Lowveld rivers were considered to be important corridors of movement for trade during the period 1818 to 1820 (Delius and Schoeman 2008) suggesting that the trade routes were being utilised by a variety of traders and not only the inhabitants of the escarpment area.

Trade routes (From De Vaal 1984)

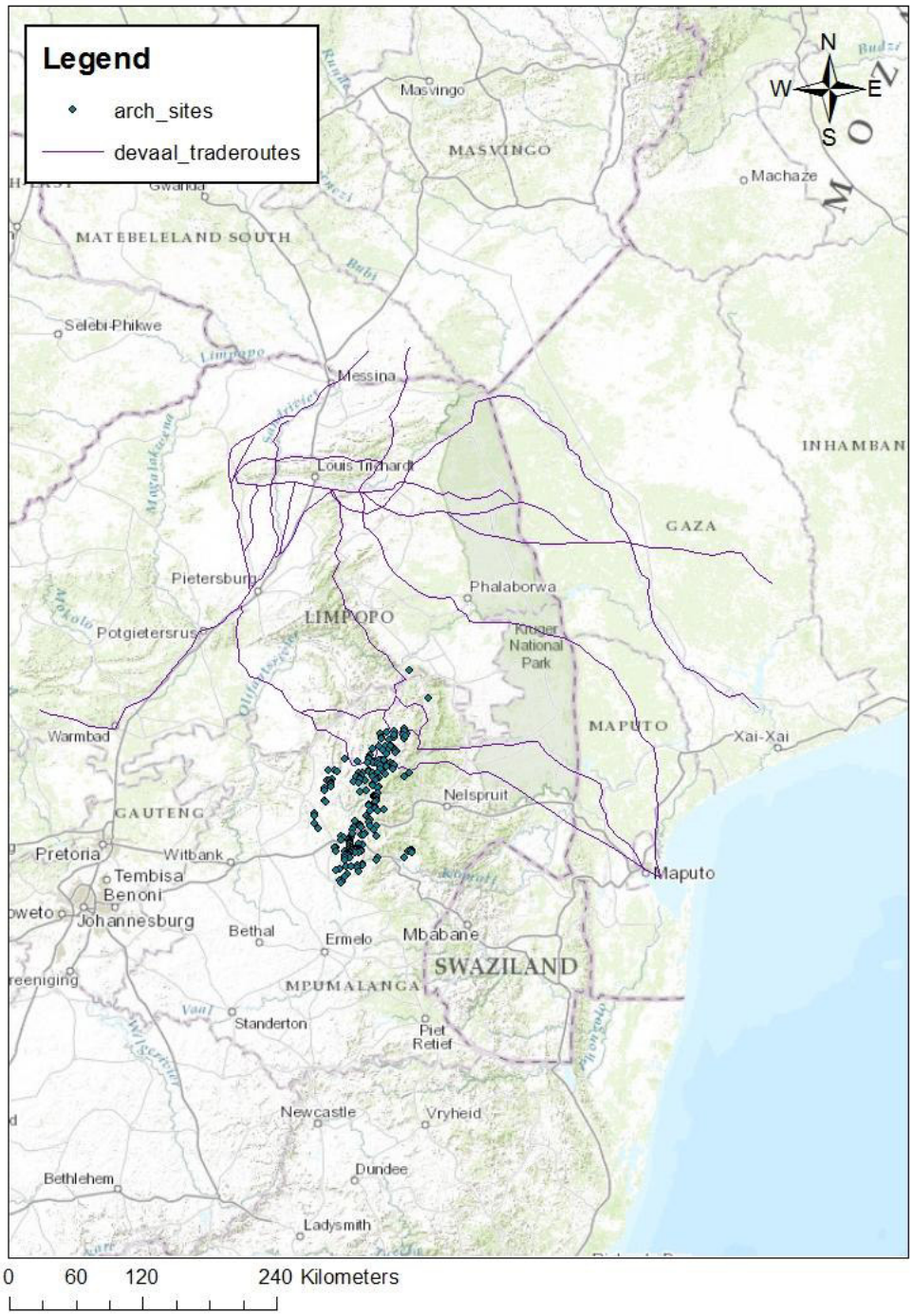


Figure 7.39: De Vaal (1984) trade routes through the interior

7.4.2 Least-Cost Paths

The least-cost paths created in ArcMap were added to De Vaal trade routes (Figure 7.40). Observing the three least-cost paths that were created over the general escarpment area, no trends emerged. Except for a section of the route from Delagoa Bay, the paths are significantly different, suggesting that other factors would have influenced the choice of paths through the landscape. Observing the least-cost path from Louis Trichardt in the second model that was specified to a specific origin point, much more correlation is evident (see Figure 7.41). This was a weighted overlay taking into consideration tsetse avoidance. Although this path is not in the tsetse belt, it is possible that travellers were cognisant of the vegetation types to avoid in general.

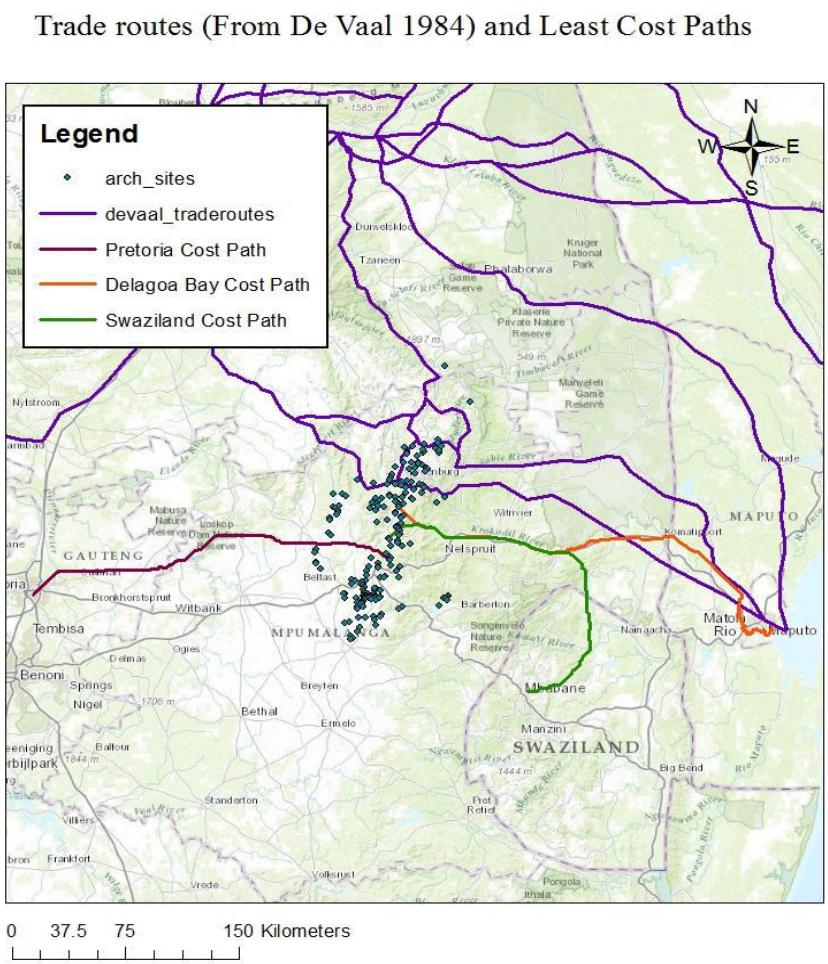


Figure 7.40: General distribution of least-cost paths and trade routes through the interior

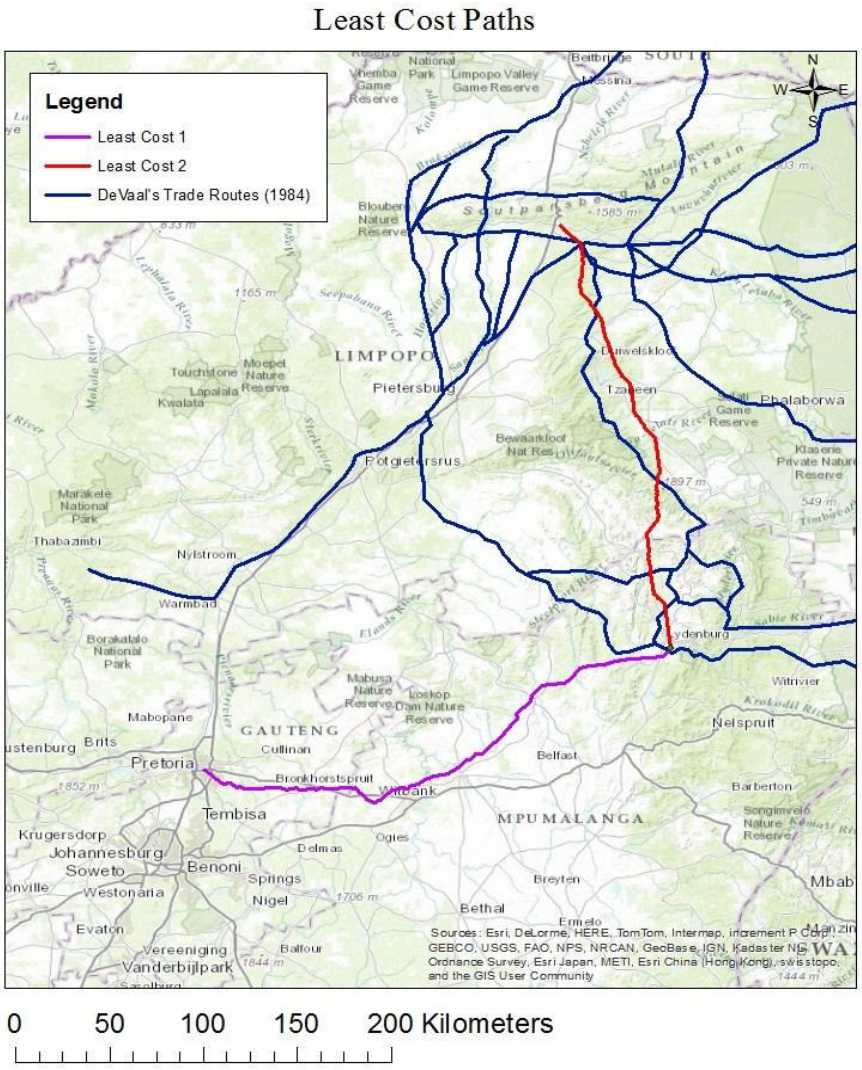


Figure 7.41: Distribution of weighted analysis least-cost paths and trade routes through the interior

7.4.3 Trade Routes and Tsetse

In order to determine what other factors may have influenced the choice of routes through the interior, the trade routes were placed over the tsetse distribution layer (Figure 7.42). The routes recorded by De Vaal (1984) show no attempt to avoid the tsetse belts. It is possible that these routes were travelled in the colder seasons when the distribution of tsetse is minimised.

