Diet and subsistence patterns in the Later Iron Age of South Africa: An analysis of stable carbon and nitrogen isotopes and the incidence of dental caries

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Abstract

Current archaeological perspectives on the change in Later Iron Age diet and subsistence patterns and the subsequent affect on the economy, are re-examined using isotopic and caries analyses. Existing perspectives have focused mainly on material archaeological evidence and are not reflective of diet at the individual level. Consequently, the focus of archaeological research has been biased towards the importance of cattle in subsistence patterns and the economy, and the role of agriculture has not been as thoroughly investigated. In order to address this problem the isotopic signatures of 72 skeletal remains, and the pattern of carious lesions of 44 of those individuals, were examined. The samples were drawn from different ethnic groups and geographical/climatic regions. Skeletons were analysed for both $\delta^{13}C$ *and* $\delta^{15}N$ *values in order to better reflect both the level of cultigen consumption and the relative importance of animal protein in the diet.*

The results were initially examined at an individual level, within the biomes from which they were drawn, to determine subsistence type. The diets of persons and ethnic groups was then compared to archaeological and ethnographical research. Combination of results demonstrates a trend towards more enriched $\delta^{13}C$ *values over time. Although there were differences between individuals diets, there is an overall increasing consumption (and therefore reliance) on domesticated grains, whilst the consumptive levels of animal protein remain relatively constant over the last 1000 years.*

Consequently, the context of previously undated skeletal material was founded on the trend towards increasing $\delta^{13}C$ *values during the second millennium. The creation of a set of criteria based on pattern, type and extent on carious lesions, has provided a further means of assessing the carbohydrate intake level of individuals. An increase in both* $\delta^{13}C$ *values and the incidence of caries during the 18th century, may reflect the introduction of maize in the interior of South Africa, via Delagoa Bay. It is suggested that population growth and increased demand resulted in maize replacing indigenous African cultigens to become a staple food source after this period. In conclusion it is postulated that further re-examination of the current outlook should be undertaken as it is clear from this study that the Later Iron Age is heterogenous with comparable but distinct dietary levels.*

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Explanatory Notes

This is a list of the abbreviations used throughout the thesis.

Site abbreviations.

BF	Boshoff's Farm
BH	Buffelshoek
BM	Bambo
BP	Buispoort
BV	Bainsvlei
DP	Derdepoort
EM	Ellerton Mine
FC	Ficus
FF	Frankfort
HB	Heilbron
K2	Bambandyanalo
KC	Kaybars Cave
KRB	Klipriviersberg
KRV	Klip River Valley
MK	Makgwareng
MS	Magozastad
MX	Maxonwa

NP	Nelspruit
NS	New Smitsdorp
NY	Nylsvlei
OP	Oliphantspoort
PK	Paardekraal
RB	Rustenburg
RK	Rooikrans
RS	Robinson's Shelter
SK	Skutwater
TW	Tavhutshwene
VK	Vechtkop
VR	Vrede
WBF	Wildebeestfontein
WE	Wellington Estates
WG	Willow Glen
WL	Welgegund
YT	Yellowtree

General abbreviations:

AD	Anno Domino
EIA	Early Iron Age
LIA	Later Iron Age

CCP	Central Cattle Pattern
CAM	Crassulacean acid metabolism

LHS	Left Hand Side
RHS	Right Hand Side
ABV	Abbreviations

REF	Reference
CG	Cheryl Gilbert
JLT	Lee-Thorp, Sealy and Morris 1993
SA	Ambrose 1986
UCT#	University Cape Town, Archaeometry Laboratory sample number

BM	Biome
G	Grassland
GN	Natal grassland
S	Savanna
SD	Dry savanna
SW	Savanna woodland

PWV	Pretoria Witwatersrand Vereeniging region (Gauteng)
OFS	Orange Free State province

$\delta^{13}C$	Delta Carbon 13
$\delta^{15}N$	Delta Nitrogen 15
C_3	Wild and domestic plant food (fruits, nuts, berries, pumpkin, gourd) and the meat of browsing herbivores
C_4	Grasses including cultigens such as maize, millets, sorghums and the meat of grazing herbivores
s	Standard deviation
‰	Parts per million
$\bar{x}$	Average
#	Number of samples/individuals
#T	Number Teeth
#C	Number Caries

Age

Y	Young Adult
M	Middle Adult
O	Old adult

Sex

M	Male
F	Female

Caries abbreviations:

TL	Tooth loss	M1	First molar
EW	Extreme Wear	M2	Second molar
WX	Wear average	M3	Third molar
I1	First incisor	IP	Inter proximal
I2	Second incisor	B	Buccal
C	Canine	L	Lingual
P1	First pre-molar	O	Occlusal
P2	Second pre-molar	A	Advanced

Chapter 1
Introduction

Southern Africa has a long history of occupation, with people living in large parts of the subcontinent during the Holocene, subsisting from a variety of marine and terrestrial foods. The migration of food producing communities to the eastern parts of southern Africa about 2000 years ago brought about a change. The set of characteristics associated with these immigrants, namely the production of metals, ceramics, domestication of livestock and the cultivation of cereal crops, has been termed the Iron Age.

Current perspectives on the Iron Age in South Africa have tended to focus on tangible archaeological evidence (ceramics, settlement patterns and metallurgy), whilst the fundamental characteristic, that of food production methods, has been largely overlooked. There has also been a tendency in past research to typify the diet of food producers in South Africa on the grounds of ethnographic evidence as comprising of; the meat and milk of domestic stock, cultivated grains, curcubits and beans supplemented by hunting and gathering. Thus the underlying assumption on subsistence patterns has been one of mixed subsistence base and there has been little investigation into the heterogeneity of populations. Changes in the economy have been attributed to the increase or decrease in the importance of cattle, which because of their abundance in the archaeological record, have been interpreted as a primary food source. This is particularly problematic as it does not discuss the contribution that women and agriculture make to the economy and by omission is biased towards cattle in what is supposed to be a mixed subsistence base. In the past the presence of agriculture has been acknowledged but it's importance not fully examined.

Two main theories on the change in subsistence patterns during the Iron Age are predominant. Hall has proposed that early Iron Age people were hunter gatherers and agriculturists, and that cattle only became increasingly important towards the later part of the Iron Age with a move towards a mixed economy (1981,1986). The change occurred gradually with the role of cattle being divided into two components: one of an allocative resource (ie a food source) and the other as an authoritative resource (use as bridewealth). Huffman on the other hand has used ceramic data together with characteristic settlement patterns, to define a Bantu Cattle Culture (1986 a and b). This Central Cattle Pattern (CCP) reflects the attitudes and values of people about politics, economy, status and religion and involves a set of principles or a "cognitive system" always associated with the CCP. Huffman draws no a distinction between early and later periods in the Iron Age, and sees the continuity of the

Central Cattle Pattern as extending back into the 4th century AD. Research on the economy of Iron Age communities has focussed on the contribution of domestic fauna together with hunting, snaring and gathering in the diet. However two recent studies have examined the subsistence patterns of Iron Age people using stable carbon and nitrogen analysis, and comparing them with other agricultural and pastoralist African populations (Ambrose 1986, Lee-Thorp et al 1992). Their conclusions challenged the concept of uniformity (Lee Thorp et al 1993) and suggested that the protein content of southern African Iron Age diet was considerably low (Ambrose 1986).

The aim of this thesis is to supplement current archaeological evidence through further stable carbon and nitrogen isotopes analysis of bone collagen together with the examination of tooth caries. Stable isotopes are indicative of the relative dietary proportions of cereals and livestock, whilst tooth caries provides a physical anthropological indicator of dietary carbohydrates. I intend to use the physical remains of people, as opposed to the material evidence of their existence, to establish the archaeological context of skeletal remains in the second millennium, distinguish agriculturists from other economies and re-evaluate the underlying assumptions on diet and subsistence patterns, inherent in South African Iron Age research. In doing so I hope to establish the importance of agriculture in the second millennium (Later Iron Age), examine the concept of uniformity amongst these people, and identify any changes in the subsistence pattern that may be reflective of the introduction of maize by the Portuguese after the 16th century AD. I also hope to provide more specific information about the relative chronology of skeletal remains in the second millennium, using the strong correlation between $\delta^{13}C$ and time. In addition, by outlining the pattern of carious lesions characteristic of agriculturists, I establish a set of criteria which can be used as a means of distinguishing high carbohydrate consumption. In choosing to examine the osteological and dental evidence rather than the material remains from a site, this study has focussed specifically on people and how changes in the economy over time have affected each individual.

Chapter 2 provides an overview of current theories and interpretations of Iron Age archaeological evidence in southern Africa, focussing on subsistence patterns and the economy. In this chapter, I briefly review the movement of food producing communities into southern Africa and their subsequent expansion during the Early Iron Age. I then outline in greater detail, the Later Iron Age marked by social and political stratification, the movement of people onto the high grassland and the introduction of maize, during the second millennium.

The basis for the techniques of stable carbon and nitrogen analyses are presented in chapter 3. This chapter also examines the distribution of carbon and nitrogen in the ecosystem together with the factors influencing them and the application of these techniques to paleodietary studies especially in an African context.

The factors influencing caries are discussed in chapter 4. Previous studies on the incidence of caries in populations with different economic backgrounds are reviewed, specifically studies conducted in an African context. The particular patterns of carious lesions, which are characteristic of agriculturists and a high carbohydrate consumption, are also examined.

Chapter 5 outlines the sampling and analytical procedures used in the present study. Detailed descriptions of the biomes in which the sample sites are situated together with specific details from each site are provided in this chapter.

36 individuals from various Later Iron Age sites were examined isotopically. These results are combined with previously published results for the South African Iron Age and presented in chapter 6. Out of a total of 72 adult individuals for which isotopic results are available only 44 had teeth suitable for caries analysis. All the dental analyses were conducted by myself for the purpose of this thesis. The results for the entire data set are subdivided into biomes. Isotopic and caries results are discussed separately.

The discussion, chapter 7, draws the results from the isotopic and caries analyses together, examining the different trends that are evident in chapter 6 and providing an interpretation of the results in terms of diet and subsistence.

Finally, the thesis is concluded in chapter 8.

Chapter 2

Two thousand years of prehistory: A review of "Iron Age" communities in southern Africa

Introduction

In this chapter I intend to provide a short overview of the introduction and expansion of food producers in the southern African Early Iron Age. I will then describe and discuss the evidence for the emergence of a new economic order at the end of the first millennium AD, the succeeding development of socially and politically stratified Later Iron Age settlements at the beginning of the second millennium, and the later occupation of the interior grasslands. Archaeological, historical and ethnographic evidence for the introduction of maize is also reviewed and evaluated. As this study focuses on the economy and subsistence patterns of Iron Age peoples, detailed descriptions of ceramic assemblages and settlement patterns are not included. A map of southern Africa and in's biomes can be found on page 118.

Terminology in the "Iron Age".

A number of different terminologies have been used to describe the past two thousand years of food producing history in southern Africa (Maggs 1992). The most broadly used term, is the 'Iron Age'. This distinguishes food producing communities from "Later Stone Age" hunter gatherers by emphasis of their technology (thereby making the assumption that these two economies are mutually exclusive). Other terms, which are perhaps more preferable as they categorise people according to their subsistence pattern or state of existence, include 'farming communities'; 'agropastoralist' and 'agriculturists' (Maggs 1992). However in the context of subsistence and economy (ie. the management of the surplus production and resulting social systems that form within a community), these terms have distinctly different connotations and it is inappropriate to use them interchangeably. In order to maintain the distinction between the different subsistence patterns, the terms 'agriculturists' (people who subsist primarily off domestic cultigens), 'pastoralists' (herders), and 'mixed farmers' (people who subsist off domestic stock and cultigens), will be referred to only in a specific economic context. Contrarily, although the terms "Iron Age and "food producer" are vague and probably unsuitable, I will continue to use them to describe the population in general.

The movement of food producers into southern Africa

Food production and animal husbandry have been established in some parts of Africa for as long as 7000 years. (Clutton Brock 1993). Around 2000 years ago, a new group of people moved into southern Africa. Archaeological investigation has provided details of their economy. The preserved remains of domesticated plants (seeds, pollen or impressions on pottery) and animals (bones/teeth) together with the presence of grinding stones and iron hoes have indicated that these people were food producers.

Documentation of the spread of Iron Age people into southern Africa has been based primarily on linguistic reconstruction and ceramic analysis. The former being used to establish common denominators between present people and their ancestors, while the latter, through analysis of stylistic types, has been used to establish group identity. As a result of the rapid growth and spread of early farming communities the migration of people has been traced in terms of "streams" of movement across the subcontinent (Huffman 1979, 1982, Phillipson 1977, 1984, 1993).

Various models have been proposed for the origin of food producers in southern Africa. Some researchers argue that the rapid dispersal of East African peoples into southern Africa resulted in the Early Iron Age (Phillipson 1993), while others argue for a western origin of the Early Iron Age (Huffman 1982). Certainly the idea that each new ceramic culture in the Early Iron Age is the result of the migration of a new group of people into southern Africa is prevalent.

This concept of the Iron Age has been challenged, prompting re-evaluation of the relationship between so-called "Later Stone Age" hunter gatherers and "Iron Age" food producers. Some believe that there is little evidence to support the notion of the rapid homogeneous invasion of southern Africa by farmers and suggests that the spread of food production be regarded as a "frontier between economic systems" (Hall 1987, p 32). Given the variability in the southern African environment, it is unlikely that farming could have spread in a uniform manner. As farming societies and their technologies spread into new areas, relationships developed with indigenous hunting and gathering communities.

Ongoing relationships between food producers and hunter gatherer people in western and central Africa were discerned by Denbow (1990). Whereas in east Africa farmers appear to absorb and eliminate foragers, the evidence in western and central Africa point towards a congruent economy. It therefore seems likely that the concepts associated with the Iron Age dispersed throughout southern

Africa in a series of moving frontiers and that Iron Age people both attracted and interacted with indigenous people (Sinclair et al 1993).

The Early Iron Age in southern Africa.
Matola phase

The first settlements of food producing people in southern Africa are associated with Matola ceramics, which occur in southeastern Zimbabwe, Mozambique, coastal Kwazulu/Natal and the Eastern Transvaal and PWV lowveld between the 2nd and 4th centuries AD (Maggs 1980, 1984, Evers 1981).

Selective settlement patterns are evident in these early Matola sites (see Map 2 page 119). In the dry savanna regions of the interior, sites are preferentially situated along river beds, while in Mozambique and Kwazulu/Natal, the majority of sites can be found within a few kilometres of the coast, in coastal dune forest (Maggs 1980, Morais 1988). These areas were suitable for early agriculturists as they provided fertile soils, sufficient water and timber for housing and fuel.

Poor preservation during this period has meant that botanical remains are seldom found and faunal samples are small. The earliest evidence for cultigens is found at Silver Leaves, dated to the 3rd century AD, where bulrush millet (*Pennisetum americanum*) has been identified from seed impressions on pottery (Klapwijk 1974). This observation, together with the number of grindstones found on sites, and the location of sites on highly fertile ground, imply that agricultural practices were widespread (Maggs and Whitelaw 1991, Maggs 1984, Sinclair et al 1993).

Cattle have been identified at a 4th century site in the Kruger National Park, and ovicaprines have been identified at 5th century Matola sites in the Kruger National Park (Plug 1989). Detailed analysis of hunter/herder strategies in the Kruger National Park have revealed catastrophic profiles of wild fauna. This indicates that communal hunting was an important source of meat and that although domestic stock may have been present in the Matola phase of the Early Iron Age, they did not constitute an important part of the diet (Plug 1989).

Hall has suggested that at the beginning of the first millennium AD, the environment on the south east coast lacked sufficient grazing and probably harboured tsetse fly, making it unsuitable for livestock (1987). He argues that the economy was dominated by cereal production and that it was not until the forests were cleared by burning and cultivation, that livestock became more of a proposition

(1986). It has therefore been proposed, at least in the woodland savanna of the east coast of South Africa, that Early Iron Age communities were largely agriculturists, exploiting fish and shellfish of nearby coastal and lagoonal systems as a supplement to their low protein diet (Hall 1981, 1986). A contrary interpretation, which attributes the occupation of these coastal Matola sites to hunter gatherers who lived in a symbiotic relationship with early neighbouring Iron Age farmers, has been put forward more recently (Parkington and Hall 1987).

Lydenburg and Msuluzi phase

South of the Limpopo, between the 4th and 9th centuries, sites succeeding the Matola tradition have been given the name of "Lydenburg cluster" in the interior savanna (Hall and Vogel 1980) or "Msuluzi phase" in Kwazulu/Natal savanna (Maggs 1980) (see Map 2 page 119). This change in ceramic type corresponds with a change in settlement patterns. Between 400-500 AD people moved into higher altitude areas of the Northern Transvaal, PWV and North West plateau and inland Kwazulu/Natal. Coastal middens also extend further southwards to East London and Port Alfred (Maggs 1984). An increase in the size of all sites during this period, marks the beginning of larger, more settled populations.

Information about economic activity in the second half of the first millennium AD is more widespread. Specific attempts have been successful in recovering floral remains using flotation (Maggs and Ward 1984, Maggs 1976). Cultigens of *Eleusine corocana*, *Pennisetum typhoides* (millet's), *Sorghum* and *Citrullus* (melon) species have been identified at Magogo in the 6th/7th century and Ndondondwane has produced *Pennisetum typhoides* (bulrush millet) from the 8th century (Maggs 1984, Maggs and Ward 1984). Once again, the presence of grindstones and grain pits at those sites with poor preservation of botanical remains indicate that agriculture was widespread.

Domestic stock have been identified at sites dated from the 2nd century AD (Mabveni) to the 8th century AD (Ndondondwane). The proportion of wild and domestic fauna varies between sites. Whereas some sites have a small hunted assemblage (Magogo), others have a wide range of wild fauna (Ndondondwane). Ovicaprines dominate the faunal assemblage at Msuluzi and Ntshekane in Kwazulu/Natal with cattle, wild bovines and small mammals also present in the faunal assemblage (Maggs and Michael 1976). It has been suggested that people that the people living at Broederstroom during this period, despite the presence of domestic stock, relied heavily on vegetable foods and that their diet resembled that of hunter gatherers as opposed to agriculturists (Mason 1986).

Thus although domestication of both plants and animals was widespread by the end of the first millennium, their utilisation appears to vary considerably.