Trade routes (From De Vaal 1984), Least Cost Paths and Tsetse Belt

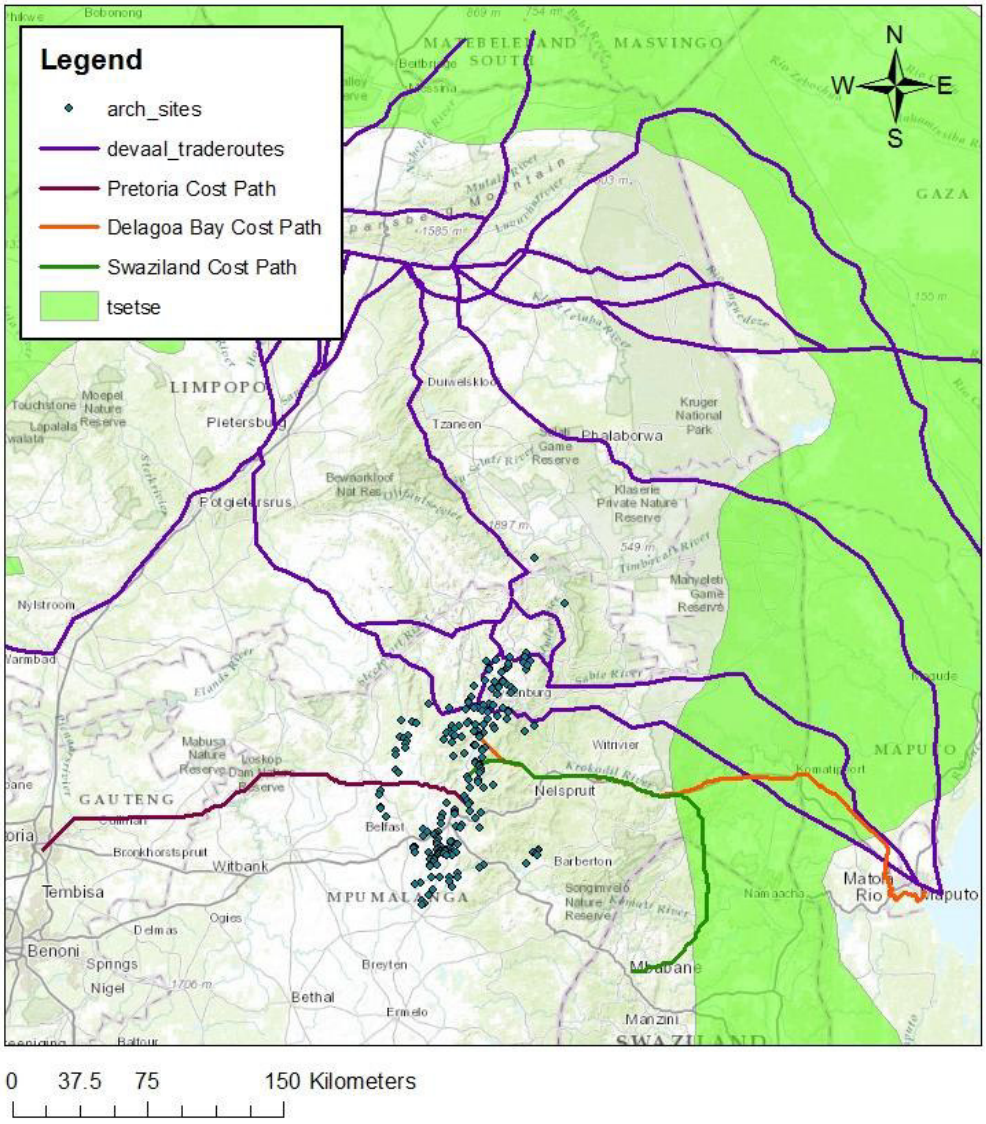


Figure 7.42: Trade routes compared with tsetse distribution

7.5 Distribution of Different Types of Sites

7.5.1 Distribution and Altitude

An analysis of site distribution over the entire escarpment region reveals a general trend of the complex, very complex and terraced sites occurring predominantly at altitudes of 1400 m to 1700 m ASL, with simple sites being

scattered around the lower altitudes. The 1500 m to 1600 m ASL range is dominated by terraced sites whereas the range of 1600 m to 1800 m ASL consists of predominantly complex sites as presented in Figure 7.43.

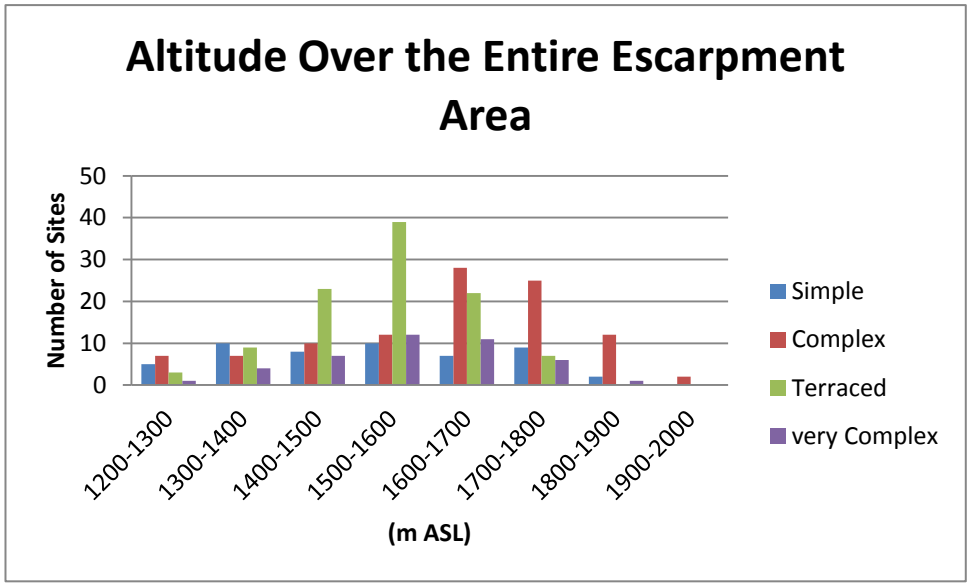


Figure7.43: Altitude of site locations

7.5.2 Distribution and Slope

The site types were placed on a slope generated image. The majority of all the sites were located at a slope percentage of 0 to 9 per cent. Few sites were located at a slope of 9 to 15 per cent or greater than 25 per cent (see figures 7.44, 7.45, 7.46 and 7.47). This points to extensive agriculture and cattle production occurring on the more favourable levelled areas.

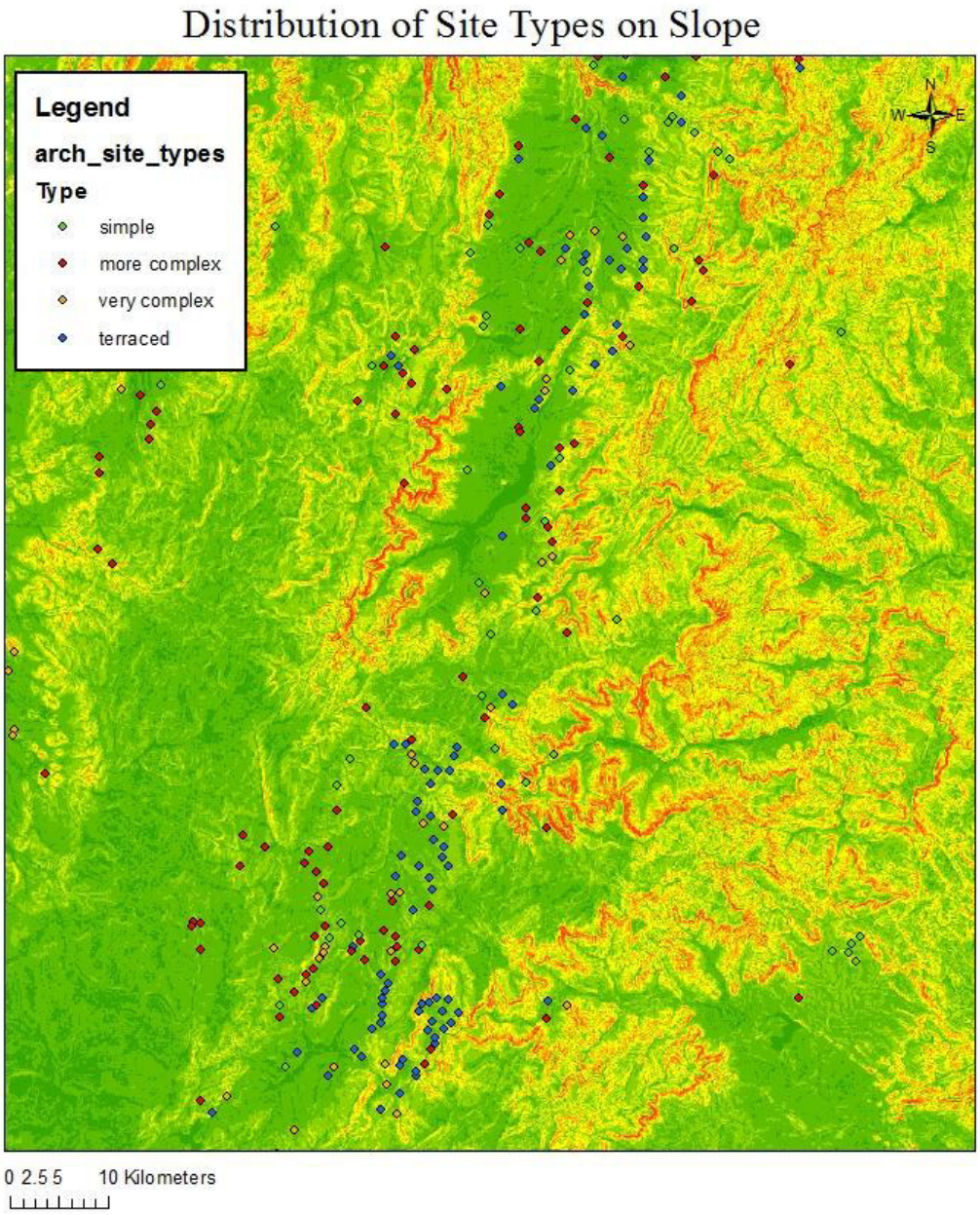


Figure 7.44: Site types distributed mainly on slopes of 0 to 9 per cent

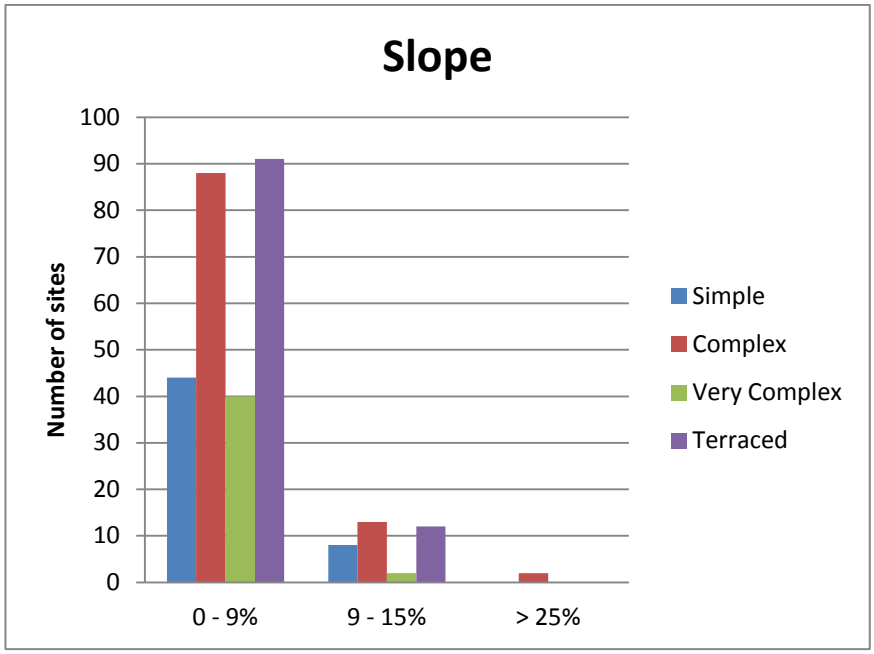


Figure 7.45: Majority of the sites occurred at a slope gradient of 0 to 9 per cent

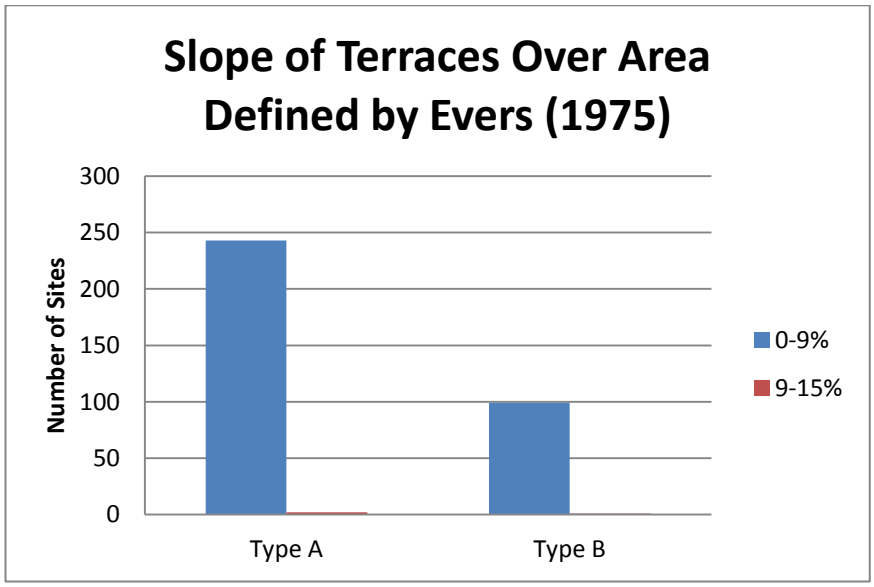


Figure 7.46: Majority of the sites occurred at a slope gradient of 0 to 9 per cent