The Later Iron Age

The beginning of the second millennium AD

Toward the end of the first millennium AD, changes in settlement patterns and ceramics begin to occur in a number of different regions. Whether these changes are a consequence of a new migration of people (Phillipson 1993), or a redistribution of southern African Early Iron Age populations (Huffman 1986a), is a question of much debate. Whatever the cause, new traditions are evident. One of the primary changes that occurs between the first and second millennium is the appearance of a characteristic settlement pattern called the Central Cattle Pattern (CCP). This is paralleled by the increase of cattle in the faunal assemblage at the beginning of the second millennium. A map of Later Iron Age sites mentioned in the text can be found on page 120

The Central Cattle Cattle Pattern

The concept of the Central Cattle Pattern (CCP) is essentially based on ethnographic work conducted amongst the Nguni by Adam Kuper (1980). This structuralist model is concerned with the symbolic importance of cattle and it's manifestation of in the organisation of villages and homesteads. The pattern is recognised archaeologically by a set of key features such as a central cattle enclosure with surrounding houses and the placement of burials and grain pits near the cattle byre, and is associated with the increased number of cattle on sites towards the end of the first millennium (Huffman 1982). Archaeologists have noted the presence of CCP characteristics on Lydenberg sites in the first millennium (Denbow 1984, Evers 1981, Whitelaw 1993). Most recently however, Huffman has argued for the existence of the CCP at Broederstroom back as far as the 4th century AD (Huffman 1982, 1993). However despite the apparent antiquity of the CCP, marked change in the economy only occur with the increase in cattle in the early second millennium. Early evidence of this changing economy can be found on sites in the Shashi/Limpopo river valley of the Northern Transvaal and Botswana, during the 8th/9th centuries AD. One of these sites, Schroda, comprised a livestock enclosure, circular hut floors and grain bins. Worked ivory and imported glass beads provide some of the earliest evidence for long distance trade with the Indian ocean.

As a result of the large numbers of cattle found on the site, it has been suggested, that the economy was centred on herding. An estimate of the level of consumption of livestock was calculated by multiplying the number of individual animals of a species by the average amount of meat that species would produce. Consequently, it was determined that domestic stock contributed to 88.5% of the meat content of the diet, with agriculture an obvious supplementary source of food (Hanisch 1981, Voigt 1981). This method of calculating the dietary meat component of a settlement is based on the underlying assumption is that all faunal remains found on a site are representative of consumption.

The concept of the CCP has been taken beyond that of merely a settlement pattern. Huffman has proposed that the CCP provides a material expression of culture (including social relations, ideology, status, wealth and power) which reflect an underlying "cognitive system" (Huffman 1986).

However, this interpretation of the Central Cattle Pattern has been criticised as being unreceptive to the changing role of cattle in the economy of farming communities. Davison has pointed out that the implicit static nature of this structuralist model has made it insensitive to social and environmental changes over time, and resulted in inadequate attention to the "social practices that necessarily would have given the spatial order meaning" (pp 53 1991). The cohesion of Huffman's interpretation of the Central Cattle Pattern has also been challenged by Hall who argues, on the grounds of changing faunal assemblages, for a increasing importance of cattle. Hall maintains that in order for cattle be a viable and attractive prospect it was necessary for the dense coastal forests to be cleared to secondary grassland. The environmental change, caused by the slash and burn agricultural practices of the first millennium, in conjunction with the reduction of tsetse fly, would have resulted in an increase in grasslands and cattle and the emergence of a new economic order at the beginning of the second millennium AD (1986, 1987).

Part of this new economic order which emerged at the beginning of the second millennium is the change in attitude to cattle. Cattle move beyond an 'allocative' role as a primary and secondary food source to that of an 'authoritative' role, where they are directly linked to the reproductive and therefore productive capacity of the homestead through the payment of bridewealth is acknowledged (Hall 1986, Davison 1991). Neither Hall nor Davison refute this fundamental attitude of Bantu speaking people towards cattle. The point of contention is the timing of this occurrence. When was this attitude or 'belief' in cattle first manifest and how long did it prevail unchanging?

This particular concept is of interest in this thesis because it epitomises the focus of researchers on cattle. What is not adequately addressed in any of these interpretations of the 'role of cattle' in Later Iron Age societies is the change in individual perception and utilisation of cattle over the period. It is my submission that what is needed in this debate is not a description of the changing function of cattle, but rather a qualification of individual perceptions toward cattle and their varied utilisation. How do cattle fit into Later Iron Age economies? Has their role been uniform through out the Later Iron Age? How important were cattle in peoples diet and subsistence? Direct analysis of people's diets has the potential to answer these questions.

The Zimbabwe Culture

Leopards Kopje tradition

Between 970 and 1070 AD, trade in the interior was centrally administered by people from Bambandyanalo (K2). This site was occupied by mixed farmers whose pottery can be associated with that of the Leopards Kopje Tradition (Huffman 1986 a&b). An increase in trade and political importance is evidenced by the amount of ivory and glass beads found at Bambandyanalo. This represents the beginning of the Zimbabwe Culture Pattern which differs with the Central Cattle Pattern in that it is characterised by marked social distinction, evident in the settlement pattern. This area was one of the first interior southern African settlements to trade directly with the Indian Ocean trade network. Control of trade resulted in the unequal distribution of wealth allowing rapid increase in political power. Ownership of cattle appears to have been restricted to royalty. The result of this increased political activity is reflected in the size of the midden in the men's assembly area.

The population at K2 increased rapidly and by 1020 AD, the midden had become so immense, that it displaced the cattle away from the settlement (Meyer 1984). Nevertheless, the importance of cattle at K2 is demonstrated by the size of the central cattle kraal, the production of ceramic cattle figurines and the contribution of cattle as the main source of meat in the diet (88%) (Voigt 1981). Occupation was intensive with people living in pole and daga huts clustered close together. Grains such as *Pennisetum typhoides* (pearl millet), *Sorghum bicolour* and *Vigna unguiculate* (bean) were found in grain storage huts.

The influence of K2 appears to have extended beyond the Shashi/Limpopo basin as far as Botswana. The presence of Leopards Kopje ceramics on Toutswe sites has caused Denbow to reflect on the relationship between Toutswe and K2 (1982). He has suggested that a reciprocal exchange of agricultural implements and cattle could have occurred as a result of marriage transactions between the two traditions. However the defensive positioning of Toutswe sites, may demonstrates less peaceful interactions between Toutswe and Leopards Kopje peoples (Denbow 1982).

The first occupation of Mapungubwe Hill coincides with the abandonment of K2 at 1075 AD (Huffman 1982). It has been concluded that the principal settlement moved from K2 to Mapungubwe, bringing with it the new tradition of a separate men's assembly area and cattle kraal that is typical of the Zimbabwe Culture Pattern (Huffman 1982).

These sites demonstrate a major change in social organisation (with ruling elite occupying the hilltop settlements both in life and death). This manifestation of social differentiation occurs only in areas articulated with the Indian Ocean trade network. The development of a new type of ceramic associated with Mapungubwe marks a further change. Population growth, together with an increase in trade (spindle whorls and gold appear for the first time), highlight an increase in wealth and power. By 1175 AD Mapungubwe had become established as the capital of a state with several district centres (Huffman 1982, Meyer 1984), linked to the Great Zimbabwe Tradition (Eloff and Meyer 1981, Huffman 1986). Surrounding settlements such as Skutwater (a smaller satellite town), were second level authority sites allied to Mapungubwe (van Ewyk 1987). The economy at Skutwater is mixed. Carbonised seeds of *Pennisetum* and sorghum have been found together with the seeds of wild fruits. Domestic stock contributed to less of the total dietary meat content than at Mapungubwe hilltop (74%). This, together with the lack of evidence for trade, suggests that the people at Skutwater, may have been custodians of the royal herd and explains their conserving of cattle as a source of food (van Ewyk 1987).

Mapungubwe was abandoned around 1220 AD and is succeeded by Great Zimbabwe which dates to between 1250-1450 AD and is said to have contained some 11000 people. Great Zimbabwe represents a culmination of political and religious power that probably stemmed from the large scale export of gold, and rose to immense power before it's sudden decline in the mid 15th century AD.

The Zimbabwe tradition was succeeded by the Khami tradition and the Shona people. Torwa is thought to have been the administrative centre of the Khami tradition from 1450-1640 AD. Smaller Khami phase sites stretch south into the northern Transvaal between the Limpopo and Soutpansberg. These people were predecessors of the Venda and settled in sites in the Soutpansberg during the 16th century AD. They interacted with the Sotho people and traded with the east coast ports of Sofala and Inhambane (Loubser 1989). A new ceramic style called Letaba evolved around 1550 AD. It represents a merging of the Sotho (Moloko ceramics) and Shona (Khami ceramics) and has been linked with the emergence of the Venda language. Letaba occurs beyond the Soutpansberg and has been reported in the eastern Transvaal as well as in south western Mozambique and southern Zimbabwe (Loubser 1989). Letaba is also present at Dzata, the capital of the Singo Dynasty who migrated into the Soutpansberg during the 17th century and subjugated the original Venda gradually adopting the language of their subjects (Loubser 1989). Settlement patterns associated with these sites are very similar to the Zimbabwe pattern. The collapse of the Singo state towards the end of the 18th century and may have coincided with the relocation of the trading port from Sofala to Delagoa Bay.

The Oori tradition

At the same time as changes in ceramics and settlement patterns were occurring in the northern Transvaal, so too were changes occurring in sites in other parts of southern Africa. In Kwazulu/Natal at the end of the first millennium, ceramics from the sites Blackburn and Mpanbanyoni dated between the 9th and 11th centuries are distinctly different to their predecessors Mzuluzi and Ntshekane (Maggs 1984). These sites are small hilltop settlements situated in the coastal forest, and reflect an economy comprising of a wide variety of hunted animals, fish and shellfish with cattle completely absent from Mpanbanyoni. Later during the 13th and 14th centuries, this ceramic tradition is paralleled by a change in the site location and settlement pattern. Moor Park dated to the 13th and 14th centuries AD is situated on the fringe of the savanna region and reflects the early attempts of Iron Age people to move into the grassland (Maggs 1980, 1984).

Changes also occur in ceramic motifs and shapes in central and southwestern Transvaal. It has been postulated that these sites, which predate the Sotho/Tswana people, are directly related to the Early Iron Age site of Broederstroom and that the ancestry of this tradition, called Oori, dates back to 350 AD (Mason 1983, 1986).

Another explanation for the change in both Kwazulu/Natal and central and southwestern Transvaal, has been proposed by Huffman (1989). He suggests that Blackburn ceramics and Nguni people originated in East Africa and moved south in a two stage migration, one characterised by Moloko ceramics and Sotho/Tswana speaking people, the other by Blackburn ceramics and Nguni-speaking people (Huffman 1989).

Communities of the southern highveld

Towards the end of the 15th century, (coinciding with introduction of Letaba ceramics in the Soutpansberg), LIA people began to occupy the grassland biome of the Orange Free State and the savanna woodland biome of the southern PWV and eastern North West provinces (Map 3 page 120). This resulted in the settlement of Iron Age food producers throughout the summer rainfall region of

South Africa and across a variety of biomes which included: the savanna biome of the Eastern Transvaal, southern Northern Transvaal, and northern regions of the North West and PWV and the interior grassland biome of Kwazulu/Natal. The spread of these people were constrained only by the sour grasslands and acid soils on the Drakensberg escarpment and the arid areas in the western and northern Cape and Orange Free State, where summer rainfall was too low for the cultivation of crops (Maggs 1976, 1980). The biome which supported the highest population densities were the partly wooded steps on the margin of the southern savanna and the low escarpment of the central grasslands. An adaptation common to all these sites, in an essentially treeless environment, was the use of stone in building. As a result of the high visibility of these sites they have been the focus of much Later Iron Age research (Hall 1987, Loubser 1985, Maggs 1976, Maggs and Whitelaw 1991, Mason 1986, Taylor 1984).

Moloko sites in the Savanna woodland

Stone wall sites in the savanna and grassland biomes, have been identified as a single cultural unit representing the predecessors of the Sotho/Tswana (Taylor 1979, Mason 1986) (Map 4, page 121). Two ceramics types have been identified amongst these sites, namely Uitkomst and Buispoort (Mason 1972, 1985). Klipriviersberg, an example of an Uitkomst large stone wall settlement, is characterised by of a number of walled enclosures with groups of inner walls connected by short sections of straight walling. central cattle kraals, small livestock pens, huts and granary bases (Mason 1986).

The large stone settlement at Buispoort is similarly comprised of walls, enclosures and beehive huts. Evidence of iron working and agriculture were found in the form of ore, slag, storage platforms and massive grinding stones. Buispoort type ceramics are also found at Oliphantspoort, another massive stone wall settlement (Mason 1986). The site Oliphantspoort 20/71 has a central cattle enclosure surrounded by huts on the periphery. It is dated to the 15th/16th century AD making it the earliest dated stone wall settlement in the Later Iron Age (Mason 1986). Social stratification is evident in the different walling, and concentrated occurrence of grain bins in one particular area has resulted in it's designation as the "chief's zone" (Mason 1986).

Mason has grouped both Uitkomst and Buispoort ceramics into the Oori Tradition which he believes represents the development of the Sotho/Tswana people (Mason 1983). However a more specific term used to refer to this type of ceramics is Moloko - a name which characterises only second phase (post 1500 AD) Sotho/Tswana ceramics thus avoiding the connotations associated with the ancestry of the Oori tradition (Evers 1983). Faunal analyses of Moloko Sotho/Tswana sites in the PWV and

North West have determined that herding dominated the economy (Mason et al 1983). The main differences between sites occurs in the age profile of the cattle. At Oliphantspoort 20/71 for example, faunal analysis has suggested that cattle were the major contributors to the diet, producing 92% of the meat. Forty two percent of these were stock at prime breeding age, thus suggesting that the inhabitants of the site had easy access to large herds. Klipriviersberg also has a high percentage of juvenile cattle in the faunal assemblage, with cattle contributing to 79% of the meat eaten at the site. Even though cattle are still the main meat source at Klipriviersberg there is a notable increase in the percentage of hunted and snared animals in the faunal sample. The contribution of sheep and goat in the economy also varies between sites, with ovicaprines outnumbering cattle at the 19th century Moloko sites of Bruma and Melville Cave. The presence of grain bins, grinding stones and sorghum seeds on Moloko sites indicate that cultivation was also practised. However the importance of cereal economy is difficult to assess (Mason 1986).

Mason has argued that the savanna woodland was particularly attractive to Later Iron Age people because it supported a diversity of natural flora and fauna. The higher rainfall of this biome, made it suitable for the cultivation of cereals such as sorghum, and the availability of sweet grasslands would also have made this attractive for settlement. The close proximity of the savanna woodland to the bushveld provided adequate timber for fuel.

The Transvaal Ndebele

During the 16th century, when the Kwene and Kgalta lineages of the Sotho/Tswana were moving south into the savanna woodland, Nguni speaking people moved across the Drakensberg and settled in the northern and western parts of the Northern Transvaal savanna (Hall 1981, Wilson 1969) (Map 4, page 121). Sites such as Ficus, Bambo and Rooikrans represent the settlement of these Transvaal Ndebele in the Northern Transvaal savanna. Characteristics of the Central Cattle Pattern are evident in the settlement patterns at Bambo and Ficus. Here the faunal assemblage suggests that domestic stock contributed to more than 80% of the dietary meat intake (Loubser 1985, Moore 1981).

The settlement patterns of the Transvaal Ndebele have been classified in three groups. Group 1 represents the first phase of occupation prior to Ndebele settlement of the region. Group 2 settlement patterns date to the early occupation of the Ndebele during 17th century and are located on hilltops (Loubser 1981). This settlement pattern is comprised of a set of concentric circles with an innermost core, the central cattle byre. These sites are succeeded by group 3 settlements, which are characterised by scalloped walling linked by straight walls to a central enclosure, in the 19th century.

Many of the sites are built in defensive locations with perimeter walls around the edge for extra protection (Huffman 1990). Although Moloko ceramics are often found in association with Ndebele sites, Hall has demonstrated, via trace element analyses, that the Moloko ceramics found at Rooikrans during the 17th century, were brought onto the site from elsewhere (Hall 1995). This concurs with the historical evidence that during the 17th/18th centuries, dispersed chiefdoms of ancestral Sotho/Tswana lived alongside those ancestral to the Transvaal Ndebele making the exchange of ceramics a feasible prospect. However, the defensive positioning of sites suggests that the relationship between these groups was far from amicable.

Moloko sites in the grassland

Extensive research has also been conducted on stone walled settlements of the high grasslands between the Vaal and Orange rivers in the Orange Free State (Maggs 1976). Although archaeologists have attributed the occupation of these sites to the ancestors of the Sotho/Tswana peoples, Maggs is somewhat hesitant to do so without more detailed consideration (Mason 1986 and Maggs 1976). Here, sites have been classified according to their pattern of stone wall settlement. The earliest Iron Age communities in the grassland biome were the builders of Type N settlements. These settlement units are estimated to have accommodated 1000 people and date to the 15th and 16th centuries AD. They are distributed primarily between the Vaal and Klip rivers and are characterised by a surrounding wall with an inner ring of primary enclosures linked by secondary walling. The pottery has some elements in common with the savanna woodland settlements but is sufficiently distinct to be regarded separately. Maggs suggests that it may have its origin in Uitkomst, although similarities with sites such as Moor Park, in the Tugela basin, are also apparent. Thus Type N may represent the initial movement of Sotho peoples onto the high grasslands.

Type V settlements replaced Type N expanding throughout the grassland. They are characterised by a ring of primary enclosures around a central secondary enclosure. The sites of Makgwareng, dated to between 16th and 19th centuries AD, best displays the Type V characteristics of hilltop settlements with corbelled huts. The dominance of domestic stock together with seed impressions of sorghum and cucurbit and the positive identification of sorghum indicate that the inhabitants practised a mixed economy. Two handed grindstones have also been found on the site. Ethnographic evidence suggests that these Type V sites may have been occupied by early Sotho lineages of the Taung and Kgalta.

Type Z sites characterised by informal groupings of primary enclosures linked by secondary walling and built close together, appear quite distinct from Type V settlements (Maggs 1976). Large stock pens indicate a much greater dependence on domestic stock. This, together with the notable shortage of grindstones, suggests a shift in the economic emphasis from agriculture to stock keeping. Type Z sites tend to be located further east in a more drought prone environment than the Type V sites. A different economy is evident in Type Z settlements where, probably as a result of the drier climate, agricultural production was less reliable.

The economy of the southern Highveld

The expansion of people onto the grassland, an area capable of providing grazing for stock throughout the year, resulted in an increase in the importance of livestock (Maggs 1976, Hall 1987). The long term surety of cattle herds, relative to agricultural crops, provided Later Iron Age people with an added economic stability. Maggs has suggested that the settlement and faunal patterns indicate that cattle were exploited essentially as a food source. The presence of large bovids in the faunal sample outline the importance of the adaptation of specialised hunting techniques in the highveld areas during the Later Iron Age. Settlements were also concentrated near the river valleys that would provide suitable arable land for cultivation. This, together with the direct evidence for domesticates, caused Maggs to postulate that agriculture must have been a staple food throughout Later Iron Age occupation of the grassland (Maggs 1976).

With the increase in livestock herds, cattle began to reflect the relative wealth and social importance of their owners. This has been viewed by historians in terms of a lineage mode of production, where cattle are controlled by the head of the homestead and senior members of the lineage (Hall 1986, 1987).

These Later Iron Age settlements in the grassland are very different from the typical Early Iron Age sites which had specialised economies. With timber and thatch being easily available during the Early Iron Age, each village had skilled iron workers. The lack of timber for fuel and iron ore in the grassland biome resulted in structured economic specialisation and the development of trade networks. Reciprocal relationships were established between agriculturists on the highveld and iron making communities in the bushy savanna (Hall 1987).

Evidence for the aggregation of Later Iron Age settlements occurs from the middle of the 18th century, resulting in the establishment of large Sotho/Tswana towns such as those found on the edge of the Vredefort Dome (Taylor 1984). It has been suggested that this concentration of people in large towns occurred for defensive purposes (Huffman 1986 a&b). Conflict and military stress were widespread during the early 19th century resulting in insecurities for many of the communities settled on the plateau and margins of the highveld. This clustering of settlements, has also been associated with a growth of population and the development of trade with the Portuguese via Delagoa Bay. It is likely that agricultural production intensified and that herds of cattle from various homesteads were consolidated. The effect of the introduction and increased importance of trade goods in Later Iron Age communities during the 18th and 19th centuries is not known. Glass beads, cloth and glazed ceramics may have been used as additional forms of bridewealth payments and there was a shift in the distribution of wealth.

With the introduction of trade during the 18th century, trade goods acquired additional political and economic significance perhaps circumventing the power of cattle and lineage elders to some degree (Huffman 1986, Hall 1986). One would argue that with the increase in trade, the importance and influence generated by large numbers of cattle decreases. Two possible social scenarios emerge. The first, that cattle become status symbols which are accumulated by the ruling elite as is demonstrated amongst the Venda. The second, that ownership of cattle remained communal but their utilisation changed as trade goods became additional indicators of social status diminishing to some degree their importance as a foodsource. With the decentralisation of people during the late 19th and early 20th centuries, families returned to living in small dispersed homesteads and cattle became the focus of economic activities (Davison 1991).

The introduction of maize (*Zea mays*)

Archaeological evidence

The earliest direct archaeological evidence for maize in southern Africa occurs in the form of carbonised seeds/cobs which have been recovered from Nqabeni and Mgoduyanuka in the savanna biome of Natal/Kwazulu and Inyanga, in Zimbabwe (Hall and Maggs 1976, Maggs 1994, Summers 1958). Nqabeni dates to the late 18th/early 19th century AD and has a settlement pattern is similar to that of Type V. (Although it differs from Type V in that all the entrances are cobbled and open either across slope or uphill). The region would have particularly favourable for the cultivation of maize as it has a high rainfall. Sorghum and cow pea (*Vigna unguiculate*) were also recovered from the site. The faunal assemblage is dominated by livestock. The surrounding sour grassland would have been suitable for grazing only during the spring and early summer months. Cattle would have been moved to the sweeter grasslands of the valleys during late summer and winter (Hall and Maggs 1976).

A sample of burnt maize cobs at Mgoduyanuka have been dated to the 17th/19th century AD (Maggs 1980). The numerous partly burnt remains suggest that the cobs were used as a supplementary fuel. Both the settlement pattern and ceramics at Mgoduyanuka are similar to Nqabeni. Domestic stock once again dominates the assemblage, contributing 98% of the meat. Large deeply hollowed grindstones, showing signs of pecking, are typical at this site and it has been suggested that they are associated with the grinding of large hard grained cereals (Maggs 1980, Walton 1953). Maize cobs have also been recovered from Inyanga in Zimbabwe (Summers 1958). The seeds of maize, *Pennisetum* and *Cucurbit* (pumpkin) were recovered from storage pits, hut floors and the ash of fire. Inyanga has been dated according to glass beads found on the site and associated with the late 17th /early 18th century AD.

Two handed grindstones are present on many Late Iron Age sites in the grassland (eg Makgwareng, Mogoduyanuka), and it was originally suggested by Walton (1953) that two handed quern stones were used for grinding maize which has tougher kernels than any of the other domesticated grains like sorghum and millet.

Consequently, on the grounds of the archaeological evidence, one could surmise that maize was introduced sometime during the 17th/18th centuries AD (Hall 1976, Hall and Vogel 1978, Huffman 1986 a&b).

Ethnographic evidence

The narratives of early travellers in southern Africa at the beginning of the 19th century suggest that maize was unknown to many people before the Difaquane wars in the early 1800's. The ancient Bapeli and early Basuto agriculturists in 1822 AD and 1836 AD respectively are reported not to have known maize (Ellenberger and Macgregor 1921, Arbousset and Daumas 1846), and in 1838 AD the Pedi discarded maize after only one trial season because it was foreign (Arbousset and Daumas 1846). However the cultivation of maize has been described between 1821 AD and 1836 AD amongst the Lighoya and Maluti, on the south east coast and at Delagoa Bay (Arbousset and Daumas 1846, Kay 1833, Owen 1835). The problem with these records, is that many early travellers fail to document the type of grain grown by agriculturists in South Africa referring to it either as corn, or using terms such as grain and wheat interchangeably (Barrow 1803, Casalis 1861). This makes ethnographic determination of the distribution of maize difficult.

The accounts of people shipwrecked along the south-east coast are also conflicting. Survivors of the Sao Bento wrecked during 1554 AD describe receiving "cakes made of seed" from the "Kaffirs". (Theal 1883). In 1622 AD the survivors of the Sao Joao Baptista came across both people with no knowledge of any seed and travelled through areas with "infinite number of kraals with herds of cattle and gardens" (Theal 1898). However in his translation of an account by a journalist reporting on the wreck of the Nossa Senhora de Belem in 1635 AD, Theal notes that people of the country also had maize. Fields of maize were reported near St Lucia by the survivors of the shipwreck Grosvenor in 1782 AD.

This diversity in the distribution of maize observed by early travellers, could be explained in terms of the fluctuating rainfall which occurred in northern Natal during the second half of the second millennium AD. This fluctuation in rainfall has as been documented by Hall using tree ring data from a 596 year old indigenous yellowwood (Hall 1976). The practice of growing a variety of different cereals with different production and harvesting requirements was probably a necessity in uncertain environmental conditions. One of the advantages of maize when compared to the other grains is the short growing period, which enables multiple cropping in a single growing season. Maize, however, needs a much higher level of soil fertility and rainfall than other grains such as sorghum which yield well on infertile, previously cropped soils. Sorghum, however, takes between 4-6 months to mature, compared to *Pennisetum's* 3-4 months and maize's 50-60 days. *Pennisetum*, the bulrush millet is the most drought resistant of the three primary cereal crops.

We can therefore argue that in areas of suitable rainfall, maize would have had a higher yield than sorghum thus resulting in the replacement of sorghum as a staple crop (Maggs 1982). The stable climatic situation from the mid 17th century and subsequent wet period towards the mid 18th century would have certainly have favoured the spread and production of maize (Hall 1976, Huffman 1986).

Increasing population in the grasslands during the terminal Iron Age correlates with the supposed adoption of maize during this time (Maggs 1980). Dense settlement patterns and large scale construction of terracing on the eastern Transvaal escarpment and at Inyanga in Zimbabwe might be explained by an increased dependence on this new crop (Summers 1958, Maggs 1994) Intensification of agriculture is also evident in the high rainfall region of the eastern Transvaal between 1650 AD and 1820 AD. Here sites characterised by Marateng pottery (a regional variant of Moloko) are marked by stone ruins with trackways and terraces (Collet 1982, Evers 1984).

Both Hall and Huffman note that the sudden decline in rainfall and ensuing droughts at the end of the 18th century would have resulted in an "acute crisis in production" especially if, as the evidence implies, there had been an increasing reliance on maize in the area. Hall suggests that this might well have triggered the political upheavals of the early 19th century.

Historical evidence

Some researchers believes that maize was most likely introduced when the Portuguese established a permanent settlement at Delagoa Bay at the beginning of the 18th century (Hall 1976, Miracle 1966, Axelson 1973). However the possibility of an earlier introduction cannot be overruled. The Portuguese had established a station at Sofala by the beginning of the 16th century. Documents of the Portuguese in Mozambique between 1497 AD and 1840 AD, record the amount and type of grain received at the port of Sofala (Da Silva Regio et al 1962). However there is some contention as to the translation of the Portuguese term *milho*, which may have referred to millet as well as maize. There is fairly good evidence that by at least 1554 AD *milho* meant maize (a reference to *milho* is accompanied by an illustration of an ear of maize) (Miracle 1966). Another Portuguese word used to describe grain is *meixoeira*. A physical description of this grain in northern Natal in 1593 AD suggests that it referred to the finger millet *Pennisetum* (Hedges 1978). In 1511 AD , although little grain was entering the port of Sofala, it is noted that 5 *alqueires* (a measure of volume) of *milho* and 1 alqueires of *meixoeira* were allocated to each person because the *milho* was worm eaten. By 1514 AD , the captain of the port of Sofala was bringing in 20 758 *alqueires* of *milho* compared with 593 alqueires of *meixoeira*. This indicates that the distinction between maize and millet was already being drawn by the beginning of the 16th century AD. The distinction was again made in the same year with the comment that milho was a staple followed by *meixoeira* and then rice (Da Silva Regio et al 1962). It is therefore feasible when considering the evidence from the Portuguese documents that maize was present in southern Africa by the beginning of the 16th century.

Contact with indigenous populations was definitely established by this time. Records of trade in ivory and gold with the Mutapa state demonstrate that it was entirely possible for people to have obtained maize from the Portuguese as early as the 16th century AD (Beach 1980, Axelson 1973). The Inyanga plateau is situated on one of these trade routes between Sofala and the interior. As a result of Inyanga's geographic position and surrounding political instability, people were under constant threat, and were forced to practice an intensive form of agriculture and build defensive structures to protect their grain and stock (Beach 1980). This, together with the archaeological evidence, points toward the introduction of maize in at least some areas of southern Africa sometime during the 16th and early

17th centuries. Maize could have spread across the Inyanga plateau to central Zimbabwe as trade was established between the Portuguese and Khami civilisation, and may already have been introduced to South Africa by descendants of the Shona when they migrated into the Soutpansberg in the 16th/17th century.

Ethnographic evidence for diet

Many of the hypotheses surrounding diet and subsistence in the Later Iron Age have been derived from ethnographic studies of agriculturists in South Africa. Certainly, studies of contemporary populations can give us clues as to the behaviour of their predecessors. However it is perhaps too presumptive to regard the behaviour of agriculturists today as typical of agriculturists throughout the Later Iron Age. Maize is a recent introduction and it cannot be assumed that the dominance of this cereal amongst present peoples was preceded by an equivalent dominance of another cereal grain. The notion of a "typical Iron Age diet" must therefore be viewed with caution. The available ethnographic studies on diet and subsistence do however concur with the archaeological evidence, which suggests that although people were herder's and agriculturists, they supplemented their diet with hunting and gathering. Monnig in his study of the Pedi describes the economy as "internally subsistent" (1967, 143). The Pedi cultivated a variety of cereals, including maize and sorghum and, to a lesser extent, millets. He claims that the popularity of maize is due to the fact that it does not need protection against birds. Pumpkins, gourds, melons, cow peas, legumes and nuts supplement the diet. Livestock, especially cattle, are valued primarily for their social and religious value as opposed their economic value. Hunting and gathering was not a regular occupation and was carried out sporadically in times of other economic activity (Monnig 1967).

Stayt (1931) also notes that cattle are of little importance economically to the Bavenda and represent instead, an insignia of wealth. He suggests that when the Bavenda migrated across the Limpopo to the Soutpansberg district they possessed large herds of cattle which subsequently did not respond favourably to the new environment and "died in great numbers until only the powerful chiefs could afford to keep them" (1931, p. 38). This migration is supposed to have taken place towards the end of the 17th century AD (Loubser 1988) (Map 4, page 121). The Bavenda depend almost entirely on agriculture for their subsistence. The three grains (maize being the staple) are grown together with beans, pumpkins, melons, nuts, gourds, potatoes and sugar cane. In a general study of agriculturists in South Africa, Schapera and Goodwin notice similar mixed farming practices with wild fruits and berries eaten as a supplement when in season, and the addition of insects such as locusts, caterpillars and ants when food was in short supply (Wilson 1969). Hunting is a welcome addition to the diet but is carried out sporadically.

A similar diet has also been observed amongst the Nguni where wild plant food substituted the daily meal of stiff porridge and meat was rarely eaten (Davison 1991). The majority of the food producing activities are conducted by women. While men take care of the domestic herds, women are responsible for the domestic duties. The daily task of keeping and cultivating the fields may take up to 6 hours. Labour forces are only combined in times of threshing, ploughing or sowing of seeds (Davison 1991). Thus women are primarily responsible for the productive capacity of the homestead.

Conclusion

Much of the research on populations in the Later Iron Age has concentrated on linking sites, through settlement and ceramic patterns, across the sub-continent. Some archaeologists have sought to draw individual sites together to create "models" which would be reflective of the entire Early or Later southern African Iron Age. Others have used these models in their interpretation of the archaeological record. As a result, there has been little investigation into the heterogeneity of populations. Yet differences are evident in the archaeological record throughout the second millennium. Ceramics and settlement patterns have been divided into numerous types, traditions and groups because of their diverse range of styles. Why then, when the proportions of cattle and wild faunal remains found at sites indicates differing use of livestock as a food resource are subsistence patterns regarded as basically homogeneous amongst Later Iron Age peoples?

During the Later Iron Age there was a rapid growth and expansion of populations into different biomes, with diverse climates. The geographic separation of populations was one of the factors that resulted in the development of different ethnic groups in South Africa. Trade with the East coast becomes widespread stretching across South Africa to Zimbabwe and Botswana. The development of large towns occurs concurrently with social and political stratification. As sedentisim evolved, so did regional conflict. I would argue, that with all these factors acting on Later Iron Age populations, the notion of an unchanging, single subsistence economy in the Later Iron Age does not appear feasible. There are just too many variables.

The idea of using various models to describe the Later Iron Age is attractive to archaeologists as it draws the prehistory of people together. However the drawbacks of using a model for an interpretation, is that it holds certain preconceived ideas and does not account for any individual variability. This has particularly limited investigations into subsistence and economy patterns during the Later Iron Age. The overemphasis of cattle in the economy, as a result of the differential preservation of animal bones as opposed to plant matter, has resulted in a lack of investigation into the importance of agriculture. Consequently, existing models do not fully address the relative importance of domestic stock and cultigens in subsistence patterns during the Later Iron Age. The models have not adequately accounted for the differential access of food resources to communities and individuals.

Current perspectives and interpretations in the archaeology of the Later Iron Age have therefore been inadequate in addressing the vast number of variables evident during this period. Investigations using isotopic and physical anthropological analyses of skeletal remains would provide a new approach to the issues surrounding diet and subsistence. This new approach will address some of the shortfalls of current models while providing evidence for diet and subsistence at the most basic level.

Chapter 3

Stable carbon and nitrogen isotopes in nature: Paleodietary reconstruction

This chapter outlines the basis for the application of stable carbon and nitrogen isotopic analyses in the determination of paleodiets. The distribution, and range in variation of carbon and nitrogen isotopes in the foodweb is examined and the relationship between diet and consumer is outlined. Consideration is also given to metabolic factors likely to affect the isotopic composition of human tissue. Archaeological application of the stable isotope technique to the study of human diet is presented and evaluated. Special consideration is given to the study of African diets and subsistence patterns. The effect of aridity on $\delta^{15}N$ values is also discussed.

An examination of the variability in the isotopic composition of carbon and nitrogen in nature has resulted in investigations into the differential distribution of these stable isotopes in the environment. The average natural isotopic composition of $^{12}C/^{13}C$ is 100:1 and $^{14}N/^{15}N$ is 100:0.4 (O'Leary 1988). However an observable change in the abundance of these isotopes in the natural environment has been seen to occur as a consequence of natural chemical and biological processes. This phenomenon, called fractionation, affects the distribution of carbon and nitrogen isotopes in the bio- and geosphere, through differential enrichment or depletion of the heavier isotope in organic compounds. This variation in the natural abundance of carbon and nitrogen isotopes has determined a basis for the study of the distribution and range of isotopic variation in nature. Differences in the isotopic ratio of living organisms (plants and animals) have established the potential for stable isotopic analyses in the reconstruction of paleodiets.

Carbon isotopes

Carbon exists in the atmosphere in three isotopes, C^{12} and C^{13} which are stable and C^{14} which is radioactive. These isotopes have the same chemical properties but because of their different atomic mass they react at different physical and chemical rates. A large part of the natural variation of stable carbon isotopes, has been attributed to photosynthesis. This has resulted in characteristic isotopic signatures of plants with different photosynthetic pathways, which are then passed onto their consumers.

The notation used to report the natural variation in the carbon isotopic composition of organisms is called delta (δ). This expresses and amplifies the isotopic relationship of carbon against a universal standard known as PDB (marine limestone) and the difference is reported as the relative ^{13}C content of the sample ($\delta^{13}C$) and expressed in parts per thousand ‰.

$$\delta^{13}C\ \mathrm{PDB} = \{[\ (^{13}C/^{12}C)\ \mathrm{sample}\ /\ (^{13}C/^{12}C)\ \mathrm{PDB}\ ]\ -1\} \times 1000$$

Atmospheric CO_2 has a $\delta^{13}C$ value of -7‰. Organic carbon containing compounds are generally negative while naturally occurring forms of carbon such as carbonates tend towards positive $\delta^{13}C$ values. (van der Merwe 1982, van der Merwe and Vogel 1983).

Photosynthetic pathways

Plants follow one of three different photosynthetic pathways, the Calvin cycle (C_3), Hatch Slack pathway (C_4) and crassulacean acid metabolism (CAM). The mode of photosynthesis is species specific. During the Calvin cycle the product of CO_2 fixation is the three-carbon compound phosphoglyceric acid while a four-carbon compound, oxaloacetic acid, is formed as a product of the Hatch Slack pathway (Vogel et al 1978). The CAM method of photosynthesis occurs in desert plants and succulents which utilise both C_3 and C_4 methods of CO_2 fixation depending on the time of day as well as the environmental conditions (O'Leary 1988). The main difference between C_3 and C_4 plants appears to be the occurrence of Kranz cells in C_4 leaf anatomy. These are vascular bundles surrounded by a sheath which contain chloroplast different from the ones found in the mesophyll, and aid in the efficient and rapid carboxylation (the assimilation of CO2) of C_4 plants. The more efficient the carboxylation the less internal CO_2 diffuses back to the outside, therefore isotopic fractionation in C_4 plants is less than that of C_3 plants (O'Leary 1988 and Vogel 1978). C_3 plants also respire at night , giving off CO_2 and thereby introducing an additional step of fractionation.