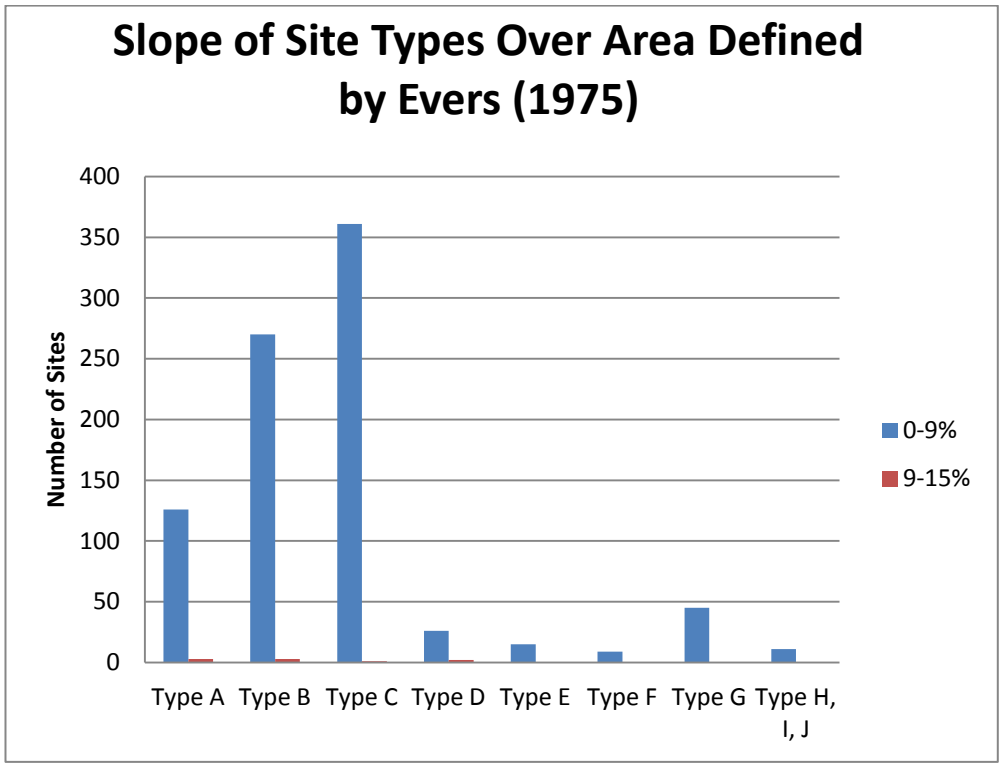


Figure 7.47: Majority of the sites occurred at a slope gradient of 0 to 9 per cent

7.6 Cluster Analysis

This process was performed in order to test the spatial characteristics of site distribution. The results indicate that the sites are clustered and not distributed randomly or regularly (figures 7.48 and 7.49). The significance of these results prove a level of social organisation occurs

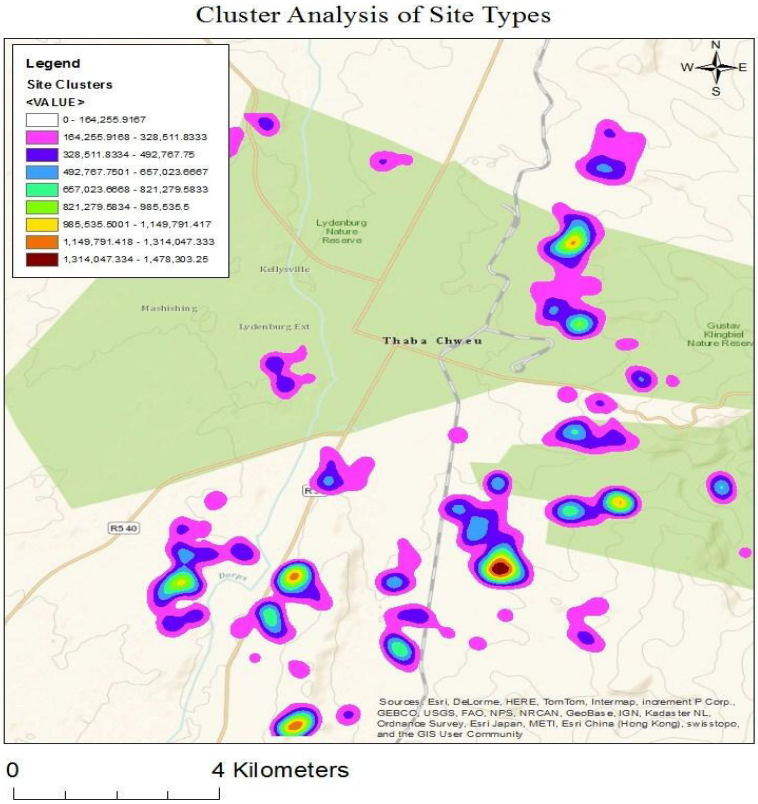


Figure 7.48: Cluster analysis on site types in the area as defined by Evers (1975)

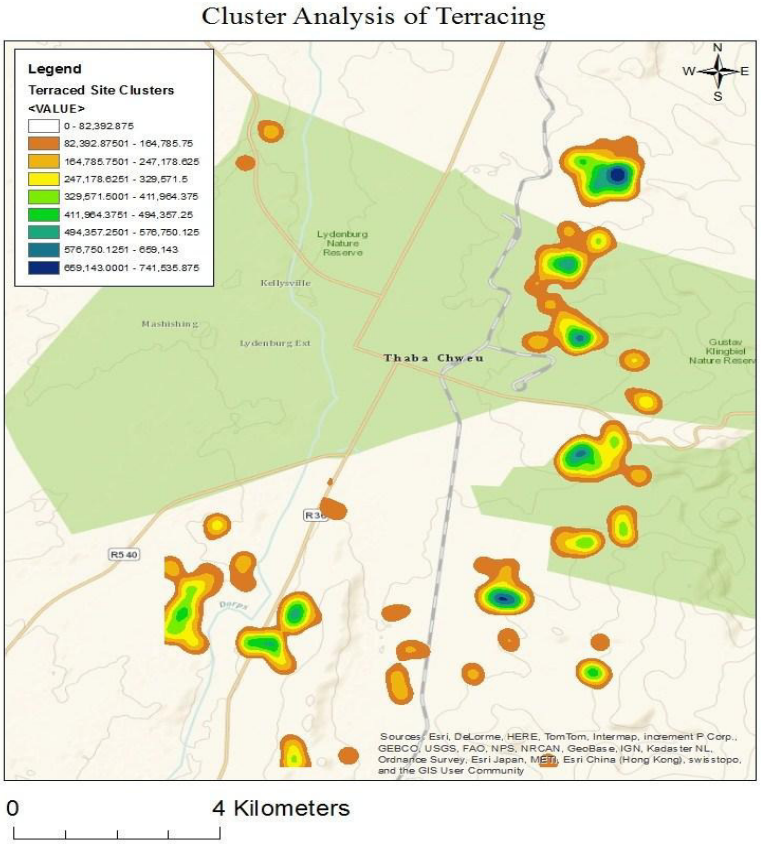


Figure 7.49: Cluster analysis of terraced sites in the area as defined by Evers (1975)

7.7 Detailed Site Analysis

7.7.1 Area (m²) of Individual Sites

The areas of individual sites were calculated. The results indicate that a variation of sizes occur for each type (Figure 7.50). Type A are predominantly in the range of 1000 m² or less with several larger sites. Type B range predominantly between 1000 m² 2000 m² with a significant proportion of sites between 2000 m² and 3000 m² with several others sites that range up to 8000 m². Type C range predominantly between 1000 m² and 3000 m² with several larger sites that range up to 8000 m². Type D range predominantly between less than 1000 m² and 2000 m². Type G range predominantly between less than 1000 m² and 2000 m². The other types are varied in sizes.

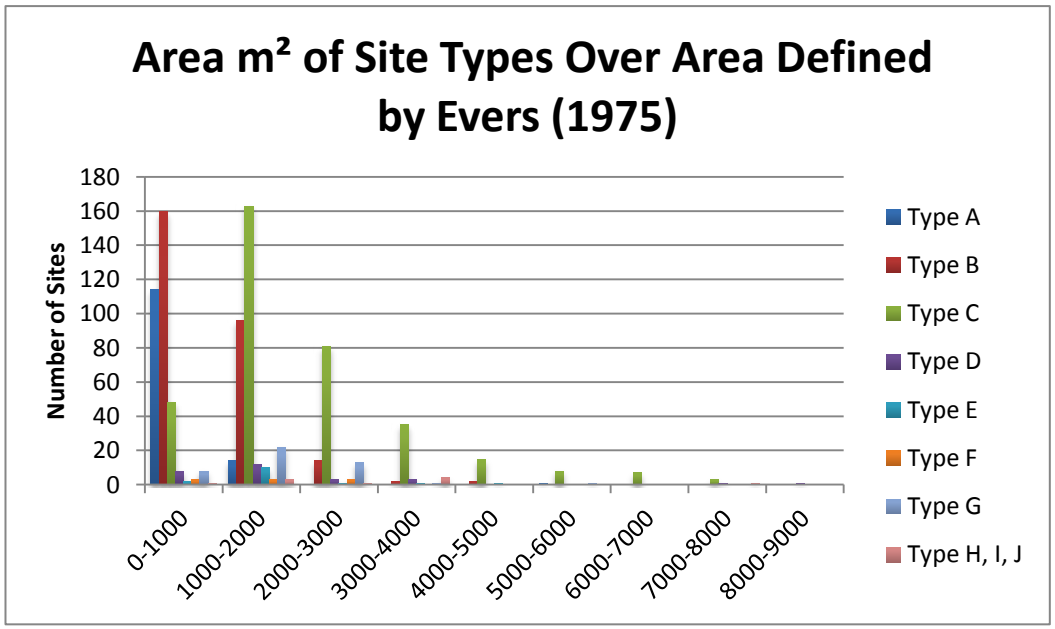


Figure 7.50: Area (m²) of site types that occur in the area as defined by Evers (1975)

7.7.2 Site Distribution in Relation to Terraces

Site types were plotted alongside terraced sites with a 150 m buffer zone (figure 7.51 and 7.52). This analysis serves to observe which types were located in areas of terracing. Type A has a higher percentage of sites that are not within the 150 m buffer zone of terracing. Type A sites which do occur in the vicinity of terraces occur mainly alongside type A terraces. Type B, C and D sites vary in their relation to terraced sites. Type F sites are almost exclusively related to Type A terracing. Type G sites show no particular pattern with 53 % of sites falling outside the buffer zones and 47 % located near both types of terraces. Sites H, I and J are very limited in numbers which makes it difficult to observe any possible patterns.