$\delta^{13}C$ in plants

Most trees and shrubs, as well as grasses in temperate environments, follow the C_3 pathway depleting atmospheric carbon by 19.5‰. The result is that the foliage of C_3 plants range between -20‰ and -36‰ (van der Merwe and Vogel 1978). The C_4 pathway is found most often in grasses adapted to hot arid climates including tropical grasses such as sorghum, millet and maize. The $\delta^{13}C$ ratio of C_4 grasses varies between -9‰ and -16‰. It was initially thought that because of their economical use of water, C_4 plants were specifically adapted for arid climates. However no relationship between rainfall and the proportion of C_3 grasses could be determined (Cowling 1983). C_3 grasses grow more successfully in areas where the mean average temperature, during the rainy season, is below 25°C and have therefore adapted to a winter growing season (Tiezsen 1991). The cover of C_3 grasses is likely to be highest in cool shaded microclimates. C_4 grasses have an advantage over C_3 grasses in conditions of light intensity, high temperature and low intercellular CO_2 content, resulting from water stress, and have adapted to a summer growing season. The effect of changes in environmental conditions, such as aridity, canopy cover and altitude, are also less pronounced in C_4 plants. In order to account for this natural variation of $\delta^{13}C$ values in plants, between 3-4‰, it is necessary to have a good understanding of both the plants species itself and the environmental condition in which it grows (Tiezsen 1991).

In Africa, most of the savanna and grassland are dominated by C_4 grasses. This holds true in South Africa, where over 95‰ of the grass species in the interior are C_4. C_3 grasses only predominate in the winter rainfall region of the south Western Cape and on the summits of the Drakensberg and Eastern Cape mountains. An analysis of 351 grass species show that the range between C_3 and C_4 plants do not overlap and that mean values (-26.5‰ and -12.5‰) differ considerably (Vogel et al 1978).

In the savanna and grassland biomes of South Africa, C_3 foods include the products of trees, shrubs, vines and tubers and certain dometicated plants (ti\ubers, pumpkins, gourds) while the indigenous African cultigens such as sorghum and millet have a C_4 signature.

$\delta^{13}C$ in animals

As a result of this marked difference in $\delta^{13}C$ ratio between C_3 and C_4 plants it is possible to distinguish between grazing (grass eating) and browsing (leaf and shrub eating) herbivores. Analysis of the carbon isotopic composition of ungulates in southern Africa show that the $\delta^{13}C$ range for browsers falls close to the range for C_3 plants (varying between -17.6‰ and -24.1‰ with an average of -21.1‰) (Vogel 1978). The $\delta^{13}C$ values for grazers on the other hand resembles that of C_4 grasses and ranges between -6.0‰ and -13.6‰ averaging at -9.7‰ (Ibid). Once again when considering the difference between pure browsers and grazers there is no overlap in the $\delta^{13}C$ values. However the ecosystem is not that simple, as many animals for example impala have wide ranging foraging habitats. The $\delta^{13}C$ values of impala vary between -9.4‰ and -21.6‰ (Vogel 1978). Environmental effects also have to be taken into account as particular species, for example springbok from the northern Cape have more depleted $\delta^{13}C$ values compared to those from Namibia probably because they eat more karoo shrubs than grass.

$\delta^{13}C$ in bone collagen

Additional secondary isotopic fractionation occurs in the formation of bone collagen, the protein component of bone. While some fractionation takes place in the protein component of the plant (and is merely sorted and stored by collagen), further fractionation occurs in animal tissue (Krueger and Sullivan 1984, Ambrose and Norr 1993). Certainly there is a difference in the isotopic composition of various tissues. Fractionation is not uniform for all animal tissues, fat is depleted by -3‰, while the approximate enrichment of bone collagen is consistent and has been recorded as +5.3‰ for ungulates in southern Africa and +5.1‰ for skeletal material in woodland North America. This has been related to differences in the composition and turnover of tissues, secondary fractionation effects, and synthesis from different constituents of the diet (Lee-Thorp et al 1989). Thus if the average $\delta^{13}C$ value for C_3 plants is -26.5‰ one would expect the average bone collagen values of pure browsers to be -21.5‰ and that of pure grazers, -6.5‰ (van der Merwe and Vogel 1986). This has been demonstrated in areas with mostly C_3 vegetation such as Western Europe and woodland North America where the $\delta^{13}C$ values of hunter gatherers are closely related to the C_3 plant average (x -20.4‰ and -21.4‰ respectively) (van der Merwe and Vogel 1978).

Interpretation of $\delta^{13}C$ bone collagen results

Collagen is the main constituent of the organic phase of bone and has the advantage, under certain conditions, of being relatively resistant to degradation, making it a highly suitable sample material for isotopic analyses (van der Merwe and Vogel 1988). Unfortunately, our understanding of the formation and metabolism of bone is limited. Although the $\delta^{13}C$ value of bone collagen is related to the ^{13}C content of the diet, it does not uniformly reflect the various dietary components. It has been determined that the isotopic composition of collagen is reflective of periods of bone growth, such as that in childhood and adolescence. In adults, collagen has a slow carbon turnover rate, consequently dietary carbon is averaged over a long period. However, periods of rapid turnover in adults do stimulate the reformation of bone possibly exaggerating the overall collagen signal in favour of the foods eaten during those times (Parkington 1991).

As a result of the preferential use of amino acids in human metabolic systems to synthesis proteins, there is also some debate as to the how much collagen carbon is derived from ingested protein (Krueger and Sullivan 1984, Ambrose and Norr 1993). This issue has been the cause of much discussion, and needs to be considered in the interpretation of the isotopic results (Lee-Thorp et al 1989). It has been suggested that collagen $\delta^{13}C$ values largely typifies the protein input in the diet (animal component) while apatite (the inorganic phase of calcified tissues) constitutes that part of the diet used for energy (carbohydrate component). This may affect the representation of dietary carbohydrate in collagen. A method of addressing the proportion of protein derived from carbon in the diet of animals and humans was established, using the difference in the $\delta^{13}C$ values of collagen and apatite (the mineral phase of bone). The difference in the $\delta^{13}C$ values between the two phases of bone was found to be smaller in carnivore than herbivores (Lee-Thorp et al 1989). This occurs because, while herbivores derive their energy from carbohydrates, carnivores derive both their protein and energy from the protein of their prey. However the extent to which bone tissue derives it's carbon from different foods is not known and although it is not possible to determine exactly how much of a particular food item is represented by the $\delta^{13}C$ value of bone collagen, one is able to determine to what extent C_3 and C_4 foods are represented (Sealy and van der Merwe 1992).

Carbon isotopes have been used to document changes in the proportion of C_3/C_4 food consumption in the diet of people. Specific applications have included tracing the transition in C_3 environments, from hunting and gathering to the cultivation of C_4 cereals, such as maize. As a result of characteristic differences in the ^{13}C content of marine organisms, this technique has also been used to determine the contributions of marine and terrestrial foods in diet. However as it is not possible to draw distinctions between C_4 derived foods and marine foods. These inferences can only be drawn when the contrasting terrestrial environment is C_3 based.

Nitrogen as a paleodietary indicator

The distribution of the $^{14}N/^{15}N$ in the environment also provides a basis for the use of stable nitrogen isotopes in studies of prehistoric diet. Unlike carbon isotopes, the most pronounced fractionation of nitrogen isotopes occurs in mammals and not in plants. As a result of this systematic enrichment, nitrogen has been used to distinguish between the proportion of plant and animal food in prehistoric diets. The clear distinction between marine and terrestrial environments has resulted in the use of nitrogen isotopes as a determinant of the amount of dietary marine food consumed by various populations (Schoeninger et al 1984).

Nitrogen isotopic values are described in very similar terms to carbon isotopes. The relative amount of ^{15}N ($\delta^{15}N$) is expressed in parts per mill, and measured against a standard, atmospheric N_2, which by definition has a $\delta^{15}N$ value of 0‰ (Heaton 1987).

$$\delta^{15}N = \{[(^{15}N/^{14}N) \text{ sample} / (^{15}N/^{14}N) \text{ air}] -1] \times 1000$$

$\delta^{15}N$ in plants

Atmospheric N_2 enters the environment as ^{15}N depleted nitrogen, through biological fixation by soil bacteria (Ambrose 1991). While this process contributes depleted ^{15}N to the soil, denitrification acts to increase the $\delta^{15}N$ values. This process is however variable and in hot arid climates decreased nitrogen fixation results in a higher $\delta^{15}N$ concentration in the soil (Ambrose 1991). In coastal environments, additional nitrogen is introduced into the atmosphere via seaspray, thus contributing to an increase in soil $\delta^{15}N$ values (Heaton 1987). Variation in the $\delta^{15}N$ values may also occur in soil profiles as a result of age, particle size and sediment fraction. Soil $\delta^{15}N$ values may therefore vary considerably depending on the environment. Cool moist forest soils will be more depleted than saline coastal environments.

As the movement of nitrogen between soils and plants is unidirectional, plants tend have similar $\delta^{15}N$ values to the soil in which they grew. Plants obtain nearly all their nitrogen from inorganic ammonium in soil nitrates or through symbiosis with atmospheric N_2 fixing bacteria. There is considerably variety and overlap between N_2-fixing plants such as legumes, which have the ability to obtain atmospheric N_2, and non N_2-fixing plants, which rely on the soil for their nitrogen (Ambrose 1991). Non N_2-fixers may have significantly higher $\delta^{15}N$ values than N_2-fixers, being between 1‰-

6‰ more positive than the soils they grow on. The variation in the $\delta^{15}N$ values of plants in southern Africa range from -0.4‰ to +13.5‰ (Heaton 1987).

$\delta^{15}N$ in animals

The nitrogen isotopic composition of animals is also influenced largely by environmental and physiological factors. Pronounced fractionation of $\delta^{15}N$ values occurs in the non-essential amino acids of animal tissues, which are consistently enriched in $\delta^{15}N$ relative to their diets (Ambrose 1991). A consistent enrichment in $\delta^{15}N$ values is observed at each trophic level step from plants to herbivore to carnivore (Schoeninger and DeNiro 1984, Sealy et al 1987, Minagawa and Wada 1984, Ambrose 1991). The difference between the $\delta^{15}N$ values of terrestrial herbivores and carnivores range from +3‰ (Schoeninger and DeNiro 1984) to +5.7‰ (Ambrose 1991) and average around +3.4‰ in marine environments (Minagawa and Wada 1984).

However a significant amount of variation in the $\delta^{15}N$ values of herbivores in different environments has been observed. This has resulted in the careful consideration of extraneous factors and their influences on the $\delta^{15}N$ value of bone collagen (Ambrose and DeNiro 1986, Sealy and van der Merwe 1986). Urea is the most common mode of nitrogen excretion in mammals and is considerably depleted in $\delta^{15}N$ compared to the diet. In situations of increased water stress, it is a strategy of mammals to excrete larger concentrations of urea in order to conserve water. Consequently, the $\delta^{15}N$ values of the nitrogen pool retained by the mammal are enriched thereby increasing the amount of 15N available for tissue synthesis. This would result in a more positive $\delta^{15}N$ value in animals that are subject to heat or water stress (Ambrose and DeNiro 1986). Drought tolerant species are observed to have $\delta^{15}N$ values between 2 - 4‰ higher than obligate drinkers (Ambrose and DeNiro 1986). Elevated $\delta^{15}N$ values (greater than +10‰) amongst herbivores and prehistoric humans in areas of South Africa receiving less than ± 400mm of rain per year, also confirm the relationship between nitrogen and climatic factors (Heaton et al 1986). A strong correlation between $\delta^{15}N$ values and aridity has been determined with $\delta^{15}N$ value of herbivores becoming enriched by 1.1‰ to 1.3‰ with every 100mm of decreasing annual rainfall (Heaton 1987).

$\delta^{15}N$ and water stress

As a result of the increased excretion of uric nitrogen in times of water stress, animals must maintain high levels of dietary protein or suffer from dehydration and nitrogen imbalances. Browsing animals in arid areas should then have higher $\delta^{15}N$ values as they generally consume more protein than grazers (during dry seasons, leaves contain more protein than the dry grasses). They are therefore more readily able to excrete urea in order to conserve water (Sealy and van der Merwe 1986).

However if this were the only factor acting on the $\delta^{15}N$ value of animals one would expect these differences to be more noticeable in arid areas as opposed to well watered areas. This is not always apparent (Sealy and van der Merwe 1986). Thus another possible explanation involving the recycling of urea in ruminants was proposed in order to address these discrepancies.

For an animal to maintain their nitrogen balance in arid climates, a higher protein content is needed in the diet. Ruminants may therefore conserve nitrogen through the process of urea recycling. This involves the diffusion of urea through the bloodstream and back into the rumen. If grazers habitually consume less protein than browsers, one would expect a greater recycling of urea amongst grazers and therefore higher $\delta^{15}N$ values (Sealy and van der Merwe 1986). Two objections have been raised in relation to these assumptions. Firstly, the recycled urea would probably have depleted $\delta^{15}N$ values therefore contributing no net enrichment of ^{15}N to the herbivore. Secondly isotopic enrichment of the animal tissue cannot occur until the ^{15}N depleted urea has been excreted (Ambrose 1991). No matter how much enrichment may occur in the internal system, enriched ^{15}N tissue cannot be created.

The model of urea excretion probably best explains the differential distribution of $\delta^{15}N$ values amongst herbivores form various environments and also offers a possible explanation for trophic level differentiation. The lower concentration of ^{15}N in the excreted urea may well account for the enriched $\delta^{15}N$ values between trophic levels when compared to their diet (Ambrose 1991). An extensive study examining the pattern and path of nitrogen throughout the foodweb in the East African Highlands notes the variability of nitrogen in each trophic level and between ecosystems. Thus, when interpreting stable nitrogen isotopes as indicators of the amount of plant and animal food in the diets of human populations, physiological and environmental factors need to be taken into consideration. However the combination of stable carbon and nitrogen isotopes in paleodietary studies can assist in quantifying the various dietary components, thus providing greater accuracy and resolution in the archaeological record.

Applications of stable carbon and nitrogen isotopes to paleodiets

Stable carbon isotopic analysis has been most frequently employed in the determination of the introduction of C_4 agricultural crops (such as maize) in C_3 based environments like North and South America (Bender et al 1981, Burger and van der Merwe 1990, Lynnot et al 1986, Matson and

Chrisholm 1991, van der Merwe 1982, van der Merwe and Vogel 1978). The introduction of maize as a primary cultigen in North and South America has resulted in a vivid contrast between the $\delta^{13}C$ values of agriculturally based subsistence economies, and the predominantly C_3 based diet of hunter gatherer populations. The $\delta^{13}C$ values of skeletons in the North American interior demonstrated that where Archaic populations had a definite C_3 diet ($\bar{x}$ $\delta^{13}C$ -21.4‰), later populations circa 1000 AD, show an increased dependence on C_4 plants ($\bar{x}$ $\delta^{13}C$ -12‰) (van der Merwe and Vogel 1978). More detailed analyses of transitional North American woodland populations confirmed this increased dependence on maize noting that populations from the Middle period, around 350 AD, were still subsisting off primarily C_3 foods (Bender et al 1981). Similar changes in C_4 dependence during the transition to agriculture have been noted in other North and South American groups. In Parmana in the Amazon the mean $\delta^{13}C$ values shift from -26‰ in the early skeletons to -10‰ around 400 AD (van der Merwe et al 1989). Enriched $\delta^{13}C$ values have also established the presence of intensive maize agriculture ca 1000 AD in the Mississippi river valley, $\bar{x}$ $\delta^{13}C$ value -13.7‰ (Lynott et al 1986), at 400 AD in southern Ontario, $\bar{x}$ $\delta^{13}C$ -11.6‰ (Schwarcz et al 1985), and at 4500 BC in the Tehuacan valley of Mexico, $\delta^{13}C$ of approximately 11‰ (Farnsworth 1985).

This quantitative approach of establishing the introduction of maize has also been used to test the archaeological evidence. For example, Burger and van der Merwe have determined that maize did not play an important role in formation of the Chavin civilisation in Peru. $\delta^{13}C$ values of -18‰ indicate that although C_4 foods were consumed, C_3 items such as potatoes formed the bulk of the dietary intake (1990). Matson and Chisholm used $\delta^{13}C$ values to show that Anasazi Basketmaker II people were not merely transitional agriculturists, as the archaeological evidence suggests but dependent on maize as a staple food source ($\bar{x}$ $\delta^{13}C$ -7.4‰) (1991).

More specific changes in the diet are also noticeable. Other studies tracking the increasing importance of maize as a staple food source have noticed shifts to an increasing C_3 dependence, in the middle of agricultural phases (Larsen et al 1992, White and Schwarcz 1989). The marked decrease in $\delta^{13}C$ values during the agricultural period in the Georgia Bight correlates with a reduction in rainfall, thus reducing the crop harvest and resulting in a change in the subsistence pattern (Larsen et al 1992).

The average $\delta^{13}C$ value for populations in the America's eating maize as a primary food source is 10.1‰, with the most positive $\delta^{13}C$ value recorded being 6.8‰ (Bender et al 1981, Farnsworth et al 1985, van der Merwe et al 1983, White and Schwarcz 1989, Matson and Chisholm 1991, Katzenberg et al 1993). This occurred in an infant under two years old who was being fed a high carbohydrate weaning diet (Katzenberg et al 1993).

Both $\delta^{13}C$ and $\delta^{15}N$ values have been used as indicators of the relative contribution of marine and terrestrial food in prehistoric diets (Schoeninger and DeNiro 1984, Sealy and van der Merwe 1986, Sealy et al 1987). The $\delta^{15}N$ values of historic Eskimo populations from Alaska and North America were compared with North and South American agriculturists (Schoeninger et al 1983). Those groups, depending primarily on marine mammals or freshwater fish, had $\delta^{15}N$ values ranging between +17‰ to +20‰. This contrasts considerably with the $\delta^{15}N$ value of the agriculturists, which ranges between +6‰ to +12‰. Further analysis of prehistoric populations demonstrates that marine/terrestrial differences are also apparent in archaeological samples. The mean $\delta^{15}N$ value for both Mesoamerican and European agriculturists has been recorded as +9‰, while marine hunter gatherers from North America and Europe had contrasting mean $\delta^{15}N$ values of +16‰ and +14‰ respectively (Schoeninger et al 1983).

Similar research has also been conducted in the African context. Carbon isotopic analysis was used as a marine/terrestrial indicator in the southwestern Cape where the terrestrial C_3 signature contrasted with the C_4 signature of the marine environment, to test the hypothesis, of a transhumant population.

Studies of dietary change in the terrestrial African environment are somewhat more complicated. The dominance of C_4 grasses in the interior grasslands and savanna of southern and east Africa can result in enriched $\delta^{13}C$ values in hunter gatherers. Thus while depleted $\delta^{13}C$ values result from the consumption of C_3 plant food (wild or domestic) and the meat of browsing animals, an enriched $\delta^{13}C$ signature could be a combination of wild or domesticated C_4 grasses and the meat of both wild or domestic grazers. Thus in order to establish whether or not the $\delta^{13}C$ value is representative of a hunter gatherer or agriculturist subsistence pattern, a detailed study of the environment needs to be made.

The $\delta^{15}N$ and $\delta^{13}C$ values of a wide variety of historic and prehistoric groups with different subsistence bases from east and southern Africa have been examined and compared with the ethnographic evidence of subsistence patterns (Ambrose 1986, Ambrose and DeNiro 1986, Lee Thorp et al 1993). Historic groups such as the Kikuyu and Kalenjin, described as being largely dependant on plant food, had $\delta^{15}N$ values between +8‰ and +12‰ while those primarily dependent on meat, milk and blood of animals such as the Turkana, Pokot and Griqua ranged from +12‰ to +18‰. On average pastoralists have a higher $\delta^{15}N$ value (13.8‰) than agriculturists

(10.4‰). Thus groups dependent on animals and their products have higher $\delta^{15}N$ values than people subsisting mainly on plants (Ambrose 1986, Ambrose and DeNiro 1986).

Populations subsisting on predominantly C_4 cultigens or the protein of animals grazing on C_4 grasses have highly positive $\delta^{13}C$ values averaging around -5.7‰ (Elmenteitan Neolithic and the Savanna Pastoral Neolithic in Kenya) (Ambrose 1986, Ambrose and DeNiro 1986). This is very different to the $\delta^{13}C$ values obtained for various coastal hunter gatherers in southern Cape which average around -13.6‰, and have been determined to consist of both C_4 marine foods and C_3 terrestrial foods (Sealy and van der Merwe 1986). These $\delta^{13}C$ values are more enriched than those obtained from maize agriculturalists suggesting that agriculturalists and pastoralists in Africa were consuming a higher proportion of C_4 foods than maize eaters from the America's.

The $\delta^{13}C$ values of Later Iron Age farmers in South Africa ($\overline{\mathbf{x}}$ -8.2‰) indicates a greater dependence on C_3 plants (possibly including a range of C_3 cultigens such as curcubits, gourds melons) when compared to other African agriculturists. A lower $\delta^{15}N$ value (+9.4‰) confirms the lower proportion of animal protein in the diet of Later Iron Age agriculturalists when compared to the Savanna Pastoral Neolithic and Elmenteitan people (+11‰ and +12.7‰), and the average $\delta^{15}N$ value for other pastoralists (+13.4‰) (Ambrose 1986). A further examination of the isotopic signature of prehistoric farmers in southern African has reported similar results (Lee Thorp et al 1993). This study included the isotopic results of 47 adults and children from a variety of geographic locations in the early and later parts of the second millennium. Both inter- and intra-site variability was higher than expected, suggesting that diet and subsistence was not uniform amongst southern African Later Iron Age food producers. A difference is apparent between 11th/12th century individuals from the dry savanna (who appear to be eating a higher proportion of C_3 based foods and thus had a wider subsistence base) and individuals from moister climates in the second half of the second millennium, whose enriched $\delta^{13}C$ values indicate a strongly C_4 based diet. Positive $\delta^{15}N$ values from the earlier group may be related to aridity and/or a higher animal food component. These results will be discussed in greater detail in chapter 6.

The results from the southern African Later Iron Age were also compared to two protohistoric communities of mixed hunter gatherers/pastoralists from the Northern Cape. The isotopic values for the Kakamas group were similar to that reported for the Griqua (Ambrose 1986). An average $\delta^{13}C$ value of -11.8‰ reflects a mixed C_3/C_4 contribution to the diet while an enriched $\delta^{15}N$ of +15.4‰ may be a reflection of aridity or a higher trophic level. The Riet River skeletons, on the other hand, fall closer to the range for the Iron Age farmers ($\delta^{13}C$ = -9.42, $\delta^{15}N$ = -12.43). It has been suggested that the people from Riet River were San hunter gatherers who had adopted pastoralism from neighbouring Iron Age farmers (Lee-Thorp 1993).

Thus, an isotopic assessment of diet in the African environment, although complex, can provide us with information as to the relative content of C_4 foods and the dependence on animal protein. In general, when comparing groups from areas with similar rainfall, highly positive $\delta^{15}N$ values occur amongst pastoralists while depleted $\delta^{13}C$ values characterise agriculturists.

Chapter 4

Caries as a physical anthropological indicator of diet

Introduction

Caries is a multifactoral disease affected by exogenous and endogenous factors. It results from the presence of microbial organisms in the oral cavity, which through the metabolism of food carbohydrates, produce acids dissolving the mineral of the tooth surfaces, and resulting in the disintegration of the organic matrix (Henneberg 1991, Powell 1985, Hillson 1986). Generally, exogenous factors, such as the texture and chemical composition of food and the frequency of dental exposure to cariogenic foods influence caries more than endogenous factors (tooth morphology and oral physiology) because they are more variable both within and between populations. Other factors such as genetically determined immunity to caries and environmental factors also affect the severity and prevalence of caries in human populations. The consumption of refined carbohydrate foods has been identified as the major etiological factor of caries, with sucrose being the most cariogenic of all dietary carbohydrates (Adiata 1975). However high incidences of caries have also been recorded amongst archaeological agricultural populations whose diet, although high in carbohydrate, does not include refined sugars (Turner 1979). In this chapter, I will examine the factors influencing the prevalence of caries, including the affect of different subsistence strategies and techniques of food preparation on dental caries.

Etiology of caries

Once teeth erupt in the mouth, they are colonised by bacteria which adhere to the tooth's surface. This build up of bacteria on the tooth's surface is called plaque (Hillson 1979). The pH of plaque varies according to the amount of protein and carbohydrate in the diet. In order for plaque to survive it needs to produce energy. In the anaerobic environment of the oral cavity food carbohydrates are used as a fermentable energy source by dental plaque micro-organisms (DePaola 1982). The metabolism of carbohydrates by bacteria in the plaque yields lactic acid (DePaola 1982, Henneberg 1991). Dental tissue dissolves at a pH of between 4 and 5.7 (Henneberg 1991). If during these acid phases the pH of plaque drops below 5.7, it will dissolve the enamel mineral causing localised destruction of hard tissues of the tooth. The process is however not unidirectional. Teeth are not situated in an isolated environment. Saliva is saturated with apatite and when the pH rises after an acid phase, remineralisation occurs (Hillson 1986). Quantitative relationships between acidogenicity and cariogenicity are difficult to establish (DePaola 1982). However if the oral cavity is exposed to fermentable carbohydrates for prolonged periods thus causing the pH to drop frequently, cavitation of the teeth may result.

Carbohydrates and caries

The bacteria *Lactobacilli* and *Streptococcus mutans* have been related to the cause of caries (Sheiham 1983). Streptococcus is considered the most active etiological agent in caries (Henneberg 1991). Because simple sugars (mono and disaccharides) metabolise quickly producing lactic acid at a very high rate, (causing periods of a very high of pH 4) they encourage the growth of the *streptococcus* bacteria (Hillson 1979, Sheiham 1983). The type of sugar also appears to have an effect on the degree of cariogenicity. Sucrose is the most cariogenic of all dietary carbohydrates followed by glucose, maltose, lactose and fructose (Maikinen 1972). The formation of the extra cellular polysaccharide - dextran - occurs when sucrose is metabolised by *streptococci* bacteria (Maikinen 1972). Dextran is the most dominant polysaccharide in dental plaque assisting the micro-organisms in adhesion to each other and the tooth surfaces (Maikinen 1972, DePaola 1982, Sheiham 1983). Although most sugars have similar properties, dextran is not synthesised from glucose or fructose (Maikinen 1972). Complex sugars and starches undergo longer periods of fermentation as they need to be hydrolysed by salivary enzymes to release glucose before being metabolised by the *streptococci*. Although dextrans are less rapidly used by cariogenic bacteria, their prolonged periods of fermentation degrade the starch into more easily utilised low weight molecules. The presence of dextran promotes the retention of food thereby extending it's residence time in the oral cavity allowing for the generation of new fermentable substances (DePaola 1982). Thus both prehistoric and modern populations (whose diets contain significant proportions of starchy tubers and cereal grains and whom lack regular oral health practices that remove plaque from the tooth's surfaces), would also be susceptible to caries.

The physical properties of food

However, although the consumption of carbohydrates is a major etiological factor in dental caries, other factors also influence the cariogenicity of foods. The chemical composition of the food including sucrose content, inherent pH, total carbohydrate, fat and protein content needs to be considered (DePaola 1982). Some carbohydrates contain protective factors eg fats, proteins and phosphates which can be extracted from foods by mastication and reduce the solubility of the enamel (Adiata 1975). Physical properties of the food including oral retention and buffering capacity influence dietary cariogenicity (DePaola 1982). Rough textured foods contain abrasive particles eg certain fruits and whole grains which require vigorous mastication stimulate the production of saliva, a natural oral cleanser. Sticky foods such as cooked starch stay in contact with the tooth for longer thus prolonging the periods of acid phase. The pattern and sequence of eating foods will also affect the caries potential as certain foods may increase the pH of plaque and if eaten at the end of a meal will thus be potentially caries protective (DePaola 1982). Morphological features of the tooth affect the susceptibility of individual teeth to caries. Food tends to accumulate in the pits and fissures of particularly the more complex posterior teeth (molars and premolars) promoting bacterial activity.

Genetic influences

The features of the tooth's surface are both genetically and environmentally determined and are subject to continual modification by dental wear throughout the lifetime of the individual (Balit 1975, Powell 1985). Genes have a greater effect in the determination of the size of the "key" tooth of each morphological class for example, the first as opposed to the third molar (Balit 1975). Studies in animals have demonstrated that genetically caries-resistant and caries-susceptible strains can be developed thus making some individuals immune to caries (Henneberg 1991, Hillson 1986, Costa 1980). However detailed studies of the relationship between genetics and the environment are necessary in order to establish the importance of the hereditary determination of caries (Henneberg 1991).

Dental wear

The relationship between caries and tooth wear appears to be inverse. Dental wear has been defined by Powell as the erosion of coronal enamel and includes both attrition (direct tooth-on-tooth contact) and abrasion (contact between enamel and foreign substances such as grit) (1985, 308). A slow gradual dental wear is beneficial as it removes potential caries from fissures and pits by smoothing out the occlusal surfaces (Powell 1985). Other non-alimentary substances may also reduce the incidence of caries. Dental health studies in Papua New Guinea have shown that the chewing of betel nut causes heavier flow of saliva, reduces food consumption, cleans the tooth surfaces and maintains an alkaline pH in the oral cavity (Powell 1985).

However although severe attrition can obliterate signs of early carious lesions by rapid removal of the occlusal surface, it can also result in enlargement of the interproximal spaces and thus an increase in the incidence of interproximal caries in older persons (Powell 1985). Heavy attrition can increase the relative cariogenicity of different parts of the mouth (Burns 1979) .

Mineral composition

Certain minerals also affect the incidence of caries. Trace mineral levels in soils and waters may affect the cariogenicity of the foods which are grown on them (Hildebolt et al 1988). The effect of elemental intake in six different Amerindian populations ranging from hunter-gatherer-fishers to maize horticulturists has been examined by Schneider (1986). The populations were drawn from different geological boundaries in order to determine what the affect of soil composition is on the incidence of caries. The presence of various elements in the dental enamel was determined using scanning electron microscopy. Correspondence analysis showed that groups, practising similar subsistence modes, were not as closely associated as one would expect. This suggests that particular elements such as zinc, copper and iron are cariostatic whereas nickel appears to be cariogenic (Schneider 1986). Calcium and phosphates also play a big role in the reduction of caries (Driessens 1986).

Fluorine

Fluorine particularly, enhances the tooth's ability to withstand acid dissolution and therefore functions cariostatically (Leverett 1982). Clinical observations have demonstrated that caries experience is much lower in fluorine as opposed to non fluorine areas (Forrest 1956, Driessens 1982, Hillson 1986). Incorporation of fluorine ions into the enamel, dentine and cement of the tooth, during formation, results in the formation of fluorhydroxyapatite, a mineral which decreases the solubility of the tooth's enamel by increasing the size, and inhibiting the diffusion of the apatite crystals (Driessens 1982). Continued exposure to fluorine causes the adsorption of fluorine ions onto the surface of the tooth thus increasing it's resistance to caries. The ingestion of fluorine post-erruptively both retards the metabolic activity of the plaque bacteria as well as accelerating remineralisation of partially demineralised tooth enamel (Driessens 1982). However the incidence and severity of fluorosis (characterised by a mottling of the enamel) is directly related to the amount of the fluorine in the water (Forrest 1956). As a result, it has been established that the ideal level of fluorine in drinking water is about 1‰ (Forrest 1956).

A number of researchers have confirmed that the low incidence of caries is a result of high fluorine ingestion (Ockerse 1947, Molnar and Molnar 1985, Luckacs et al 1985). In all cases dental fluorosis has been clinical diagnosed. In a study of both rural and urban South African school children, Ockerse has compared the incidence of caries with the availability of fluorine in drinking water (1949). Increase in the incidence of caries was directly correlated with a decrease in the natural fluorine content of the water. Areas, such as the southern Cape coastal region, where fluorine concentrations are low or completely absent have the highest incidence of caries.

Age, sex and the location of carious lesions

Skeletal material from different populations in Greece, England, New Mexico and Sudanese Nubia were used to investigate the interrelationship between other factors (age, sex, location) and caries (Burns 1979). It was determined in general, that a higher incidence of caries occurs amongst women, on maxillary teeth and as a result of heavy attrition. In these cases, caries will occur more frequently in the anterior teeth. Larsen also notices a larger increase in the frequency of carious lesions in females between preagricultural and agricultural populations (1983). It has been suggested that the reason for this disparity between men and women is the result of subsistence role differences (Larson 1983). The sexual division of labour has also been offered as an interpretation for the higher incidence of caries in females on Santa Rosa island, off the Californian coastline, between 4000 and 900 BP (Walker and Erlandson 1986). This difference is more pronounced in the earlier period where men specialised in hunting and fishing and women in gathering plant food. When the dietary emphasis shifted from exploitation of high carbohydrate roots and tubers to intensive exploitation of fish and shellfish in the later period, the difference in caries incidence between males and females is not as marked. It is possible that gender variation can be caused by physiological differences. However there is no consistent pattern amongst world populations that would support this (Larsen et al 1991). This difference is therefore best explained in terms of behaviour ie the pattern and frequency of eating practices and sexual division of labour

Dental caries is an age related phenomenon. The older a person is, the longer their teeth have been exposed to cariogenic bacteria. The number of carious lesions in the mouth can be directly associated with the number of years the teeth have been exposed to cariogenic bacteria (Larsen 1984). Poor oral hygiene over an extended period increases the risk of periodontal disease and tooth loss. Comparison of caries incidences are therefore most meaningful when age comparisons can be made (Hillson 1986, Larsen 1984). Carious lesions occur where plaque can accumulate (Hillson 1986). The most common sites of lesions are the occlusal surfaces of the molars, which as a result of their morphology and large surface area tend to be more susceptible to the build up of plaque than anterior teeth. The second most common site is the contact areas of neighbouring teeth ie the interproximal surfaces.

Methods of scoring carious lesions

The frequency of caries in a population is measured by dividing the number of individuals with one or more carious lesion by the total number of individuals in the sample. The intensity of caries is measured by counting the number of carious teeth in each individual dentition and dividing that by the total number of observed teeth. Both indices are expressed as a percentage and provide two different estimates of the prevalence of caries in a population. Another index often used to describe the occurrence of caries in skeletal samples is the decayed and missing (DM) index. This expresses the ratio of carious teeth and teeth lost antemortem to the total number of teeth and/or toothless sockets observed in each dentition in terms of a percentage. The assumption which underlies this estimate is that antemortem tooth loss is related to carious destruction (Powell 1985. Henneberg 1991). As most archaeological studies tend to refer to the incidence of caries in terms of the percentage of teeth with caries, this index will be used in the comparisons to maintain consistency. Should this index not be available for comparison, the prevalence of caries will be referred to in terms of the percentage of individuals with caries of the DM index.

Caries in different economies

An examination of some 64 different pre- and proto-historic populations from different economic backgrounds demonstrates that the percentage of carious teeth in hunting and gathering economies is considerably lower than agricultural groups (Turner 1979). The percentage of carious teeth reported for hunter gatherer economies is 1.3%; mixed economies, 4.8%; and agricultural groups, 10.4%. This confirms other observations that agriculturists generally display far more carious teeth than non-agriculturists or those people relying on mixed economies. Leigh (1925) examined the incidence of caries in four prehistoric American Indian groups with different subsistence strategies. The lowest incidence of caries was recorded in the dentition of the Sioux Indians, a population whose diet is low in carbohydrate and high in animal protein. Here 11% of individuals were affected by caries. Mixed semi sedentary farmers such as the Arikara and Kentucky tribes displayed an intermediately incidence of caries (28% and 30% respectively) while the Zuni maize agriculturists, whose diet consisted largely of vegetable matter, exhibited the highest incidence of caries (75%). Herrala (1961) also notes a increase in the incidence of caries amongst those populations who included maize in their diet as opposed to those who were strictly hunter and gatherers. The aim of Turner's study was to provide a basis for independent physical anthropological examination of populations. As a result, it has now been established that prehistoric diet can be estimated on the base of oral health.

Comparison of the incidence of caries amongst Middle and Late Joman people of central Japan demonstrates a significant difference between the Jomonese and other populations with a hunting and gathering or mixed economy (Turner 1979). As no significant difference between the Jomonese, and the average agricultural society was found, analysis of their oral health appears to indicate that Jomonese people had domesticated some cultigens. A comparison of caries between Jomonese with other Asian agricultural groups shows that the Jomonese had at least as many carious teeth as many other Asian agricultural groups, and a significantly higher incidence of caries than the An-Yang Chinese and Ainu agriculturists of Japan. Millet is the most likely cereal to have been eaten by the An-Yang while the Ainu eat rice and noodles. Both domesticates appear to have had less of a cariogenic effect on people than whatever foodstuffs were eaten by the Jomon people. Analysis of food debris in both of these populations show Jomon people to be consuming a larger proportion of marine and animal protein. The difference in the incidence of caries can therefore not be attributed to a difference in the proportion of carbohydrate consumption. Turner has proposed that the Jomonese were indeed eating more carbohydrate than the archaeological evidence has thusfar shown and that the source of carbohydrate is probably the starchy tuberous cultigen taro, which was introduced from southeast Asia and is more cariogenic than the millets and rice (Turner 1979).