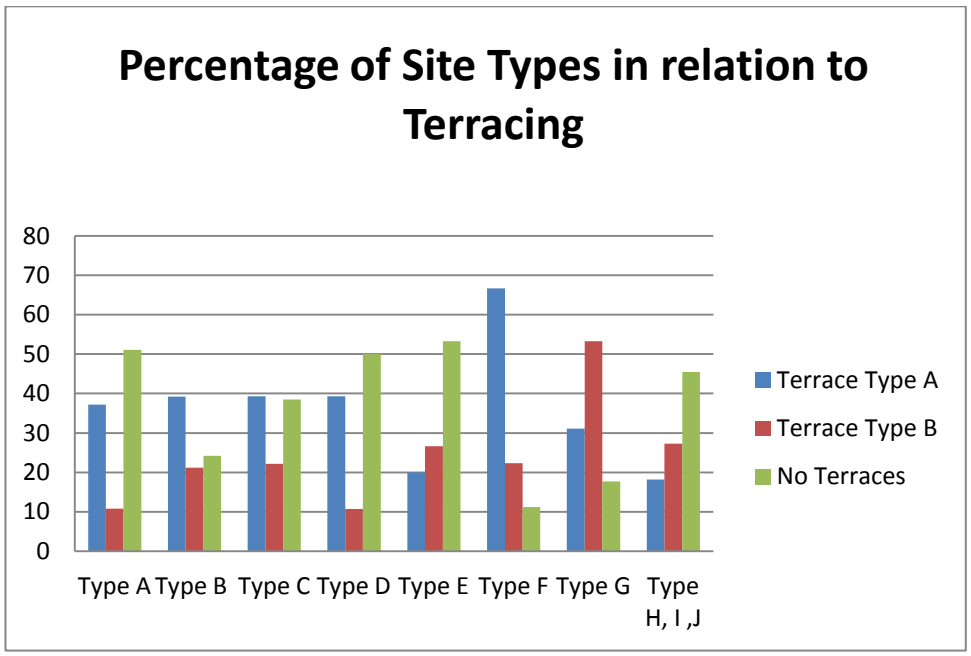


Figure 7.51: Percentage of site types in relation to terracing

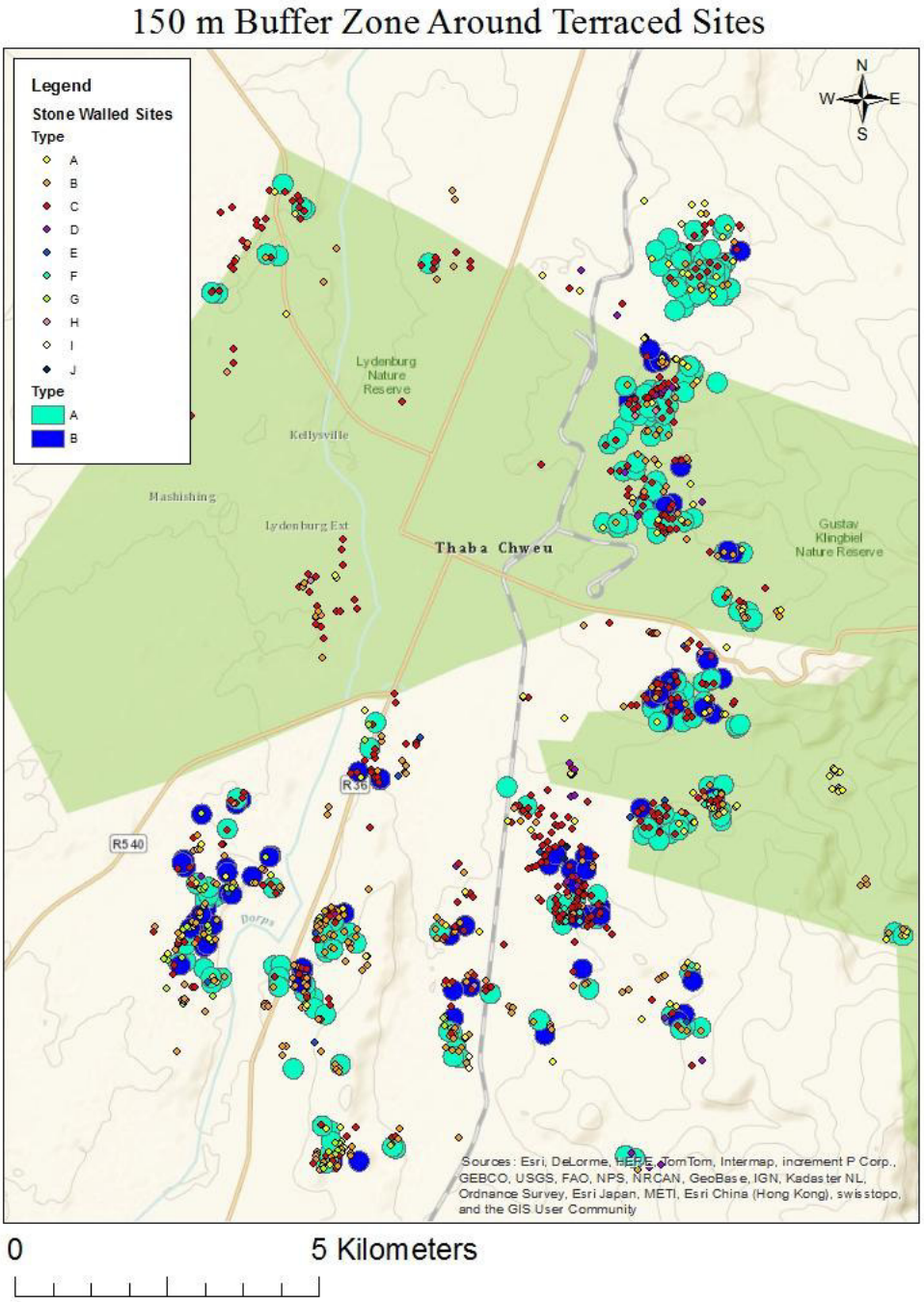


Figure 7.52: Site types in relation to terracing

7.8 Viewshed Analysis

The final factor in determining the choice of site location is a viewshed analysis. The results of the general area analyses demonstrate that a significant portion of land was visible from the sites (see Figure 7.53). This would have provided the occupants with an increased defence mechanism or control over trade routes.

The second set of viewshed analyses indicated that the views are generally of a northern and north-westerly direction. This corresponds with the slope analysis where sites were located more in this orientation (see Figure 7.54).

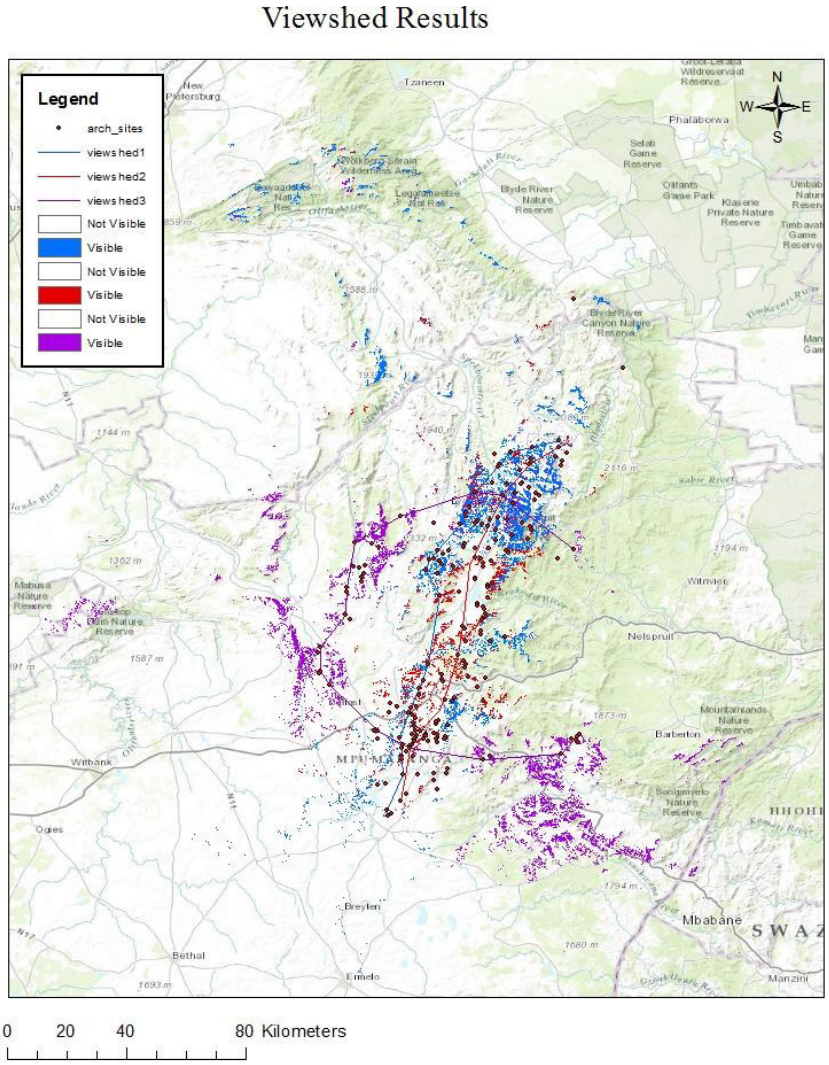


Figure 7.53: Viewshed analysis over entire escarpment area

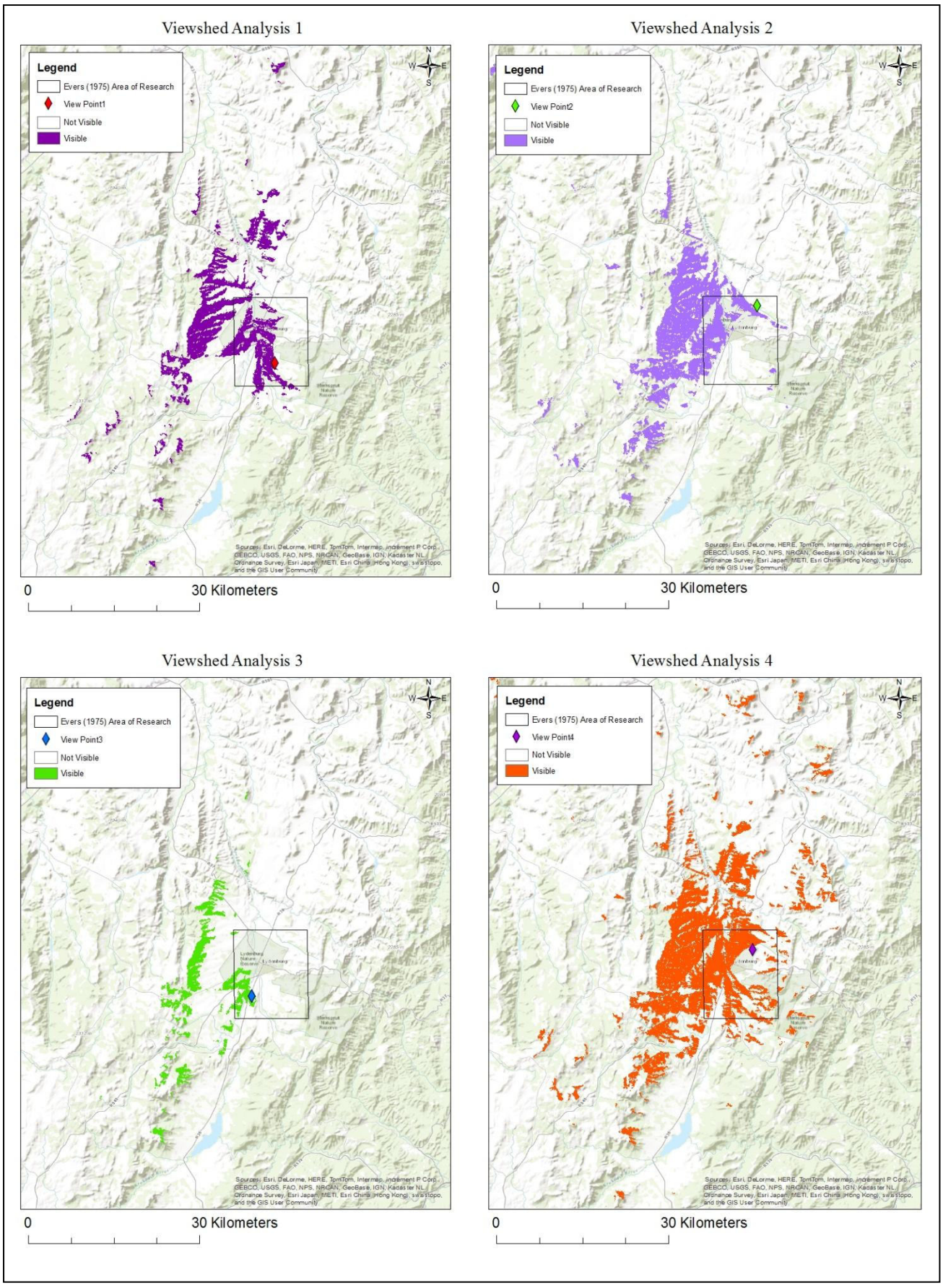


Figure 7.54: Four variants of viewshed analyses

7.9 Conclusion of Results

By considering the impact of agricultural suitability, access to surface minerals that are suitable for mining, prevalence of disease and the connection to trade on site selection it is possible to draw conclusions about the reasons why LFC settled so extensively along the Mpumalanga escarpment. The rainfall patterns, temperature variations, soil composition and geology all indicate that the area would have been suitable for the production of maize, sorghum, beans or legumes, and cucurbits. Furthermore, these crops could be harvested extensively during the summer seasons and thus produce a surplus of food. The vegetation of the area suggests sufficient ability for grazing at certain periods within the year. Mining of gold and iron was also a possible factor in the site selection as these minerals occur throughout the area. Due to the elevation of the area it can be concluded that the area was free of the dread diseases of malaria and nagana throughout the year, even with the consideration of a severe change in climate. The close proximity to trade routes would also have been beneficial to LFC and may have influenced their site selection. Landscape features in particular, offering great visual ability from the high altitude, would also have played a role in their choice of site location. Each one of these five factors undoubtedly played a role in the LFC choosing to live along the Mpumalanga escarpment. The extent and importance of each above mentioned factor is considered in chapter eight of this paper.

Chapter Eight

Discussion

The analysis of this research demonstrated that the site location of LFC across the Mpumalanga escarpment is determined by a variety of different factors. These include the agricultural potential of the land, access to surface level minerals suitable for mining, prevalence of disease, landscape features, connection with trade routes and lastly the impact of political structures. These factors in turn are influenced by different factors such as climate and seasonality. Each of these factors are discussed in detail in this chapter. Below (Table 8.1) follows a summary of the events that have occurred over the past 500 years, including climate shifts.

The use of a GIS helps with garnering knowledge of the landscape under investigation and gaining familiarity with it (Llobera 2012). By using Google Earth software, it was possible to locate and document sites on the landscape that would otherwise have been an expensive and time-consuming task. Classification of the sites is a necessary step as this serves as a means of establishing comparable terms of reference for the sites within the area of research (Cooper 2010). Other software such as ArcMap and QGIS are valuable tools for landscape analysis as they have the ability to easily calculate various scenarios and provide essential data related to research questions. The use of cost path, viewshed and clustering analyses provide researchers with new information on a particular landcsape. As site location preferences are the result of complex decision making processes, a GIS can aid in determining reasons behind the choices made as to the selected areas of settlement (Garcia 2013).