Since Turner's pioneering study on the determination of diet from the study of the incidence of dental caries, the method has been widely used as a means of paleodietary reconstruction. Caries has also been used to discriminate between hunter-gatherers and horticulturists in Ohio (Schneider 1986), Brazil (Turner and Machodo 1983), Channel islands (Walker and Erlandson 1986), Kodiak Island (Costa 1980), Chile (Kelley et al 1992), Georgia Bight (Larsen et al 1992), Hungary (Molnar and Molnar 1985), Italy (Formicola 1986), and Pakistan (Luckacs et al1985), amongst other places. A comparison of both pre- and post-agricultural populations from the Georgia coast documented an increase of nearly 9% in the frequency of caries, more notable amongst women, during the agricultural period (Larsen 1984). The increased caries was attributed to a combination of the adoption of maize as a primary food source as well as the increased survivorship which is associated with the advent of agriculture. It must be noted that a change in subsistence strategy brings about more differences than the introduction of a high carbohydrate food source. Caries could have been affected by the increased life expectancy as it is an age related phenomena, lack of protein in the diet, change in diet, change in pattern and frequency of food consumption (Larsen 1984). Archaeological evidence of agriculture does not necessarily mean that all populations in the same area are dependent on an agricultural foodbase. Rose et al (1984), use caries to interpret the archaeological evidence in the Caddoan culture from the Mississippi valley. The presence of maize cobs indicate that an agriculture economy was definitely present during the Caddo II period, however the contrasting high and low rates of caries suggest that not all people were subsisting off agricultural produce thus making this a period of transition. Although agricultural intensification is evident in the Valley of Oaxaca in Mexico, the decline in the incidence of caries during this period of intensification implies that the increased agricultural yields were not for personal consumption. It is therefore probable that the surplus crops were redistributed to non food producers, an interpretation which would coincide with the increasing social complexity of the Oaxaca during this time (Hodges 1987).

The incidence of caries in African populations

The incidence of caries has also been examined amongst African populations. Primary animal protein eaters, such as the Masai, have a negligible incidence of carious lesions (9% of individuals are effected) (Schwartz 1946). Central African horticulturists whose diet consists primarily of manioc, plantains, maize and rice exhibit a high incidence of caries (8% of teeth with caries) compared with neighbouring Pygmys whose incidence of caries range between 5.1% and 5.8% of teeth (Walker and Hewlett 1990). Efe bow-hunters, who lived close to the horticulturists, have a higher frequency of caries when compared to Mbuti and Aka net hunters of the same age and sex (Walker and Hewlett 1990). This added exposure to cariogenic foodstuffs as well as the seasonal exploitation of honey contribute to an overall higher component of carbohydrates in the diets of the Efe. Sex difference in the incidence of caries are also evident. Pygmy men consume more meat than Pygmy women and as a result the women display a higher rate of caries. Amongst the horticulturists however, men have a higher rate of caries as a result of their greater access to refined carbohydrates. Food consistency and oral health practices also differ between the pygmies and the horticulturists, increasing the differential rate of caries between the two. These variables are also important to consider.

Studies of hunter gatherers in South Africa fall within the range for hunter-gatherers worldwide. In the high fluorine areas of the Kalahari caries occurs in 13% of San individuals (van Reenen 1966). Other hunter gatherers from the Holocene are differentially affected by caries. 2.6% of the teeth of hunter gatherers in the southwestern Cape coastal belt of South Africa are affected by caries. Those individuals identified isotopically as eating a large proportion of marine food are not affected by caries at all. Higher rates of caries identified at Oakhurst on the south coast, and Faroskop in the inland southwestern Cape are attributed to the incredibly low concentrations of fluoride in the southern Cape and the genetic relationship between individuals at Faroskop (Sealy et al 1992).

Proto historic pastoralists from the northern Cape display a higher percentage of carious lesions than hunter gatherers, but are much lower when compared to agricultural groups. Groups from Riet River and Kakamas have an economy based on hunting and gathering with an element of pastoralism. They exploit a variety of wild plant food as well as milk, honey, locusts, gum and wild game which is occasionally supplemented by domestic stock (Morris 1992b). The high fluoride content in the northern Cape probably contributes to some extent to the low incidence of caries in the Kakamas sample (1.3% teeth, 18% individuals). The Riet River sample has a slightly higher rate of caries (4.3% teeth, 41.7% individuals). The pattern of the carious lesions corresponds with that of an essentially hunting economy and higher rate of carious lesions have been ascribed to the lack of fluorine in the groundwater. The Griqua community, 19th century pastoralists, were subsisting off a mixed diet and display the highest incidence of caries of these proto historic peoples (5.2% teeth, 42% individuals). Reports by early travellers in the area indicate that their chief foods were milk, game, domestic stock as well as wheat and vegetables. Contact with the Europeans also provided access to refined sugars. This may well account for the inflated incidence of caries amongst the Griqua (Morris 1992b).

The incidence of caries amongst the Griqua are comparable to that of historic rural agricultural peoples in South Africa (Shaw 1931, Oranje 1935). Examination of skeletal material of rural agriculturalists indicate that 37% of individuals and 2.3% teeth were affected by caries (Shaw 1931). The percentage of rural farmers with caries have been recorded as 33% (Oranje et al 1935) and 36% (Shaw 1931) repectively. Maize and sorghum beer contribute largely to the diet together with other vegetables. Meat is eaten infrequently. Caries also increases with exposure to refined sugars.

Patterns of caries

Another method of distinguishing agriculturist economies is through the examination of the pattern, of caries. Because agriculturists eat cooked starchy cereals frequently and have a low proportion of abrasive, cleaning foods in their diet, the pattern of carious lesions is very different to that of other economies. Differences are evident in the type of teeth affected, the location of the carious lesion, the amount of antemorten tooth loss as well as the degree of severity of the carious lesion. Patterns of caries amongst agriculturalists and hunter gatherers were elucidated from data from 24 different studies of the incidence of caries amongst populations throughout the world (Costa, 1908, Formicola 1986, Herrala 1961, Hodges 1987, Kelley et al 1991, Larsen 1981, 1984, Larsen et al 1991, Leigh 1925, Luckacs et al 1985, Molnar and Molnar 1985, Morris 1992b, Oranje 1935, Patrick 1989, Powell, 1985, Rose et al 1984, Schneider 1986, Sealy et al 1992, Shaw 1931, Smith 1984, Turner 1976, 1979, Turner and Machado 1983, Walker and Erlandson 1986, Walker and Hewlett 1990). Characteristic trends were then noted and a set of criteria was established.

Criteria

Distribution of caries by tooth type

The most cariogenic teeth are molars. This is a result of the large numbers of pits and fissures present in the morphology of the molar teeth. Amongst hunter gatherers the dominant cariogenic molar is the 3rd whereas in agriculturists the 2nd molar is most frequently affected (Morris 1992b). However these factors are not really distinguishing as some overlap does occur. The real difference in the distribution of caries between hunter gatherers and agriculturists occurs between the anterior teeth (canines and incisors) and posterior teeth (molars and premolars). The anterior teeth of hunter gatherers are rarely affected by caries The highest incidence of anterior caries amongst hunter gatherers has been recorded as 1.2% (Kelley et al 1991) and most other hunter gatherer groups display no anterior caries at all (Larsen 1983, Schneider 1986, Sealy et al 1992, Morris 1992). Caries amongst agriculturists, on the other hand, occurs more frequently on the anterior teeth. In order for food particles to adhere to the smooth surfaces of the anterior teeth they need to be sticky and starchy (a characteristic typical of cereals consumed by agriculturists). Premolars are also more often affected in agriculturists. In a comparison of 22 populations in 8 different studies only 0.8%, with one exception, of non agriculturists had caries on the P1 and P2 (Kelley et al 1991, Larsen 1983, Schneider 1986, Sealy et al 1992, Morris 1992). This makes the presence of caries on premolars a secondary rather a primary factor in the determination of a pattern of caries amongst agriculturists.

Location of carious lesions

The location of caries lesions common to all populations are the interproximal and occlusal surfaces. These are the areas of the tooth where food particles are frequently trapped. However occlusal caries is rare amongst hunter gatherers as the texture of their food (large amounts of coarse, fibrous, uncooked plant material) acts as cleaning agent on the occlusal surface (Morris 1992). Buccal and lingual caries which affect the smooth surfaces of the tooth are characteristic of high carbohydrate food consumption and appear only in populations with an agricultural economy (Kelley 1986, Powell 1985).

Antemortem tooth loss

Although antemortem tooth loss is evident in all populations it is particularly high amongst agriculturists. The majority of antemortem tooth loss has been attributed to abscessing resulting from the invasion of caries (Powell 1985). Previous studies have shown that antemortem tooth loss affects under 5% of the teeth of younger adults (under 40 yrs old) but increasingly more older adult amongst hunter gatherers (Morris 1992). Thus if an individual has a high antemortem tooth loss of > 20%, it can be surmised that this is representative of an agricultural economy. Where age can be determined, an incidence of over 10% of teeth lost antemortem in young adults, would be reflective of an agriculturalist.

Advanced caries

Carious lesion are more likely to be advanced (ie over 50% of the crown decayed) in agriculturists. Kelley (1986) recorded no incidence of gross caries in non-intensive agriculturists while Walker and Hewlett recorded less than half of the carious lesions in Pygmies were advanced (1990).

Conclusion

Examination of the research into the occurrence of caries in archaeological populations has demonstrated that caries affects populations with different subsistence patterns to varying degrees. In general, hunter gatherers and populations with a mixed economy have a low incidence of caries whilst agriculturists (as a result of their high carbohydrate consumption), exhibit a high incidence of caries. However as caries is a multifactoral disease, other factors act in collaboration to alter the cariogenicity of various foodstuffs. The age, sex and natural tooth wear of each individual needs to be taken into account in the comparison of caries, as well as the genetic susceptibility of some populations to cariogenic bacteria. Environmental and behavioural factors also play a part in influencing caries. Nevertheless, when all factors are taken into consideration, the incidence of caries has been successfully applied to the determination of prehistoric diets. The pattern of carious lesions can also aid in the identification of subsistence patterns. Agriculturists display a number of specific differences in the location, type and intensity of carious lesions. Agriculturists are most likely to have caries on: premolars and anterior teeth and buccal and lingual surfaces of their teeth, display a high percentage of antemortem tooth loss and advanced/ gross caries Together, these characteristics may be used to distinguish populations with a staple agricultural economy from other subsistence modes.

Chapter 5
Methodology and Sampling

The fundamental level of investigation into prehistoric diets is the analysis of skeletal remains. This provides direct evidence of individual food consumption. Examination of bone collagen, through $\delta^{13}C$ and $\delta^{15}N$ analysis, together with the effect of carbohydrates on dental health, can determine the relative amount of domestic food in the diet. In this chapter, I describe the sampling and analytical procedures employed in this study, as well as the biomes and sites from which the samples are drawn. This establishes the context of the skeletal material, and provides a background for a re-evaluation of diet and subsistence in the Later Iron Age of South Africa

Sample Selection:

An initial list of all Iron Age human remains from South Africa was compiled using *the Master Catalogue of Holocene Skeletons from South Africa* (Morris 1992). As skeletons from the Early Iron Age are rare and often poorly preserved, only Later Iron Age skeletal remains were sampled. The catalogue made it possible to select skeletal material according to the following criteria

- Accessibility of the samples: The sample selection was confined to material curated in South African institutions.
- An established archaeological context: Only material dated to the second millennium AD or with a Late Iron Age archaeological association was examined.
- Age of the individual: The sample set was restricted to adults (ie individuals with fully erupted third molars) in order to minimise the variation.
- Good bone preservation: This was necessary to obtain sufficient collagen for analysis
- The presence of a cranium and/or mandible: To conduct physical anthropological observations on teeth

Various institutions in South Africa were subsequently visited and relevant skeletal material was examined and sampled. (Table 5.1).

✓

Department of Anatomy and Human Biology, Witwatersrand University
Department of Anatomy and Cell Biology, University of Cape Town
Department of Anatomy, University of Pretoria
Department of Anthropology and Indigenous Law, University of South Africa
Department of Archaeology, University of the Witwatersrand
National Cultural History and Open Air Museum, Pretoria
National Museum, Bloemfontein
Transvaal Museum, Pretoria

Table 5.1: A list of institutions visited

This resulted in the selection of 52 skeletons which were suitable for isotopic and/or caries analysis. Of these skeletons, 28 were sufficiently preserved to enable both isotopic and caries analyses, 8 were sampled for isotopic analysis while the teeth of 16 were examined for caries. So in total, I examined 44 skeletons for caries, and 36 for isotopes. These skeletons, dated to between the 13th to 19th centuries, were drawn from 22 different sites and 4 biomes/sub-biomes. By using previously published isotopic data, it was possible to increase the total number of isotopically analysed skeletons to 72 (33 skeletons from Lee Thorp et al 1993 and 3 from Ambrose 1986), which covered 5 biomes/sub-biomes, 34 sites and spanned the entire second millennium.

As this study involves only the analysis of adults, previously published isotopic data for juveniles has not been included. The unfortunate consequence of combining data from different studies is that is becomes necessary to account for sample bias's. Of those additional samples incorporated into this study 33 skeletons (of which 13 were from a single site), were analysed by Lee-Thorp et al (1993), whilst 3 individuals, from 3 different sites, had been analysed by Ambrose (1986). When considering the diversity of the skeletal material, it is not surprising that the isotopic averages, variation and ranges obtained in these studies varied (see Table 6.1). These discrepancies were not considered to pose a problem, rather they provided an excellent reflection that diet in the Iron Age was not homogeneous. By combining the results obtained in all these studies, we can greatly increase the number and diversity of sites examined. From this, now broad based set of results, more accurate theories and patterns can be formulated, thus providing a more complete overview of the isotopic and caries evidence for Later Iron Age diets. A differentiation is drawn between the isotopic results analysed by the author in Appendix 1, and those results which have been previously published in Appendix 2. Appendix 3 contains a list of those skeletons which have been examined for caries. A description of the sites from which the skeletal material was derived is provided in Appendix 4 (which also includes details on the date or context of the site, the human remains found on the site, burial patterns and when available, a description of the settlement pattern, ceramics and economy). Map 6 (page 123), shows the distribution of sites from which the samples were selected.

Examination of skeletal material

Both cranial and postcranial remains were examined. In this study, the sex of the individual was determined through examination of the pelvis only. Although it is possible to determine sex of an individual, by examining various characteristics of the skull, this method was not employed here. It is necessary, when conducting essentially morphological analyses, to have a large group of fairly complete skeletons in order to assess the variability of that population (Brothwell 1981). The pelvis yields the most reliable information on the sex of an individual and is between 90% and 95% accurate (Ferembach 1980, Brothwell 1981). As all the individuals from this study were mature, they were grouped into three age categories, young adult, middle aged adult and old adult, using attrition patterns as outlined by Brothwell (1981). It is also possible to estimate the age of adults by observing the change in formation and fusion of the surfaces of the pubic symphysis. However as a result of poor pelvic preservation this method was not used as an aging technique.

Diagnostic features of sex in the pelvis

Differences in the male and female pelvis are related to the fact that the female pelvis is adapted for childbirth. Two major morphological differences are the presence of the pre-auricular sulcus in females (even if it is poorly developed or present only on one side), and a wider and shallower sciatic notch which enlarges the pelvis cavity. Metrical differences in the female pelvis include a sub-pubic angle of 90° or more, a high ischia-pubic index and a large angle of the sciatic notch. Morphological points of lesser value in the female pelvis are a) it is less robust and has poorly defined muscular impressions than the male pelvis b) has a smaller pubic symphysial depth c) smaller acetabulum d) smaller and more triangular obturator foramen (in males it is larger and more oval in shape) (Brothwell 1981).

Age determination using tooth wear patterns

Attrition is the wearing away of the enamel and dentine of the occlusal surface of the tooth by processes of mastication. It is used as a method of aging as there is a continual increase in attrition as a person gets older. There are problems with using attrition standards from one population and applying them to another, as cultural and physical differences may alter the rate of tooth wear. However the age groupings used in this study are not specific and place an adult in a group of either young adult (between

19 and 25 years of age with little or no tooth wear); middle aged adult (between 25 and 35 years of age with a moderate amount of tooth wear) and old aged adult (between 33 and 45 years of age and older with severe tooth wear - cases of extreme wear occur in this category where the pulp cavity becomes exposed). This method of designating age categories has been applied to other South African populations. (Morris 1992, Patrick 1990, Sealy et al 1992). Appendix 5 contains a chart of the wear patterns.

Examination of teeth

This was conducted macroscopically. Loose teeth were identified with the aid of books on forensic odontology (Gustafson 1966, Steele 1975). The conditions of the teeth were noted (ie presence, absence, state of eruption, resorption of sockets). The wear on each tooth was scored on a scale of 1 to 6 and both the presence of caries, as well as the position and severity of carious lesions were recorded. (Appendix 6 is a sample of the data sheet on which these observations were recorded).

Sampling for isotopic analysis

Bone samples from whole and well preserved skeletons were taken from the ribs or phalanges so as not to damage the skeleton. In the case of poorly preserved fragmented skeletal material, the preference was for fragments of long bone, since dense cortical bone is better preserved than other skeletal elements and was likely to provide more bone collagen for analysis. In special cases where only the cranium or mandible were preserved, small samples were taken under the supervision of the Departmental Head.

Sample Preparation

Whole bone specimens were manually cleaned in order to remove any external soil particles from the bone. Those specimens which had been glued were soaked in acetone for 2 to 3 days. The bone was then decalcified in 0.2M hydrochloric acid for 7 - 10 days. Humate contaminants were removed in a solution of 0.1M sodium hydroxide (Ambrose 1990). They were then rinsed to a neutral pH in distilled water and then freeze dried. This method produces pseudomorphs of the original bone fragments (Sealy and van der Merwe 1986), resulting in the isolation of the acid-insoluble protein component, consisting of mostly collagen, although non-collagenous proteins may also be present (Tuross et al 1989). Poorly preserved bone tends to disintegrate and dissolve during this procedure as a result of the lack of collagen and can therefore not be analysed. Between 8 - 10 mg of collagen was then weighed out into a clean quartz glass tube along with copper oxide and a twist of silver wire. The copper oxide provides the necessary oxygen required for combustion, while the silver acts as a catalyst to remove any metals that may be produced during combustion. These were then evacuated to less than 10^{-2} Torr, sealed with a glassblowers torch, and combusted at 800°C for 6 hours producing carbon and nitrogen gases together with water vapour (Sofer 1980). The gases were then separated by cryogenic distillation, a procedure which involves the separation of carbon and nitrogen gases on a vacuum line by alternately freezing and heating the gases. Sample gases are inserted into a cracker attached to a stainless steel gas separation line, evacuated to 10^{-4} Torr. Once introduced into the line, the gases are separated, frozen into clean tubes and sealed off. Carbon and nitrogen isotopic ratio's were then measured on a VG 602E mass spectrometer against a calibrated reference gas. Results are reported in d notation relative to PDB limestone and atmospheric N_2 standards, for carbon and nitrogen respectively.