Tabel 8.1

Year	Climate	Trade and politics	Disease	Author
1400	Wet phase			Norström *et al* 2005
early 1400	Dry phase			Norström *et al* 2005
late 1400's	3°C higher than present			Holmgren *et al* 2001
1500		Start of occupation on Mpumalanga Escarpment		Tyson *et al* 2002
1520-1560	Severe drought			Norström et al 2005
1544		Copper trade during Lourenço Marques and Antonio Caldeira expeditions		Evers 1973b Eldridge 1992
mid 1500	Dry phase			Norström et al 2005
1575	Drought			Norström et al 2005
1600's-1700's	Occasional wet phase			Norström et al 2005
1600's		Violent phase		Delius and Schoeman 2008
1640	Dry phase			Norström et al 2005
1650		Maroteng settled the area		Delius and Schoeman 2008
1600-mid1700s		Violent phase		Delius and Schoeman 2008
1700-1730	Dry phase			Norström et al 2005
1720		Copper trade with Europeans at Delagoa Bay during occupation of the Dutch East India Company		Evers 1973b
1720	Drought			Norström et al 2005
1721-1729		Dutch settlement at Delagoa Bay (main export ivory)		Eldridge 1992
1731		No slaves available at Delagoa Bay (no wars)		Eldridge 1992
mid 1700	Dry phase			Norström et

				al 2005
1750-1760		English dominated Delagoa Bay (Main export ivory)		Eldridge 1992
1770		Austrian rule at Delagoa Bay (Main export ivory)		Eldridge 1992
1780	Drought			Norström et al 2005
1780		Increase in cattle raiding to supply European ships with meat		Wright and Hamilton 1989
1790-1800		Demand for food stuffs and meat from American, French and British whalers		Bonner 1983 Eldridge 1992
1800's			Traveller reports of tsetse and malaria in low-lying areas of Mpumalanga	Packard 2001
1810-1820		Active trade		Eldridge 1992
1837			Louis Trichardt accounts of tsetse fly and fever on route to Delagoa Bay	Fuller 1923 Packard 2001
1840			Boers in north and east lowland areas of Mpumalanga forced to move to higher ground due to fever	*Packard 2001*
1843-1848			Fever reported in Ohrigstad valley	Packard 2001
1875	Wet phase			Norström et al 2005
1878			Infestation of tsetse fly	Fynney 1878
1897			Tsetse from north to south of the north east of southern Africa	Fuller 1923
early 1900's	Dry phase			Norström et al 2005

8.1 Climate

The greatest influential factor on site location and success is climate. This is because climate has the greatest influence on what type of vegetation can grow in a specific area and on the agricultural potential of the land, as well as in determining the prevalence of diseases. When considering the primary reasons behind the site locations of the LFC, an accurate investigation into climatic phases and temperature shifts of the past is vital. As mentioned in Chapter Seven, major climate shifts such as the temperature increase from 1440 to 1520 and the cooler periods of 1540 to 1575 and 1730 to 1725 would have had a profound effect on the escarpment settlements.

8.1.1 Paleo-climates

Several studies have been based on observing paleo-climates. These include using speleothem data (Holmgren *et al*. 2001, Holmgren and Öberg 2006). These data show that the annual maximum temperatures were 3 °C higher than the present-day temperatures in the late fifteenth century, (see Chapter Four). This is important in discerning site location as it was at this time that the LFC began to expand into the Mpumalanga escarpment, which suggests a connection between the rise in average temperature and the suitability of the area for supporting human settlement. This is most probably due to the massive improvement of the micro climate within the Mpumalanga escarpment which could also lead to the production of a food surplus.

A second method to observe paleo-climates is dendrochronology, (see Chapter Four) (Norström *et al.* 2005, Visagie 1985, Tyson 1991, Tyson *et al* .2002, Hall 1976). These data show drier periods in the early 1400s, mid 1500s, mid 1700s and early 1900s and wetter periods in the late 1400s and 1600s (Norström *et al.* 2005). The wet phase in the late 1400s correlates with the above mentioned 3 °C peak recorded from derived speleothem data. This increase in temperature and rainfall appears to be one of the primary instigators in the expansion of the LFC into the escarpment region. The high increase of temperature on the escarpment would have made the area ideal for agriculture as suggested in Chapter Seven.

The dendrochronological study conducted by Norström *et al.* (2005) suggest that there was a severe drought phase between 1520 and 1560 which would have had a significant impact on any developing societies in the area. The escarpment also has a moisture advantage of mist belts.

8.1.2 Mist belts

It is crucial to consider that a regular mist belt occurs in the area and therefore the moisture levels would have remained slightly higher on the Mpumalanga escarpment when compared to the surrounding areas. This is a key factor as to choice of site location as during severe drought the mist belt would have continued to help sustain seasonal agricultural activity and grazing for livestock. Another factor to consider is that between 1300 and 1850 the Little Ice Age occurred where annual rainfall could have possibly decreased to below 500 mm (Smith *et al.* 2007). This point is important as this drier phase extends over the occupation time of the LFC on the escarpment, suggesting the capability of the LFC to utilise the mist belt to their advantage.

8.1.3 Contemporary climate data

By using contemporary weather data and a GIS the favourability of the Mpumalanga escarpment climate for the cultivation of maize, sorghum, legumes and cucurbits could be examined. Although the current temperature conditions are somewhat lower than the ideal temperature; they still meet the minimum temperature requirement of 20 °C for the cultivation of all the above mentioned plants. Furthermore, when observing current data, the escarpment area is exposed to higher amounts of annual rainfall and precipitation than the surrounding areas. Even in a dry year the precipitation on the escarpment is always suitable for the production of maize, sorghum, legumes and cucurbits. Lastly, if the dry phases of the past are comparatively similar to current conditions (Smith *et al* 2007), then this would further suggest that agriculture was potentially sustainable in the dry phases and that the warm phases would have provided ideal conditions for large-scale food production during the summer months.

8.2 Soil and geology

Climate is not the only determining factor for potential agriculture. Soil type also plays a significant role. Therefore it was necessary to plot the sites over soil type maps and geological maps to determine whether the areas are suited to the cultivation of the above mentioned plants. All the above mentioned plants require moderately fertile, well drained soils (see Chapter Three). As mentioned in Chapter Three, the magnesium levels on the escarpment hill slopes are better suited to plant production than the higher levels in the valley areas further below. By scrutinising the maps in Chapter Seven it is evident that the soil types are suitable.

8.3 Manipulation of the environment

8.3.1 Intercropping

Cultivation of maize, sorghum, legumes and cucurbits is possible on the Mpumalanga escarpment according to the basic physical environment. The LFC would also have manipulated the environment to further enhance agricultural potential. One method they would have used is the system of intercropping (Smith 2005) which would have improved agricultural potential in weaker soils. By mixing legumes into the crop it is possible to fix nitrogen into depleted or infertile soils. Cucurbits create a ground cover which inhibits evaporation by providing shade over the soil as well as maintaining a warm temperature during cooler times. By utilising these techniques the LFC on the escarpment could have grown large quantities of food, even producing an excess.

8.3.2 Terracing

The terracing present in many sites represents further manipulation of the area to enhance agricultural potential. First, the area around the sites was exceedingly rocky, as they were located on dolerite intrusions (Hall 1987). Creating terraces would have been a successful method of clearing rocks from the area chosen for agriculture without having to spend the energy to carry them across extensive

distances. Secondly, as the area is, according to current climate observation, on the fringe of being too cold for agriculture, the terracing technique could also have served as a method of protection for the plants against the cold, thereby sheltering vulnerable saplings from cold winds and acting as a thermal trap during cold nights. The benefits of this new form of agriculture resulted in the long-term sustainability and therefore empowerment of these settlements. The terraces represent large scale advanced agriculture that during times of famine could have supported a larger population base by supplying a surplus above local needs.

The maps created with the GIS also showed the sites to be located on areas that provide building material in abundance as well as being suitable ground for agriculture. The two types of terracing present on the escarpment also represent different methods of manipulation with some terraces completely enclosed by outer walls. This method could possibly create vacuums of high agricultural potential.

This practical application of environment manipulation for the benefit of agriculture provides evidence that although climate controls the environment, it does not necessarily entirely control the choices made concerning the location of settlements. It will of course play a large role, however it is not the primary determinant.

8.4 Disease

Another environmental factor that would have had an effect on the choice of site location is disease. As discussed in Chapter Five, malaria and nagana or sleeping sickness were in abundance in the north-eastern parts of southern Africa. The maps produced show that the Mpumalanga escarpment sites are beyond the reach of the diseases. The main determining factor of malaria and tsetse fly distribution is elevation, with the limiting elevation for malaria being 600 m ASL and that of the tsetse fly being 920 m ASL. With the sites at elevations of more than 1200 m ASL it is evident that site location was carefully chosen to provide a safe haven from the ravages of both diseases.

8.4.1 Climate influence on disease

Climate is a primary determinant in the distribution of disease. During the warmer wetter periods the diseases would have been in greater abundance. Site locations relied on sustaining human and cattle numbers; therefore, settlers would have avoided positioning themselves on more favourable agricultural land in the lower areas where diseases were prevalent and loss to economic wealth was a high possibility. The above suggests that the occupation of the escarpment would have been marginal, being utilised during times of need. The warmer wetter periods being the times of occupation as diseases would be in abundance in the lower areas and the climate could sustain agricultural potential at the higher altitudes.

8.5 Minerals and mining

The last environmental factor that may have played a role in determining the choice of site location is that of available minerals. The maps produced indicate the sites to be in close proximity to iron, lead, gold and copper. Mining these minerals would have been beneficial to the LFC by providing them with convenient trade items as well as increasing the economic power of the community.

8.6 Trade

So far we have investigated the environmental factors that would have influenced the choice of site location. However Delius (2007) mentions that during the settlement time of the LFC intensive trade networks existed and that Mpumalanga was an important throughfare for long distance trade

As mentioned in Chapter Three, two forms of trade occurred; local trade in the interior and long distance trade. With the escarpment sites being located within such a unique environment this would have afforded them the benefit of producing food during times of famine or sustaining cattle numbers during times

of high disease prevalence. This in turn would have further empowered the society as a whole as they were able to trade food products locally. Furthermore, with the abundance of precious minerals the LFC on the escarpment had a great advantage in economic empowerment if they were mining these minerals.

8.7 Cattle

If the LFC increased their livestock to the point where it formed their principle resource; the escarpment area would have become valuable open grazing land. As mentioned in Chapter Seven, the soils in the area were sufficient for grazing potential. The LFC in this case, would have initially occupied the land in order to graze cattle (Hall 1987). It is viable that they had large amounts of cattle as the presence of large cattle kraals suggest. The latter can be seen with Google imagery and as Chapter Six presented, these sites are significant in size. As mentioned in Chapter Three and Chapter Seven, the practice of transhumance would have occurred as the vegetation is only suitable for grazing during spring and early summer. This suggests seasonal occupation of the escarpment.

8.8 Social pressure

Another factor to take into consideration is the social pressure existing at the time. During times of famine and political instability, as Mason (1968) mentions, site placement was influenced by inter-settlement conflict over cattle and other resources. Therefore, as defence against sudden attack or control of resources became more important, so did site selection. It is possible that it was during these times of regular conflict that the occupation of the escarpment would have begun in order to gain access to better resources or to avoid conflict. There is no direct evidence of defensive walling on the escarpment, suggesting that during severe times of violence LFC would have fled elsewhere or the high altitude would have allowed visual advantages which would provide sufficient warning against attacks, as the viewshed analysis in Chapter Seven suggests.

8.9 Advantages of settlement on the Mpumalanga escarpment

With the increase in temperature during the late 1400s and early 1500s the escarpment would have been settled due to warmer temperatures having influenced an increase in diseases such as malaria and nagana in the low-lying areas which would have driven the LFC to higher altitudes. A profusion of diseases would have had a negative impact on populations that had settled on lower lying lands, further increasing and empowering the population on the escarpment as they would not have been negatively affected.

With the ability to produce surplus foods in conjunction with the warmer temperatures the population that had settled on the Mpumalanga escarpment would have increased due to an abundance of food products, as the climate was particularly favourable at that time. The occupants, and their cattle, would have remained free of dread diseases. When drought occurred the LFC were still able to produce food during the summer months due to their position within the mist belt. This again would further have empowered the society as they could increase their localised trade with less fortunate farmers in drier regions. The extent of terracing would suggest a large-scale production of surplus.

Shortly after the start of occupation on the escarpment a severe drought was recorded between 1520 and 1560. It is during this time that copper trade during the Lorenço Marques and Antonio Calderia expeditions at Delagoa Bay were recorded (1544). The above statement suggests that trade was initiated at this time as a result of difficult environmental conditions. A trade route to and from the Mpumalanga escarpment would possibly have been recognised from this time.

Precious minerals obtained in the area would have increased the economic power of the society. This would have been beneficial because if the agricultural activities had failed due to droughts and there was a food shortage, these minerals could then be traded locally and long distance for nutritional products.

Specialist trading items such as minerals or ivory would also have attracted long distance European trade. Europeans would have brought in other specialist items such as glass beads, that would be further used during local trade, thereby creating

a further attraction towards the escarpment settlements and further embedding that specific trade route.

It is believed that the Maroteng settled in the Mpumalanga escarpment in 1650. Delius and Schoeman (2008) recorded an exceptionally violent phase in the area between 1600 and the mid 1700s. This suggests that during this time the area became a profitable estate and competition over ownership became rife. Dry phases in climate are recorded over this period again suggesting that the area was able to sustain grazing and agriculture during drier periods.

An extended drought occurring around 1720 coinciding with records of copper trade with Europeans at Delagoa Bay during the occupation of the Dutch East India Company. During 1721 to 1729 the Dutch had settled at Delagoa Bay; their main export being ivory (Chapter Three). This suggests that during particularly difficult times the LFC were able to sustain livelihoods through their connections with the trade routes that would have been previously established into the area, creating a permanent trade route to the escarpment settlements thereafter.

Between 1780 and 1800 there are reports of cattle raiding to supply European ships with meat as well as a high demand for food stuffs by British, French and American whalers (Wright and Hamilton 1989, Eldridge 1992). A well defined trade connection has clearly been established at this point. Political instability appears to be the result of competition to trade as opposed to competition over land resources. This suggests that the trade networks had become well defined and prominent features of the landscape.

From the 1800s, reports of malaria and nagana in the low-lying areas occur (see Chapter Five). These reports coincide with warmer wetter climate conditions. The large cattle kraals on the escarpment present large-scale cattle production for trading. The area being free from disease presents an attractive location. As the trade routes have already been established into the escarpment, these sites would have become a regular stop off point for European traders as they would be able to purchase large numbers of cattle as well as rest their oxen with an easy mind.

The LFC of the Mpumalanga escarpment society could produce a surplus of food, had access to a large variety of minerals, were well placed in regards to defence and were free of disease. Therefore, the area was extremely appealing to travellers and traders alike. Over time this society possessed the potential to advance to a seasonal central trading port as it provided significant advantages.

8.9.1 *Trade port?*

The large cattle kraals mentioned above suggest that a considerable number of cattle were in their possession. It is possible that the cattle represented massive wealth to the LFC themselves or it may be possible that this "port" provided "safe ground" for travellers and traders with cattle to remain free of disease. The port would provide a convenient stop off point for long distance trade between Durban and Delagoa Bay. It would also provide an opportunity for replenishing supplies and trading without the risk of losing cattle or members of the trekking group to disease. Furthermore, the constant movement of traders and travellers through this area would have brought information into the society regarding political structures outside the escarpment area. This would have benefited the escarpment settlements as they could have mitigated the risk of raids.

8.10 Summary

The Mpumalanga escarpment settlements began to develop during a time of favourable climatic conditions. The escarpment provides a good environment for the grazing of cattle and during warmer conditions has high potential for agriculture. The use of a GIS displayed that the elevation of the sites provides a safe zone from the dread diseases of malaria and nagana which would have occurred during the warmer periods, providing the opportunity for this new society to grow and become more sustainable.

When the climate cooled, the new technique of terrace agriculture which was initially developed on mild hill slopes to avoid areas of high magnesium levels

(Chapter Three), continued the ability to settle the area as terracing provides protection for plants from cooler conditions.

Trade connections began during these times as surplus food and livestock would have been available from the escarpment settlements as opposed to less fortunate farmers away from the mist belt. The trade routes to the area were established at that time. The least-cost paths developed over the region resulted in different routes through the landscape as compared to the historical routes on record. This suggests that there are a multitude of factors that need to be taken into consideration other than the physical environment alone. Social economic factors of movement through the region needs to be researched further in the future to better understand the movement through this landscape.

It is the uniqueness of the Mpumalanga escarpment that allowed for continued agricultural practices and therefore increased empowerment, which resulted in increased populations. The ability of the LFC on the Mpumalanga escarpment to manage their environment successfully in times of need demonstrate that the sites were on marginal environments; being occupied seasonally and during periods of severe climate shifts, using the mist belt during times of increased drought and avoiding disease during increased wet phases.

This successful settlement would subsequently have become attractive to outside parties of traders and travellers as a safe zone during the summer months when disease was in abundance elsewhere, where replenishment of supplies, resting of cattle without the threat of illness and specialist trading could occur – suggesting a seasonal trading port.

Chapter Nine

Conclusion

Much of the existing body of the Late Farming Community (LFC) archaeological research is based on the stone walled sites of the Mpumalanga escarpment, with a particular interest in the terraced sites. A considerable amount of research has been conducted on these sites, however, very little is known as to why the terraced sites occur along the escarpment, at an altitude that is unfavourable for agricultural practice, and nowhere else in southern Africa, and furthermore what benefits these terraces may have provided for the LFC. With the use of a GIS, a variety of different data relating to the area of concern can be viewed simultaneously and compared in order to gain further insight into the sites themselves. As mentioned in the previous chapter, landscape analysis is a valuable tool in understanding settlements in specific areas as it can conduct analyses on site distribution patterns and present possible trends in land use.

The purpose of this paper was to investigate the following questions;

- Why are the sites positioned on the Mpumalanga escarpment?
- What do the terracing structures represent?
- To what extent did environmental factors such as climate, vegetation and disease influence the choices made concerning site distribution?
- How did the environmental factors shape social networking?
- Is the environment a primary determining factor in the selection of site distribution?
- Are the stone walled sites on the Mpumalanga escarpment representative of a central trading port?

In attempting to answer the above questions, it became evident that there are a multitude of intertwining elements that would have exerted an influence on site selection. Questions surrounding these factors include:

- What was the agricultural potential in the area?
- Would endemic diseases affect the choices made in site selection?
- What do available minerals in the area present for the LFC?
- How did trade routes influence the community?

It can be concluded from the results that:

- Agricultural exploits of maize, sorghum, legumes and cucurbits were possible on the escarpment, even during a dry year, as the precipitation levels on the escarpment remained relatively high.
- Malaria and nagana were not prevalent on the escarpment area as the limiting elevations were below that of site locations. Even when the limiting elevations band was increased significantly the diseases were not prevalent at the sites on the escarpment.
- Geological maps of the area present that iron, lead, gold, copper, bismuth and chrysotile asbestos were present in the area. These may have been mined for trade items.
- Trade and traveller routes most certainly passed through the area, representing a complex network of trade and advanced social behaviour.

Why are the sites positioned on the escarpment?

This research proposes that it is a combination of climate, disease prevalence, and social and political structures that determined site location. Not one factor is a primary determinant as the LFC present a complex society that cannot be explained by one simple factor. With the increase of climate in the late 1400s, the Mpumalanga escarpment became favourable as it would have provided good grazing for cattle, it had a high potential for agriculture and it was free of disease during the summer months.

How did the environment shape social networking and choices made in site selection?

During a severe drought from AD 1520 to 1560 occupation on the escarpment was continued as the mist belt provided essential moisture for the production of

food surplus. During this time trade with the Portuguese at Delagoa Bay would have initiated a trade route through the area.

The Maroteng settled the area during 1650 as the area had the capability to resist extremes in climate due to available moisture during periods of drought and being free of disease during warmer periods. Furthermore, with the previous establishment of a trade route the appeal of the site increased. Political instability occurred from this time up till the mid 1700s, suggesting that competition prevailed over the area and its wealth potential.

What do the Terracing structures represent?

Terraces represent advanced agriculture systems. The terraces in the area would have provided protection of cultivated plants from the cold thereby allowing the continuation of settlements and agriculture during periods of drought. Terracing was also used to provide sufficient arable areas on mild hill slopes in order to avoid the high magnesium levels found in the soil further down the escarpment. The two types of terracing that are described in Chapter Six present a complex method of agriculture designed specifically for the landscape in which they occur.

Do the Mpumalanga settlements represent a past central trading port?

It appears that a central trading port was established but only seasonally and during extreme climate phases as the sites were found in areas with marginal environments. The ports were used mainly during warmer seasons when the production of crops and extensive grazing of cattle could occur. During these warmer seasons disease would have had an effect on the local populations within the greater region around the escarpment, as well as on the Europeans and the cattle. During extreme climate phases the escarpment provided the necessary moisture to continue agricultural production. The escarpment settlement must have become a powerful economy as long distance traders and travellers would have begun to detour in order to pass the escarpment settlements. They would have done so in order to replenish supplies, rest and feed cattle without the risk of disease.

Summary

Literature and GIS observations suggest that with the favourable climatic conditions, the increase in the demand for or number of cattle and the growing need for resources, the escarpment was settled. Due to the practice of terraced agriculture the occupation was able to continue during times of drought which empowered the settlement in comparison to other, low lying settlements. As the settlement increased in size so the appeal of the area grew for travellers and traders. The use of a GIS in the basic landscape analysis has presented that the Mpumalanga escarpment is a unique setting that is capable of sustaining a population and can continue to sustain it even during climate shifts.

The terraces are the key to the survival and growth of the Mpumalanga escarpment settlements. During times of drought the area would have had sufficient moisture available for food production; however, the temperatures were on the fringe of being too cold. Terracing provided a means to maintain adequate moisture and heat levels for growing crops during extreme climate shifts. The significant advantage of being able to produce a surplus during these times is what ultimately led to the development and success of the LFC sites on the Mpumalanga escarpment. Being a large, well-stocked settlement that resided in a nagana and malaria free zone made these sites a regular stop off point for traders and travellers, suggesting that the Mpumalanga escarpment settlement was indeed a seasonal central trade port.

References

Aldenderfer, M. 1996. Introduction to *Anthropology, Space and Geographic Information Systems.* In Aldenderfer, M. & Manschner, H. D. G. (ed.) 3 – 18. Oxford: Oxford University Press.

Austen, E. E. 1911. *A Handbook of the Tsetse-Flies [Genus Glossina]*. London: William Clowes and Sons, Limited.

Beaumont, P. B. & Vogel, J. C. 1972. On a new radio carbon chronology for Africa south of the equator. In: Evers, T. M. 1977. Recent progress in studies of the Early Iron Age in the Eastern Transvaal, South Africa. *South African Journal of Science* 73: 78-81

Blom, R. G., Crippen, R., Elachi, C., Clapp, N., Hedges, G. R. & Zarins, J. 2007. Southern Arabian desert trade routes, frankincense, myrrh and the Ubar legend. In Wiseman, J. & El-Baz, F. (ed.) *Remote Sensing in Archaeology*: 71 - 87. New York: Springer Science and Business media, LLC.

Bonner, P. 1983. *Kings, Commoners and Concessionaires: The Evolution of the Nineteenth-Century Swazi State*. Great Britain: Cambridge University Press.

Cairncross, B. 2004. *Field Guide to Rocks and Minerals of Southern Africa.* Cape Town: Struik Publishers.

Clarke, D. L. 1977. *Spatial Archaeology*. London: Academic Press.

Cockcroft, M. J., Wilkinson, M. J. & Tyson, P. D. 1987. The application of a present-day climatic model to the late quaternary in southern Africa. *Climate Change* 10: 161-181.

Collins Family Atlas. 1985. Marshalltown: Collins Vaal (Pty.) Ltd.

Collett, D. P. 1982. Excavations of stone-walled ruin types on the Badfontein valley, eastern Transvaal, South Africa. *The South African Archaeological Bulletin* 37: 34 – 43.

Cooper, J. 2010. Modelling Mobility and exchange in pre-Columbian Cuba: GIS led approaches to identifying pathways and reconstructing journeys from the archaeological record. *Journal of Caribbean Archaeology* Special publication #3

Crawford, O. G. S. 1924. *Air Survey and Archaeology.* London. H.M.S.O.

Dart , R. A. & Beaumont, P. B. 1969. Iron Age radiocarbon dates from W. Swaziland. *South African Archaeological Bulletin 24*: 91.

Darvill, T. 2003. *Oxford Concise Dictionary of Archaeology.* New York: Oxford University Press.

Delius, P. 1983. *The Land Belongs to Us.* Johannesburg: Ravan Press.

Delius, P. 2007. In: Delius, P. (ed) *Mpumalanga: History and Heritage*. KZN: University of Kwazulu Natal Press.