Description of sites

Early Iron Age peoples are known to be very selective about where they lived, choosing the well wooded savanna regions of Kwazulu/Natal and the Eastern Transvaal escarpment that provided nutritional grazing, adequate summer rainfall and timber for fuel and housing (Maggs 1980, 1984, Maggs and Whitelaw 1991). Towards the end of the first millennium people moved from around the margins of major river systems, such as the Shashi-Limpopo river basin in the Northern Transvaal and the Tugela river in Kwazulu/Natal, and relocated on the hilltops (Maggs 1980). Occupation of the large expanse of interior grasslands of the North West, PWV and Orange Free State, and at the foothills of the Drakensberg, occurred toward the end of the fourteenth century. The only areas subsequently avoided by these food producing peoples were very arid interior and sour grasslands. Later Iron Age occupation in South Africa continues up until the late 19th/early 20th century when disruptions caused by the Zulu Difaquane wars and expansion of the colonial settlers ended the lifestyle that had characterised the population for the past millennium (Hall 1987).

The majority of grass cover in the summer rainfall biomes of the savanna and grassland are C_4 grasses. One exception is the Drakensberg which has a higher proportion of C_3 grasses because of it's cooler, moister climate (Vogel and Fuls 1978). The sites sampled in this study encompass a variety of different vegetation and rainfall zones. (Map , page 118, shows the distribution of biomes in southern Africa, and Map 5, page 122, shows the distribution of rainfall, in southern Africa).

Biome: Savanna

The savanna biome spans the Northern Transvaal, Eastern Transvaal, PWV, North West and Kwazulu/Natal making it the largest biome in South Africa. It is situated in the summer rainfall area and has warm temperatures during the growing season resulting in predominantly C_4 grass cover. As a result of the huge expanse of land which it covers, some botanists subdivide the savanna into further biomes (Acocks 1976). However, as has been noted by Adamson in Rutherford and Westphal (1986), one would expect such a large area to exhibit some diversity and that despite differences, the essential characters and features remain the same. In this study, however, the savanna biome has been subdivided according to the amount of rainfall it receives. This is particularly important for isotopic comparisons, as nitrogen is sensitive to the effects of aridity. The savanna has therefore been subdivided into 3 groups, the dry savanna, savanna, savanna woodland and Natal savanna. The dry savanna is the only area which receives less than 400mm of rainfall per annum. Consequently, $\delta^{15}N$ values from this area cannot be compared with those from the other biomes and sub-biomes.

Sub-biome: dry savanna

The dry savanna occurs in the northern region of the Northern Transvaal and is marked by the Shashi-Limpopo river basin in the north, and the clear geographical boundary of the Soutpansberg mountains in the south. Although this area is arid, with a mean annual rainfall below 400mm per annum, it has fertile rich soils. The vegetation is predominantly savanna bushland and mopane veld with sweet nutritious grazing for domestic stock throughout the year (Huntley 1984).

Sub-biome: savanna

The savanna of the Northern Transvaal, Eastern Transvaal northern regions of the PWV and North West receives between 400-600mm rainfall per annum. The vegetation in this central region is dry thornveld and the grasses tend to be sweet all year round (Plug and Voigt 1985).

Sub-biome: savanna woodland

Further south, the savanna thornveld merges into mixed woodland. The rainfall increases to between 600-800mm in the higher central and south western parts of the PWV and North West while grasses become "sour" providing nutritious grazing for only part of the year. Areas such as the Springbok Flats in the western central area of the savanna woodland and the interface between the savanna woodland

and grassland further south provide the best climate for the cultivation of crops (Rutherford and Westphal 1986).

Biome: Grassland

The Natal and Transvaal savanna woodland biomes border on the grasslands of what is known as the southern Highveld (the plateau of the Orange Free State). This area is particularly suitable for agriculture with fertile soils and high rainfall (800mm per annum). The grassland although mixed sweet and sour veld is sufficiently nutritious to maintain stock throughout the year but it is likely that Later Iron Age people would have moved their livestock to better pastures in the winter months (Maggs 1976, 1980). The expansion of Later Iron Age people was contained only by extreme sourveld to the east of the grassland in the foothills of the Drakensberg and by the arid western interior which was occupied mostly by hunter gatherers.

Sub-biome: Natal grassland

The Natal grassland biome is situated to the southeast of the Orange Free State plateau. It is an area with that receives an annual rainfall of about 400mm, and is characterised mixed sweet and sourveld grasses in the foothills of the Drakensberg (Maggs 1980). This biome has a higher percentage of C_3 grasses as a result of the cooler, moister condition during the growing season (Vogel et al 1978).

All the sites discussed in this study have been sorted categorised into the biome in which they are situated (Appendix 4). This was necessary in order to evaluate the environmental effects acting on both isotopic and caries results. The results from the skeletal material are initially discussed according their biomes and sites. Later, results are combined in order to examine LIA population characteristics and trends over time.

Chapter 6

Presentation of the isotopic and caries results

The isotopic results for each site and skeleton are examined in Part 1. In order to determine whether there is any geographic/climatic affect acting on the results, sites are examined in biomes. The results of individual skeletons are discussed chronologically. Where possible, the results are tied into the broader context of the Iron Age ie. if any archaeological or historical evidence exists on the possible ethnic affiliation of an individual skeleton, this is mentioned. Although the ancestry of many southern African ethnic groups is questionable, archaeologists have been able to determine similarities (in ceramics, settlement pattern, social systems) between various sites. Although this cannot identify sites with particular ethnic groups, it does suggest certain cultural similarities between sites and their inhabitants. It is not the purpose of this thesis to challenge these assumptions but rather to identify the skeletal material with concepts and cultures familiar to the Iron Age. This will make the results more meaningful in the broader context of Iron Age studies.

The isotopic results are then combined, and the isotopic values for all Later Iron Age samples are plotted against time. Consequently, a trend towards enriched (less negative) $\delta^{13}C$ values during the second millennium, becomes evident. This relationship has lead to a more precise means of relatively ordering skeletal material within the framework of the Later Iron Age. This provides more detailed information on the context of those skeletons whose archaeological associations can only place them sometime in the later second millennium.

In Part 2, the results from the caries analyses are presented. The individual incidence of caries at each site, in each biome, is examined. The results are then combined in order to examine the age and sex distributions for Later Iron Age populations, as well as the change in caries over time. All skeletons with caries were evaluated according to a set of criteria which establishes the type of carious lesion characteristic of agriculturists. This is used as a further indicator of dietary carbohydrate intake.

The results of the stable carbon and nitrogen analyses conducted by the author, are presented in Appendix 1. Previously published results are listed in Appendix 2 (Lee-Thorp et al 1993, Ambrose 1986, Ambros and DeNiro 1986). Appendix 3 contains a list of those samples whose teeth were examined for caries.

Part 1: Isotopic results

Synthesis

The range in $\delta^{13}C$ (-5.5‰ to -12.6‰) and $\delta^{15}N$ (6.6 ‰ to 14.4‰) values for all skeletons, falls within the expected distribution for a population subsisting off largely C_4 foods (cereals and domestic stock), together with some wild C_3 plant foods (wild and domestic) plus the meat of wild animals. As this thesis includes data from different studies, the average, variation and range in $\delta^{13}C$ and $\delta^{15}N$ values obtained in each study is presented in Table 6.1.

Site	× $\delta^{13}C$*	s^+	Range	× $\delta^{15}N$*	s^+	Range	#	Ref
LIA	-8.0	±-1.7	-11.2 to -5.6	9.1	±1.2	6.6 to 12.2	36	CG[1]
LIA	-9.0	±-2	-12.6 to -5.5	11.0	±1.2	9.3 to 14.4	33	JLT[2]
LIA	-8.2	±-0.3	-8.6 to -7.8	9.5	±1	8.3 to 11.1	3	SA[3]

Table 6.1: The ×, s and range of $\delta^{13}C$ and $\delta^{15}N$ values of skeletal material from this and other studies .[1]

Differences in the isotopic values obtained by these various studies have been attributed to sample bias. The bias is due in part to the number of skeletons analysed, the number of sites from which they are drawn, the range of biomes in which the sites are situated, and the range of time represented by the skeletal material. As I am not seeking to make comparisons between these studies this was not perceived to be a problem. Rather a combination of all the available isotopic data will provide a more complete overview of the isotopic evidence for diet in the Later Iron Age.

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[1] Note: All isotopic results are reported in parts per thousand (‰). Abv is the site abbreviation, * the average isotopic value for the entire data set, + the standard deviation, # number of individuals in each data set, [1] results obtained by the author, [2] results obtained by Lee-Thorp et al (1993), and [3] the results obtained by Ambrose (1986).

The Savanna Biome

Sub-biome: dry savanna

Site	Abv	$\times \delta^{13}C$	s	Range	$\times \delta^{15}N$	s	Range	#	Ref
Bambandyanalo	K2	-10.3	±1.2	-12.6 to -8.9	11.2	±1	9.0 to 12.9	13	JLT
Skutwater	SK	-11.2	±0.7	-12.6 to -10.7	13.3	±1	11.7 to 14.4	4	JLT

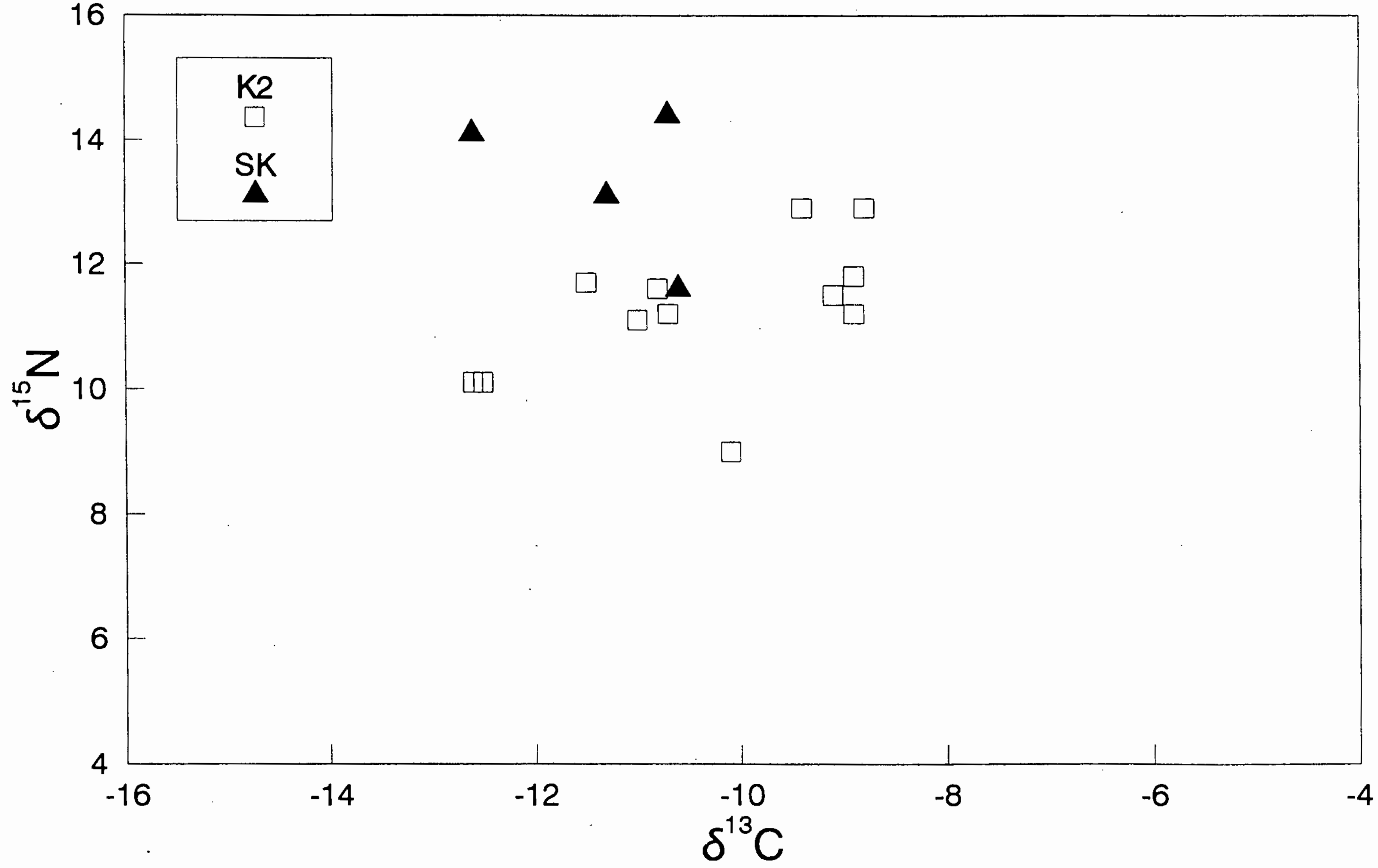
Table 6.2: The $\times$, s and range of $\delta^{13}C$ and $\delta^{15}N$ values for skeletal material from sites in the dry savanna biome.

The sites from this biome date to the 11th and 12th centuries respectively and it has been suggested, represent the ancestors of the Shona people (see chapter 2). Comparison of the sample averages, variability and range in values for the skeletons from Bambandyanalo (K2) and Skutwater (SK), are listed in Table 6.2. The $\delta^{13}C$ values for both Bambandyanalo and Skutwater fall towards the negative end of the range for the entire Later Iron Age population analysed in this study. (The range in $\delta^{13}C$ values for all Later Iron Age skeletons is between - 5.5‰ and -12.6‰. The $\overline{x}$ value for K2 = -10.3‰ and SK = -11.2‰). (Table 6.1 and 6.2). Both $\delta^{13}C$ and $\delta^{15}N$ results are plotted in Figure 1.

While the average $\delta^{13}C$ values of Bambandyanalo are Skutwater are similar, there is a notable difference in the $\delta^{15}N$ (the average $\delta^{15}N$ values for Skutwater are elevated by 2‰ compared with Bambandyanalo). As both sites are situated in an arid area (se Map 5, page 122), it would appear that inhabitants at Skutwater had a higher trophic level diet than those at Bambandyanalo (Lee-Thorp et al 1992).

Another pattern worth noting in this sample set, is the high variability in $\delta^{13}C$, particularly at Bambandyanalo (Figure 1). This large range in variation demonstrates a significant difference in diet from one individual to the next. It is, however, impossible to discern the cause for this variation without more detailed information about the burials as well as the age, gender and status of the Bambandyanalo skeletons.

Figure 1: The $\delta^{13}C$ and $\delta^{15}N$ values for skeletons from the dry savanna sub-biome.



Sub-biome: savanna

Site	Abv	× $\delta^{13}C$	s	Range	× $\delta^{15}N$	s	Range	#	Ref
Bambo	BM	-8.2	±0.3	-8.6 to -7.9	10.6	±0.4	10.2 to 11.1	2	JLT & SA
Ellerton Mine	EM	-8.5	±1.1	-9.6 to -7.4	7.8	±0.05	7.8 to 7.9	2	CG
Ficus	FI	-7.1			10.2			1	CG
Maxonwa	MX	-8.3			9.1			1	SA
Nelspruit	NP	-10.5			7.4			1	CG
New Smitsdorp	NS	-8.4			9.9			1	JLT
Nylsvlei	NY	-7.9			7.8			1	JLT
Rooikrans	RK	-10.1	± 0.4	-10.5 to -9.5	8.4	±0.4	8.2 to 8.9	2	CG
Tavhutswene	TW	-7.8			8.3			1	SA
Wellington Estates	WE	-6.9	±0.5	-7.8 to -6.1	10.5	±1	8.4 to 12.2	12	CG & JLT

Table 6.3: The ×, s and range of $\delta^{13}C$ and $\delta^{15}N$ values for sites from the savanna biome

The average, variability and range in $\delta^{13}C$ and $\delta^{15}N$ values for sites in this biome, are outlined in Table 6.3 and plotted in Figure 2. The average $\delta^{13}C$ result for the entire biome is -7.8‰ and the average $\delta^{15}N$ result is 9.8‰.

The earliest dated skeletons from this sub-biome come from the site of Ellerton Mine (EM) in the 14th century. The × $\delta^{13}C$ value for Ellerton Mine are between 2‰ - 3‰ lower than other early sites, namely Bambandyanalo and Skutwater, from the dry savanna. The difference in $\delta^{15}N$ between these sites, is even more pronounced (average $\delta^{15}N$ values for EM are 4‰ lower). Whether this affect is a results of climatic or trophic level difference cannot be determined. The isotopic values of the two individuals from Ellerton Mine are also very different from each other. While the $\delta^{15}N$ value remains similar between the two, the $\delta^{13}C$ values differ by 2‰. Both the skeletons fall into the younger adult age category (18 to 25 years) and the individual with the most positive $\delta^{13}C$ value, UCT 4920, is a female found buried together with a foetus.

The isotopic results from this biome are plotted in Figure 2. Although $\delta^{13}C$ values range between -6.9‰ and -8.4‰ and $\delta^{15}N$ between 8.3‰ and 10.3‰, the isotopic values of some of these sites appear as a cluster in Figure 2. Skeletons from sites associated with ancestral Sotho/Tswana people living in this biome after the 15th century, ie Nylsvlei (NY), New Smitsdorp (NS), and Wellington Estates (WE), all have isotopic values which fall within this distinct cluster.

Three samples fall out of the range of the main cluster of samples (see Figure 2 bottom left of the graph) Two of these, UCT 4948 and 4949 come from Rooikrans (RK), situated in the Waterberg and dated to the 17th century AD movement of Ndebele/Nguni people in to the region. The other, UCT 4945, is associated with a stone wall settlement in Nelspruit (NP). These three samples have very negative δ^{13}C values (RK × -10.1‰, NP -10.5‰) more comparable with Bambandyanalo and Skutwater than with other samples from the savanna. The δ^{13}C values of these samples may be compared to that of Kgopolwe 3 (-10‰), an 11th century inhabitant from the Phalaborwa region, which, although found in association with an Iron Age village, may well have been a hunter gatherer who had been absorbed into a settlement of Iron Age farmers (van der Merwe 1982).

Other sites associated with the Transvaal Ndebele, Bambo (BM), Ficus (FI), and Maxonwa (MX), do not exhibit the same differences as the individuals from Rooikrans (RK). Their average isotopic values are similar to other skeletons in this biome (× δ^{13}C = -7.9‰ & × δ^{15}N = 10.1‰). However, there does appear to be a difference in the δ^{13}C value of the 16th/17th century individuals (BM 9A -7.9‰, FI -7.1‰) and the 19th century individuals (BM 9C -8.6‰, Maxonwa -8.3‰). The latter group are depleted in δ^{13}C by nearly 1‰.

Intra-site variation is not as marked in this sub-biome. When comparing the standard deviation of the isotopic results at Wellington Estates to those at Bambandyanalo, it is apparent that while the standard deviation of nitrogen is ±1‰ at both sites, carbon is more tightly clustered at Wellington Estates. This demonstrates that a more uniform subsistence base at Wellington Estates. However intrasite variation in δ^{15}N values reveals individual differences in the amount of animal protein in the diet of people. While individuals from Nelspruit (NP), Tavhutshwene (TV) and Nylsvlei (NY) have the lowest δ^{15}N value for this biome some skeletons from Bambo and Wellington Estates exhibit extremely high δ^{15}N values (δ^{15}N 12.2‰).