Delius, P. & Schoeman, M. H. 2008. Revisiting Bokoni: populating the stone ruins of the Mpumanalga Escarpment. In Swanepoel, N., Esterhuysen, A. & Bonner, P. (eds) *Five Hundred Years Rediscovered: Southern African Precedents and Prospects*: 135 - 167. Johannesburg: Wits University press.

Delius, P. & Hay, M. 2009. *Mpumalanga: An Illustrated History.* Johannesburg: The Highveld Press.

De Meillon, B. 1931. Illustrated keys to the full-grown larvae and adults of South African anopheline mosquitoes. *Publication of the South African Institute for Medical Research* 4: 275-375.

De Meillon, B. 1934. Entomological studies-observations of *An.funestus* and *An. Gambiae* in the Transvaal. *Publication for the South African Institute for Medical Research* 32: 195-248.

De Meillon, B. 1986. The control of malaria with special reference to the contributions made by the staff of the Institution for Medical Research. *South African Medical Journal* 76 suppl: 67-69

De Vaal, J. B. 1984. Ou handelsvoetpaaie en wapaaie in Oos- en- Noord-Transvaal. *Contree: Journal for South African Urban and Regional History* 16. In

Esterhuysen, A. B. & Smith, J. 2007. Stories in stone. In: Delius, P. (ed) *Mpumalanga: History and Heritage*. KZN: University of Kwazulu Natal Press.

Eldredge, E. A. 1992. Sources of the conflict in Southern Africa, c. 1800-30: The Mfecane' reconsidered. *Journal of African History* 33: 1-35.

Esterhuysen, A. B. & Smith, J. 2007. Stories in stone. In: Delius, P. (ed) *Mpumalanga: history and heritage*. KZN: University of Kwazulu Natal Press.

Evans, D. L. & Farr, T. G. 2007. The use of Interferometric Synthetic Aperture Radar (InSAR) in archaeological investigations and cultural heritage preservation. In Wiseman, J. & El-Baz, F. (eds), *Remote Sensing in Archaeology*: 89 – 101. New York: Springer Science and Business media, LLC.

Evers, T. M. 1973. Iron Age research in the Eastern Transvaal, South Africa. *Current Anthropology* 14(4): 487 – 489.

Evers, T. M. 1973b. Iron Age trade in the Eastern Transvaal, South Africa. *South African Archaeological Bulletin* 29: 33-37.

Evers, T. M. 1975. Recent Iron Age research in the Eastern Transvaal, South Africa. *South African archaeological Bulletin* 30:71 – 83.

Evers, T. M. 1977. Recent progress in studies of the Early Iron Age in the Eastern Transvaal, South Africa. *South African Journal of Science* 73: 78-81.

Fagan, B. M. 1965. *Southern Africa: During the Iron Age.* London: Thames & Hudson.

Fry, G.L.A., Skar, B., Jerpåsen, G., Bakkestuen, V. & Erikstad, L. 2004. Locating archaeological sites in the landscape: A hierarchical approach based on landscape indicators. *Landscape and Urban Planning* 67: 97-107.

Fuller, C. 1923. *Tsetse in the Transvaal and Surrounding Territories: An Historical Review.* Pretoria: Division of Entomology.

Fynney, F. B. 1878. The Geographical Features of the Transvaal, the New British Dependency in South Africa. *Journal of the Royal Geographical Society of London* 48: 16-25.

Gaffney, V. & Stančič, Z. 1991. *GIS Approaches to Regional Analysis: A Case Study of the Island of Hvar.* Oxford: Oxbow.

Garcia, A. 2013. GIS-based methodology for paleolithic site location preferences analysis: A case study from late Palaeolithic Cantabria (Northern Iberian Peninsula). *Journal of Archaeological Science* 40: 217-226.

Govere, J. M. 2000. Anopheline mosquitoes, malaria transmission and control in Mpumalanga Province, South Africa. Unpublished PhD dissertation. Johannesburg: University of the Witwatersrand.

Glasgow, J. P. 1963. *The Distribution and Abundance of Tsetse.* Oxford: Pergamon Press.

Gullan, P. J. & Cranston, P. S. 2005. *The Insects: An Outline of Entomology.* Oxford: Blackwell Publishing.

Hadfield, J. 2001. *The A-Z of Vegetable Gardening in South Africa.* Cape Town: Struik Publishers.

Hall, A. L. 1912. Geology of the Murchison Range and District. In. Evers, T. M. 1975. Recent Iron Age research in the Eastern Transvaal, South Africa. *South African Archaeological Bulletin* 30:71 – 83.

Hall, M. J. 1976. Dendroclimatology, rainfall and human adaption in the Later Iron Age of Natal and Zululand. *Annals of the Natal Museum* 22: 693-703.

Hall, S. J. 1981. Iron Age sequence and settlement in the Rooiberg Thabazimbi area. Unpublished PhD dissertation. Grahamstown, University of the Witwatersrand.

Hall, M. 1987. *The Changing Past: Farmers, Kings and Traders in Southern Africa, 200-1860.* Chicago: University of Chicago Press.

Hall, M. 1988. A Consideration of gender relations in the Late Iron Age 'Sotho' Sequence of the Western Highveld, South Africa. In Kent, S. (ed) *Gender in African Prehistory.* London: AltaMira Press.

Hammel, A., White, C., Pfeiffer, S & Miller, D. 2000. Pre-colonial mining in southern Africa. *The Journal of the South African Institute of Mining and Metallurgy* 100: 49-56.

Hill, E. & Hayden, L. G. 1905. The Epidemic of Malaria in Durban in 1905. *Journal of Hygiene* 5: 467-484. In. Govere, J. M. 2000. Anopheline mosquitoes, malaria transmission and control in Mpumalanga Province, South Africa. Unpublished PhD dissertation. Johannesburg: University of the Witwatersrand.

Hodder, I. & Orton, C. 1976. *Spatial Analysis in Archaeology.* Cambridge: Cambridge University Press.

Holcomb, D.W. & Shingray, I.L. 2007. Imaging radar in archaeological investigations: An image processing perspective. In Wiseman, J. & El-Baz, F. (eds) *Remote Sensing in Archaeology*: 11 - 45. New York: Springer Science and Business media, LLC.

Holmgren, K., Karlén, W., Lauritzen, S. E., Lee-Thorp, J. A., Partridge, T. C., Piketh, S., Repinski, P., Stevenson, C., Svanered, O. & Tyson, P. D. 1999. A 3000-Year High Resolution Stalagmite-Based Record of Paleoclimate for North-Eastern South Africa. *Holocene* 9: 295-309.

Holmgren, K., Tyson, P. D., Moberg, A. & Svanared, O. 2001. A preliminary 3000-year regional temperature reconstruction for South Africa. *South African Journal of Science* 97: 49-51.

Holmgren, K. & Öberg, H. 2006. Climate change in southern and eastern Africa during the past millennium and its implications for social development. *Environment, Development and Sustainability* 8: 185 – 196.

Howey, M. C. L. 2007. Using multi-criteria cost surface analysis to explore past regional landscapes: A case study of ritual activity and social interaction in Michigan, AD 1200-1600. *Journal of Archaeological Science* 34: 1830-1846.

Howey, M. C. L. 2011. Multiple pathways across past landscapes: circuit theory as a complementary geospatial method to least cost path for modelling past movement. *Journal of Archaeological Science* 38: 2523-2535.

Hu, D. 2011. Advancing theory? Landscape archaeology and geographical information systems. *Papers from the Institute of Archaeology, University College London* 21.

Huffman, T. N. 1982. Archaeology and ethnohistory of the African Iron Age. *Annual Review of Anthropology* 11: 133-150.

Huffman, T. N. 1996. Archaeological evidence for climate change during the last 2000 years in southern Africa. *Quaternary International* 33: 55-60.

Huffman, T. N. 2000. Mapungubwe and the origins of the Zimbabwe culture. In Leslie, M. & Maggs, T. (eds) *African Naissance: The Limpopo Valley 1000 years Ago:* 14 – 29. The South African Archaeological Society: Goodwin Series, 8.

Huffman, T. N. 2007. *Handbook to the Iron Age: The Archaeology of Pre-Colonial Farming Societies in Southern Africa.* Pietermaritzburg: University of Kwazulu-Natal Press.

Jochim, M. A. 1976. *Hunter Gatherer Subsistence and Settlement: A Predictive Model*. New York: Academic Press.

Kamermans, H. 2006. Problems in paleolithic land evaluation: A cautionary tale, In Mehrer. M. W. & Wescott, K. L. (ed.) *GIS and Archaeological Site Location Modeling.* Boca Raton*:* Taylor & Francis.

Katsamudanga, S. 2009. Past, present and future applications of geographic information systems in Zimbabwean archaeology. *Azania: Archaeological Research in Africa* 44 (3): 293-310.

Kuper, H. 1980. Symbolic dimensions of the southern Bantu homestead. *Africa* 50: 8 – 23.

Kuper, A. 1982. *Wives for cattle: Bridewealth and marriage in southern Africa.* London: Routlegde.

Kvamme, K. L. 1989. Geographic information systems in regional archaeological research and data management. *Archaeological Method and Theory* 1. Tucson: The University of Arizona Press.

Kvamme, K. L. 1990. The fundamental principles and practice of predictive archaeological modelling. In Voorrips, A. (Ed.) *Mathematics and Information Science in Archaeology: A Flexible Framework*. *Studies in Modern Archaeology* 3: 257-295. Bonn. Holos-Verlag.

Kvamme, K. L. 1995. A view from across the water: the North American experience in archaeological GIS. In Lock, G. & Stančič, Z. (eds) *Archaeology and Geographical Information Systems: A European Perspective.* London: 1-14. Taylor and Francis.

Kvamme, K. L. 2006. There and back again: Revisiting archaeological location modeling. In: Mehrer, M. W. & Wescott, K. L (eds) *GIS and Archaeological Site Location Modeling:* 4-39. Taylor & Francis, Boca Raton.

Kvamme, K. L. 1991. Terrain form analysis of archaeological location through geographic information systems. In: Lock, G. R. M (ed) *Computer Applications and Quantitative methods in Archaeology:* 127-136.Tempus Reparatum, Oxford.

Laidler, P. W. 1932. The Bantu potting industry and its impact on other native potting industries in South Africa. *South African Journal of Science* 29: 778-791.

Leslie, M. & Maggs, T. 2000. *African Naissance: The Limpopo Valley 1000 years ago.* Goodwin Series, 8: The South African Archaeological Society.

Le Sueur, D., Sharp, B. L. & Appleton, C. C. 1993. Historical perspective of the malaria problem in Natal with emphasis on the Period 1928 – 1932. *South African Journal of Science* 89: 232-239.

Llobera, M. 1996. Exploring the topography of mind: GIS, social scape and archaeology. *Antiquity* 70: 612-622.

Llobera, M., Fábreda-Álvarez, P. & Parcero-Oubiña, C. 2011. Order in movement: A GIS approach to accessibility. *Journal of Archaeological Science* 38: 843-851.

Llobera, M. 2012. Life on a Pixel: Challenges in the Development of Digital Methods Within an "Interpretive" Landscape Archaeology Framework. *Journal of Archaeological Method and Theory* 19(4): 1-15.

Maggs, T. M. O'C. 1973. The NC3 Iron Age Tradition. *South African Journal of Science* 69: 326.

Maggs, T. M. O'C. 1974. *Early Farming Communities on the Southern Highveld: A Survey on the Iron Age Settlements. Volume I. PhD thesis: University of Cape Town.*

Maggs, T. M. O'C. 1976. *The Iron Age Communities of the Southern Highveld.* Pietermaritzburg: Published by the Council of the Natal Museum.

Maggs, T. 1984. The Iron Age south of the Zambezi. In: Klein, R. G. (eds) *Southern African Prehistory and Paleoenvironments:* 329-360. Balkema: Rotterdam.

Maggs, T. & Whitlaw, G. 1991. A review of recent archaeological research on food-producing communities in Southern Africa. *Journal of African History* 32: 3-25.

Maggs, T. 2007. Iron Age Settlements of the Mpumalanga Escarpment: Some answers but many questions. *The Digging Stick* 24(2):1-4.

Maggs, T. M. O'C. 2008. The Mpumalanga escarpment settlements: Some answers, many questions. In Swanepoel, N. Esterhuizen, A. & Bonner, P. (eds) *Five Hundred Years Rediscovered: Southeren African Precedents and Prospects*: 169 - 181. Johannesburg: Wits University press.

Marker, M. E. & Evers, T. M. 1976. Iron Age settlement and soil erosion in the Eastern Transvaal, South Africa. *South African Archaeological Bulletin* 31: 153-165.

Martin, P. H. & Lefebvre, M. G. 1995. Malaria and climate: Sensitivity of malaria potential transmission to climate. *Ambio* 24: (4) 200-207.

Mason, R. J. 1963. *The Prehistory of the Transvaal.* Johannesburg: University of the Witwatersrand press.

Mason, R. J. 1968. Transvaal and Natal Iron Age settlement revealed by aerial photography and excavation. *African Studies* 27: 1 – 14.

Mason, R. J. 1974. Background to the Transvaal Iron Age – New discoveries at Olifantspoort and Broederstroom. *Journal of the South African Institute of Mining and Metallurgy* 74: 211-216.

Mason, S. J. & Lindesay, J. A. 1993. A note on the modulation of southern oscillation – southern African rainfall associations with the quasi-biennial oscillation. *Journal of Geophysical Research* 98: 8847-8850.

McCarthy, T & Rubidge, B. 2005. *The Story of Earth and Life: A Southern Africa Perspective on a 4.6-Billion-Year Journey.* Cape Town: Struik Publishers.

Mc Cauley, J.F., Vreed, C. S., Schaber, G. G., McHugh, W. P., Haynes, C. V., Groilier, M. J. & Kilani, A. E. 1986. Paleodrainages of the eastern Sahara – The radar rivers revisited, *IEEE Transactions on GeoScience and Remote Sensing,* GE-24 (4): 624-647.

Mehrer, M. W. and Wescott, K. L. 2006: *GIS and Archaeological Site Location Modeling.* Florida: Taylor & Francis, Boca Raton.

Mitchell, J. M. 1963. On the world-wide pattern of secular temperature change. Proceedings of the Symposium on Climate Change, Rome 1961, UNESCO Arid Zone Research 20: 161-181. In Tyson, P. D. 1986. *Climate Change and Variability in Southern Africa.* Cape Town: Oxford University Press.

Mitchell, P. 2002. *The Archaeology of Southern Africa.* Cambridge: Cambridge University Press.

Nagara, T., McNaughton, D. L. & Lineham, S. 1983. Seasonal rainfall fluctuations in Zimbabwe. *Zimbabwe Agricultural Journal* 80: 149-150.

Norström, E., Holmgren, K. & Mörth, C. M. 2005. Rainfall-driven variations in δ^{13} C composition and wood anatomy of Breonadia salicina trees from South Africa between 1375 and 1995. *South African Journal of Science* 101: 162-168.

Ogallo, L. J. 2000, Predicting drought in Kenya: Prospects and challenges. In: Wilhite, D. (eds) *Drought, A Global Assessment, Vol II:* 52-67. London: Routledge.

Ogburn, D. E. 2006. Assessing the level of visibility of cultural objects in past landscapes. *Journal of Archaeological Science* 33: 405-413.

Packard, R. 2001. 'Malaria Blocks Development' revisited: The role of disease in the history of agricultural development in the eastern and northern Transvaal lowveld, 1890-1960. *Journal of South African Studies* 27: (3) 591-612.

Pistorius, J. C. C. 1992. *Molokwane an Iron Age Bakwena Village: Early Tswana Settlement in the Western Transvaal.* Johannesburg: Perskor Printers.

Parsons, N. 1993. *A New History of Southern Africa.* London: Macmillian.

Reddy, S. J. 1986. Climatic fluctuations in the precipitation of Mozambique during the period of meteorological record, in preparation. In Tyson, P. D. 1987. *Climate Change and Variability in Southern Africa.* Cape Town: Oxford University Press.

Rees, J. A. 1992. Health patterns in the Northern Transvaal 1900 – 1932. Unpublished MA Dissertation. Johannesburg: University of the Witwatersrand.

Sadr, K. & Rodier, X. 2012. Google Earth, GIS and stone-walled structures in southern Gauteng, South Africa. *Journal of Archaeological Science* 39: 1034-1042.

Sandeman, E. F. 1975. *Eight Months in an Ox Wagon: Reminiscences of Boer Life.* Johannesburg: African Book Society.

Saturno, W., Sever, T. L., Irwin, D. E., Howell, B. F. & Garrison, T. G. 2007. Putting us on the map: Remote sensing investigation of the ancient Maya landscape. In Wiseman, J. & El-Baz, F. (eds), *Remote Sensing in Archaeology*: 136 - 160. New York: Springer Science and Business Media, LLC.

Schofield, J. F. 1935. Natal coastal pottery from the Durban district: A preliminary survey. In: Evers, T. M. 1977. Recent progress in studies of the Early Iron Age in the Eastern Transvaal, South Africa. *South African Journal of Science* 73: 78-81.

Schofield, J. F. 1936. Natal coastal pottery from the Durban district, II. In Evers, T. M. 1977. Recent progress in studies of the Early Iron Age in the Eastern Transvaal, South Africa. *South African Journal of Science* 73: 78-81.

Schofield, J. F. 1948. Primitive pottery. In Evers, T. M. 1977. Recent progress in studies of the Early Iron Age in the Eastern Transvaal, South Africa. *South African Journal of Science* 73: 78-81.

Seddon, J. D. 1968. An area survey of settlement and living patterns in the Transvaal Iron Age: Preliminary report. *African Studies* (27)4: 189 – 194.

Sevenant, M. & Antrop, M. 2007. Settlement models, land use and visibility in rural landscapes: Two case studies in Greece. *Landscape and Urban Planning* 80: 362-374.

Smith, J. M. 2005. Climate change and agropastoral sustainability in the Shashi/Limpopo River basin from AD 900. Unpublished PhD thesis. Johannesburg: University of the Witwatersrand.

Smith, J. M., Lee-Thorp, J. & Hall, S. 2007. Climate change and agropastoralist settlement in the Shashi-Limpopo River basin, Southern Africa: AD 880 to 1700. *South African Archaeological Bulletin* 62 (186): 115-125.

South African Weather Service. Monthly Climate Data Records 1992 and 2000.

Strebel, P. M., Hansford, C. F. & Kustner, H. G. V. 1988. The Geographic Distribution of Malaria in South Africa in 1986. *The Southern African Journal of Epidemiology and Infection* 3: 4-8.

Stump, D. 2010. Intensification in Context: Archaeological Approaches to Precolonial Field Systems in Eastern and Southern Africa. *African Studies* 69 (2): 254-278.

Sutton, J. E. G. 1985. Irrigation and terracing in Africa. In: Farrington, I. S. (ed) *Prehistoric Intensive Agriculture in the Tropics*, Part ii: 737-763. Oxford: BAR International Series 232.

Swellengrebel, N. H. 1931. Malaria investigations in some parts of the Transvaal and Zululand. *South African Institute for Medical Research* 4: 245-274.

Thomas, D.H. 1974. *Predicting the Past: An Introduction to Anthropological Archaeology.* New York: Rinehart & Winston.

Thompson, G. D. 1981. Water use by sugar cane. South African Sugar Industry Agronomists Assosiation Reveiw Paper No8 Experimental Station, Mount Edgecombe, Natal. In Tyson, P. D. 1987. *Climate Change and Variability in Southern Africa.* Cape Town: Oxford University Press.

Trevor, T. G. 1912. Some observations on ancient mine workings in the Transvaal. In Evers, T. M. 1975. Recent Iron Age research in the Eastern Transvaal, South Africa. *South African Archaeological Bulletin* 30:71 – 83

Trigger, B. 1989. *A History of Archaeological Thought.* Cambridge: Cambridge University Press.

Tyson, P. D., Dyer, T. G. J. & Mametse, M. N. 1975. Secular changes in South African rainfall: 1880 to 1972. *Quarterly Journal of the Royal Meteorological Society* 101: 817-833.

Tyson, P. D. 1980. Temporal and spatial variation of rainfall anomalies in Africa south of Latitude 22° during the period of meteorological record. *Climate Change* 2: 363-371.

Tyson, P. D. 1986. *Climate Change and Variability in Southern Africa.* Cape Town: Oxford University Press.

Tyson, P. D. 1991. Climate change in southern Africa: Past and present conditions and possible future scenarios. *Climate Change* 18: 241-258.

Tyson, P. D., Karlen, W., Holmgren, K. & Heiss, G. 2000. The Little Ice Age and Medieval Warming in South Africa. *South African Journal of Science* 96: 121-126.

Tyson, P. D., Lee-Thorp, J., Holmgren, K. & Thackeray, J. F. 2002. Changing gradients of climate change in southern Africa during the past millennium: implications for population movements. *Climate Change* 52: 129-135.

Van Hoepen, E. C. N. 1939. Pre-European Bantu culture in the Lydenburg District. *Argeologiese Navorsing van die Nasionale Museum, Bloemfontein* 2: 47-74.

Van Leusen, M. 2002. Pattern to process: Methodological investigations into the formation and interpretation of spatial patterns in archaeological landscapes. Published PhD thesis, Faculty of Arts, University of Groningen.

Van Rooi, M. P. 1980. Extreme rainfall anomalies over extensive parts of South Africa during periods of 1 to 5 successive 'summer years'. *South African Weather Bureau Technical Paper* No 8: 32. In Tyson, P. D. 1987. *Climate Change and Variability in Southern Africa.* Cape Town: Oxford University Press.

Verschuren, D., Laird, K. R. & Cumming, B. F. 2000. Rainfall and drought in Equatorial East Africa during the past 1,100 Years. *Nature* 403: 410-414.

Vines, R. G. 1980. Analysis of South African rainfall. *South African Journal of Science* 76: 404-409.

Visagie, P. J. 1985. An investigation into wet and dry cycles of rainfall in South Africa. Report to Hydrology Engineering Division, Electricity Supply Commission, Sandton. pp 39. In Tyson, P. D. 1986. *Climate Change and Variability in Southern Africa.* Cape Town: Oxford University Press.

Vogel, C. H. 1989. A documentary-derived climatic chronology for southern Africa, 1820-1900. *Climate Change* 14: 291-306.

Vogel, J. C. 1995. The temporal distribution of radiocarbon dates for the Iron Age of southern Africa. *South African Archaeological Bulletin* 50: 106-109.

Vogel, J. C. 2000. Drought, migration and chronology in the Lake Malawi Littoral. *Transafrican Journal of History* 9: 70-90.

Wheatley, D. 1995. Cumulative veiwshed analysis: A GIS-based method for investigating intervisibility and its archaeological application. In: Lock, G. S. & Stancic, Z. (eds) *Archaeology and Geographical Information Systems: A European Perspective:* 171-185. London: Taylor & Francis.

Wheatley, D. & Gillings, M. 2002. *Spatial Technology and Archaeology, The Archaeological Applications of GIS*. London: Taylor & Francis.

Wint, W. 2008. Mapping historical tsetse fly distributions in southern Africa. Unbublished Report. Prepared for the Insect Pest Control Group, FAO/IAEA Joint Division, International Atomic Energy Agency, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria.

Witcher, R. 1999. GIS and landscapes of perception. In Gillings, M., Mattingly, D & Dalen, J. (eds) *Geographical Information Systems and Landscape Archaeology*: 13-22. Oxford: The Alden Press.

Wright, J. & Hamilton, C. 1989. Traditions and transformations: The Phongolo-Mzimkhulu region in the late eighteenth and early nineteenth centuries. In A.H. Duminy & B. Guest (eds), *Natal and Zululand from Earliest Times to 1910: A*

New History. Pietermaritzburg: University of Natal Press and Shuter & Shooter, pp. 48-82.

Zubrow, E. B. W. 2007. Remote sensing fractals, and cultural landscapes: An ethnographic prolegomenon using U2 imagery. In Wiseman, J. & El-Baz, F. (eds), *Remote Sensing in Archaeology*: 219 - 235. New York: Springer Science and Business media, LLC.

Zuchini, W. & Adamson, P. T. 1984. The occurrence and severity of droughts in South Africa, WRC Report 91/1/84, Water Research Commission, Pretoria, 198pp. In Tyson, P. D. 1987. *Climate Change and Variability in Southern Africa.* Cape Town: Oxford University Press.

Internet sources:

Web Addresses

www.fao.org/docrep/U3160E/u3160e04.htm

Last visited 29/11/11

http://www.environment.gov.za/enviro-info/prov/mp/mpsoil.jpg

Last visited 29/11/11

http://www.environment.gov.za/enviro-info/prov/mp/mpvege.jpg

Last visited 29/11/11

http://www.environment.gov.za/enviro-info/prov/mp/mprain.jpg

Last visited 29/11/11

http://www.environment.gov.za/enviro-info/prov/mp/mpgeol.jpg

Last visited 29/11/11

http://www.environment.gov.za/enviro-info/prov/soil.htm#dsoill

http://agriculture.kzntl.gov.za/publications/production_guidelines/veld_in_natal/veld_9.7.htm.

http://reverb.echo.nasa.gov/reverb/#utf8=%E2%9C%93&spatial_map=satellite&spatial_type=rectangle

Last visited 15/11/12