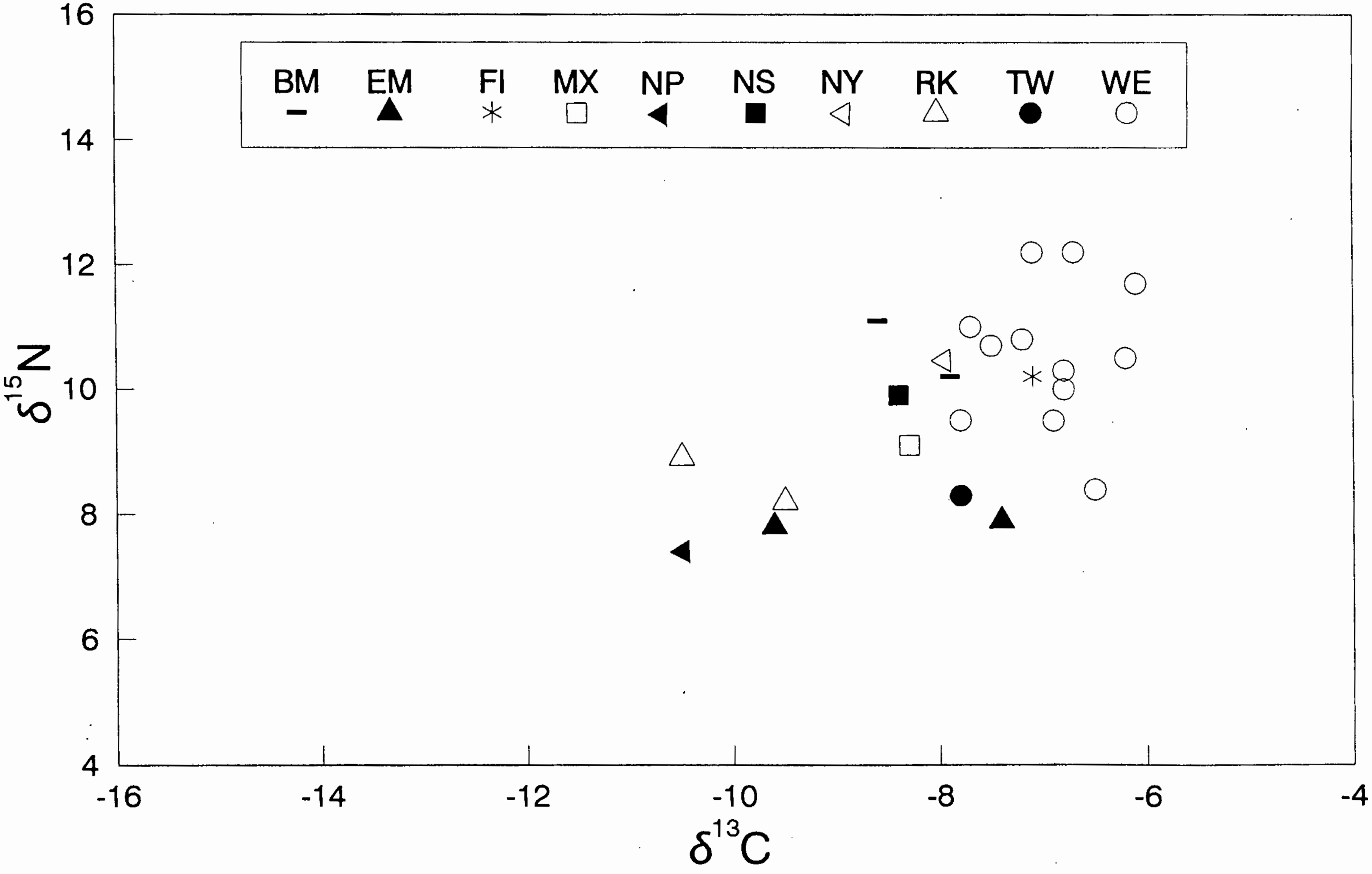


Figure 2:The $\delta^{13}C$ and $\delta^{15}N$ values for skeletons from the savanna sub-biome

Sub-biome: savanna woodland

Site	Abv	x δ^{13}C	s	Range	x δ^{15}N	s	Range	#	Ref
Boshoff's Farm	BF	-6.0			9.2			1	CG
Buispoort	BP	-7.8	±1	-8.8 to -6.8	8.9	±0.2	8.7 to 9.1	2	CG & JLT
Derdepoort	DP	-7.8			10.2			1	JLT
Magozastad	MG	-7.2			9.2			1	CG
Paardekraal	PK	-7.5			10.5			1	JLT
Rustenburg	RB	-8.0			9.6			1	CG
Oliphantspoort	OP	-7.7	±1.1	-9.4 to -6.7	9.1	±0.9	7.9 to 10.5	3	CG & JLT

Table 6.4: The ×, s and range of δ^{13}C and δ^{15}N values for sites from the savanna woodland sub-biome.

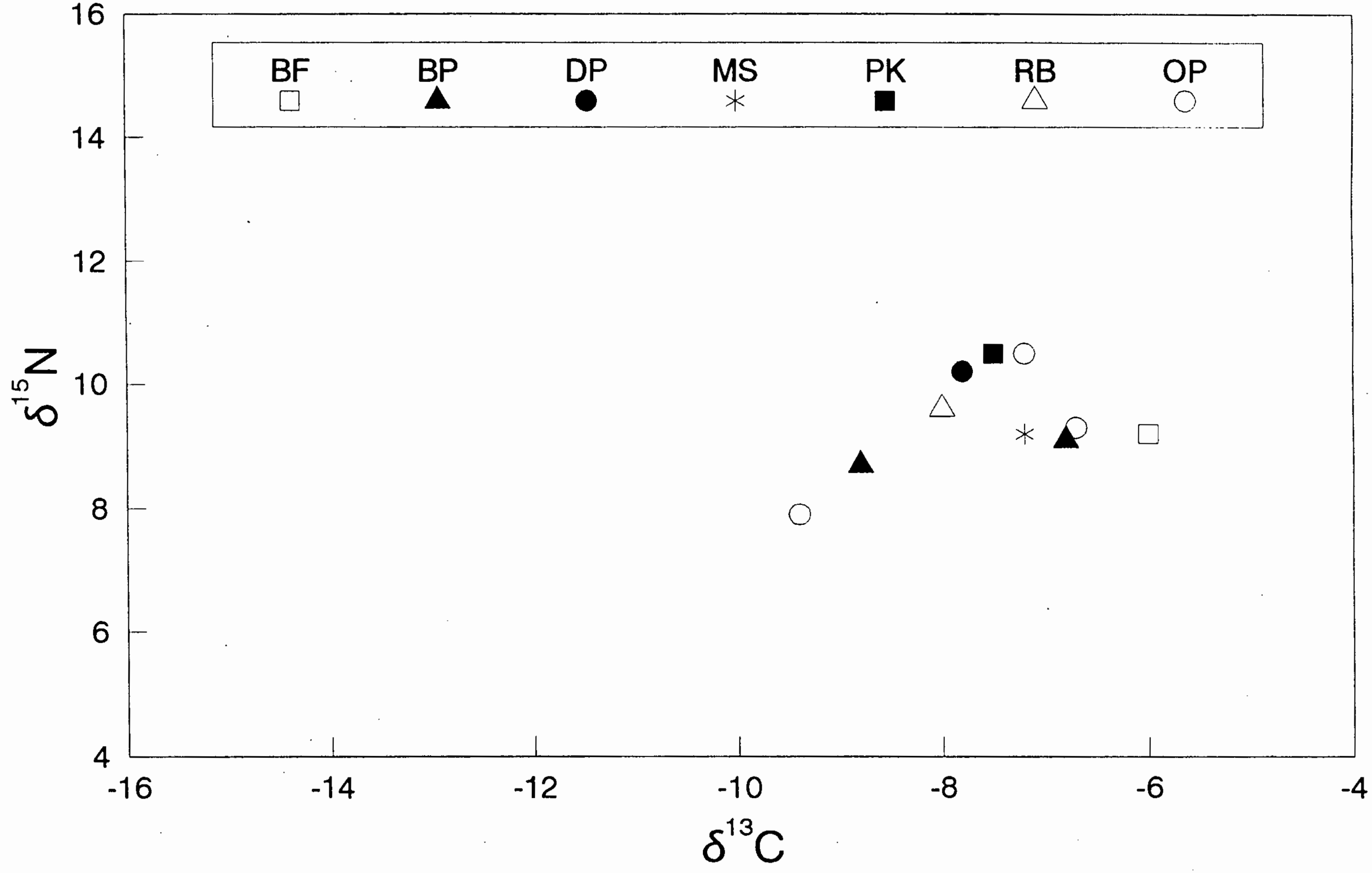
The next sample set is drawn from a number of sites clustered in an area on the border of the savanna and grassland biomes, the savanna woodland. All these sites are situated within a narrow margin of woodland in an area of higher rainfall. Their geographic distribution, as well as the similarities in ceramics and stone walling, suggest that they are of Sotho/Tswana origin. The averages, variability and range of δ^{13}C and δ^{15}N values for samples from this sub-biome, are presented in Table 6.4, while the δ^{13}C versus δ^{15}N values are plotted in Figure 3.

The average δ^{13}C and δ^{15}N values for the whole sub-biome are -7.5‰ and 9.4‰ respectively. This is almost identical to the average value for the savanna sub-biome individuals ($\delta^{13}C = -7.8‰$, $\delta^{15}N = 9.8‰$).

However some individual variation in diet, does occur. The δ^{13}C values vary between -6‰ (indicating a nearly pure C_4 diet) to -9.4‰ (indicating slightly higher consumption of C_3 food stuffs and perhaps a greater variation in diet). The relative stability in the δ^{15}N values of all these skeletons suggests that there was no considerable difference in the amount of animal protein consumed by each individual. The fluctuation in δ^{13}C values is therefore indicative of different proportions of C_4 plant foods in the diet (ie different amounts of cereals eaten) compared to C_3 foods (ie wild plant and domestic cultigens).

Two points lie towards the lower left hand side of Figure 3 (UCT 4934 and UCT 4941), and fall towards the edge of the range of variation for this biome. The former, from Oliphantspoort (OP), dates to 15th century AD and is significantly depleted in δ^{13}C and δ^{15}N (-9.4‰, 7.9‰) compared to the 19th century individuals from the same site (-6.9‰, 9.9‰). The latter from Buispoort (BP) (UCT 4941) has a more negative δ^{13}C and lower δ^{15}N values (-8.8‰, 8.7‰) and may well be earlier than

Figure 3: The $\delta^{13}C$ and $\delta^{15}N$ values for skeletons from the savanna woodland sub-biome



the 18th century skeleton from the same site (-6.8‰, 9.1‰). Isotopic values for the earlier skeletons appear similar and contrast with the values for the later skeletons. The lower δ^{15}N values of the earlier individuals from Oliphantspoort and Buispoort are associated with more negative δ^{13}C values suggesting an increased emphasis on C_3 plant food. Browsers may also have contributed to the depleted δ^{13}C values.

The Grassland biome

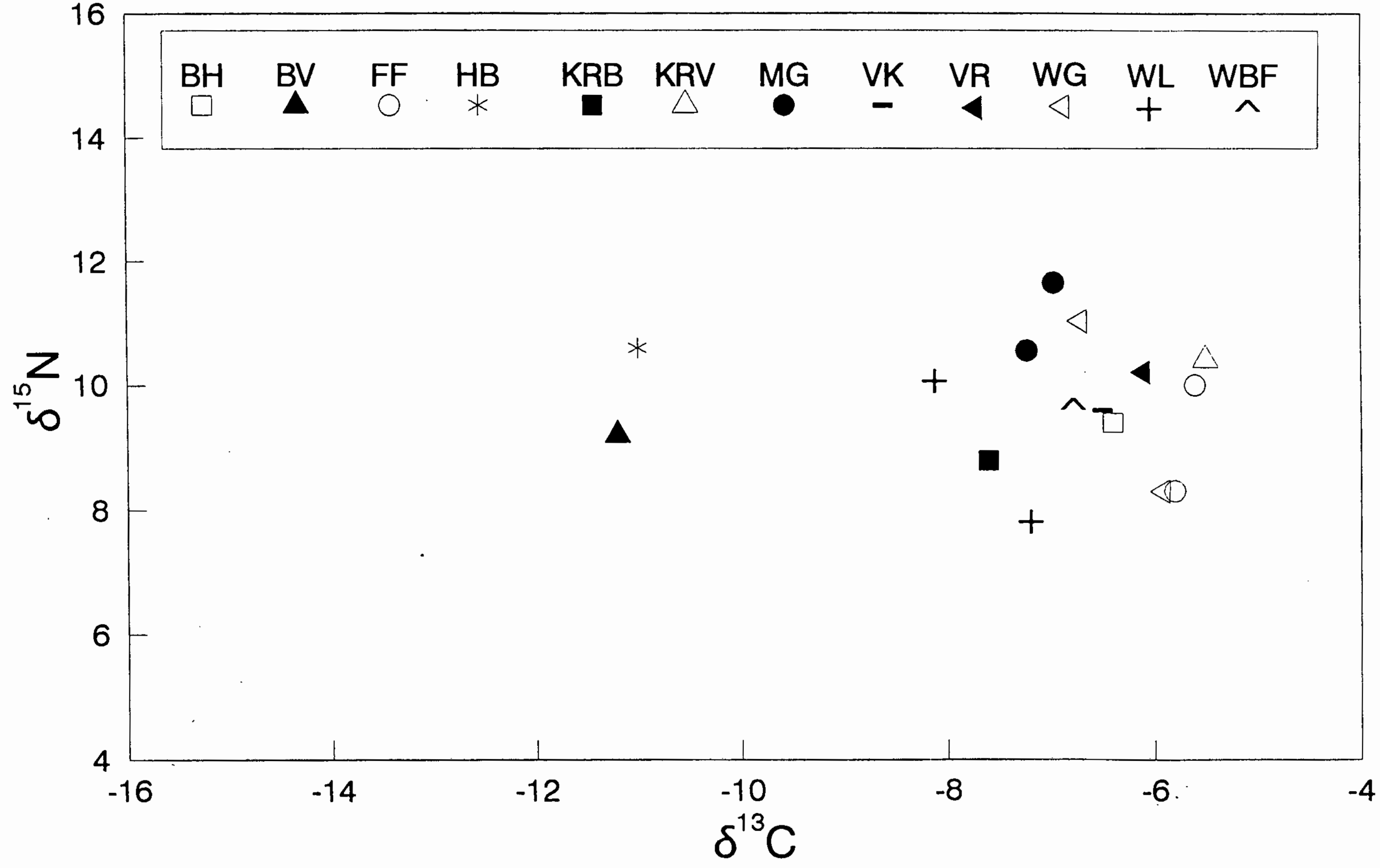
Site	Abv	× δ^{13}C	s	Range	× δ^{15}N	s	Range	#	Ref
Buffelshoek	BH	-6.4			9.4			1	CG
Bainsvlei	BV	-11.2			9.2			1	CG
Frankfort	FF	-5.7	±0.1	-5.8 to -5.6	9.1	±0.8	8.3 to 10.0	2	CG
Heilbron	HB	-11.0			10.6			1	JLT
Klipriviersberg	KRB	-7.6			8.8			1	CG
Klip River Valley	KRV	-5.5			10.4			1	CG & JLT
Makgwareng	MG	-7.1	±0.1	-7.2 to -7.0	10.8	±0.4	10.4 to 11.3	2	JLT
Vechtkop	VK	-6.5			9.6			1	CG
Vrede	VR	-6.1			10.2			1	CG
Willow Glen	WG	-6.3	±0.4	-6.7 to -5.9	9.6	±1.3	8.3 to 11.0	2	CG & JLT
Welgegund	WL	-7.6	±0.4	-8.1 to -6.4	8.9	±1.2	7.7 to 10.2	2	CG & JLT
Wildebeestfontein	WBF	-6.8			9.7			1	CG

Table 6.5: The ×, s and range of δ^{13}C and δ^{15}N values for sites from the savanna grassland biome.

The grassland biome includes samples from 12 different sites. This set of results has the most enriched δ^{13}C values of all the skeletons analysed in this study, while δ^{15}N results are similar to other biomes (× δ^{13}C -7.2‰; × δ^{15}N 9.7‰). The averages, variability and range of δ^{13}C and δ^{15}N values for samples from this sub-biome, are presented in Table 6.5. At an initial glance, this biome appears to exhibit the highest amount of δ^{13}C variation (ranging from -5.5‰ to -11.2‰). However examination of the distribution of samples in Figure 4 indicates two outliers. Recalculation of the average δ^{13}C values, excluding these samples, demonstrates that in fact the isotopic results of skeletons from this biome are very tightly clustered despite the increased number of sites included in the analysis of this biome.

One outlier, UCT 3686, from Heilbron (HB) was included in the study by Lee-Thorp et al as a post 1500 Later Iron Age agriculturist (1992). However recent radiocarbon dating has revealed the date of this skeleton to be from the 10th century AD (Morris 1993). As we have no knowledge of Iron Age

Figure 4: The $\delta^{13}C$ and $\delta^{15}N$ values for skeletons from the grassland biome



occupation on the plateau prior to 1500 AD, it would appear that UCT 3686 was a hunter gatherer living in this region at the end of the first millennium AD. This makes the isotopic values particularly interesting as they apparently represent the characteristic signature for a hunter gatherers in a C_4 area. It is also interesting to note that the $\delta^{13}C$ values of Heilbron are almost identical to that of the early second millennium skeletons from Bambandyanalo and Skutwater. The other outlier in this region is UCT 4942 from Bainsvlei. This individual's isotopic values are very similar to the Heilbron individual (BV -11.2‰, 9.2‰). The context of Bainsvlei is unclear and although the interment was initially thought to have been associated with proto-historic people living on a farm near Bloemfontein, it now appears likely that the individual was a hunter gatherer.

Excluding the two previous skeletons the remaining isotopic values of the other skeletons from this biome are once again similar to those from other biomes, varying between $\delta^{13}C$ values of -5.5‰ and -8.1‰ and $\delta^{15}N$ values of 7.7‰ and 11.3‰. Skeletons from Welgegund (WL) and Klipriviersberg (KRB) (dated to the 17th/early 18th century) are more depleted in $\delta^{13}C$ (x -7.6‰) compared to later skeletons (x -6.1‰). $\delta^{15}N$ values also vary with the highest value occurring at Makgwareng (MK) (11.3‰) and the lowest at Willow Glen (WG) (7.7‰). While intrasite variability in $\delta^{15}N$ is pronounced at Welgegund, the two individuals at Makgwareng (MK) have tightly clustered $\delta^{15}N$ values.

Sub-biome: Natal grassland

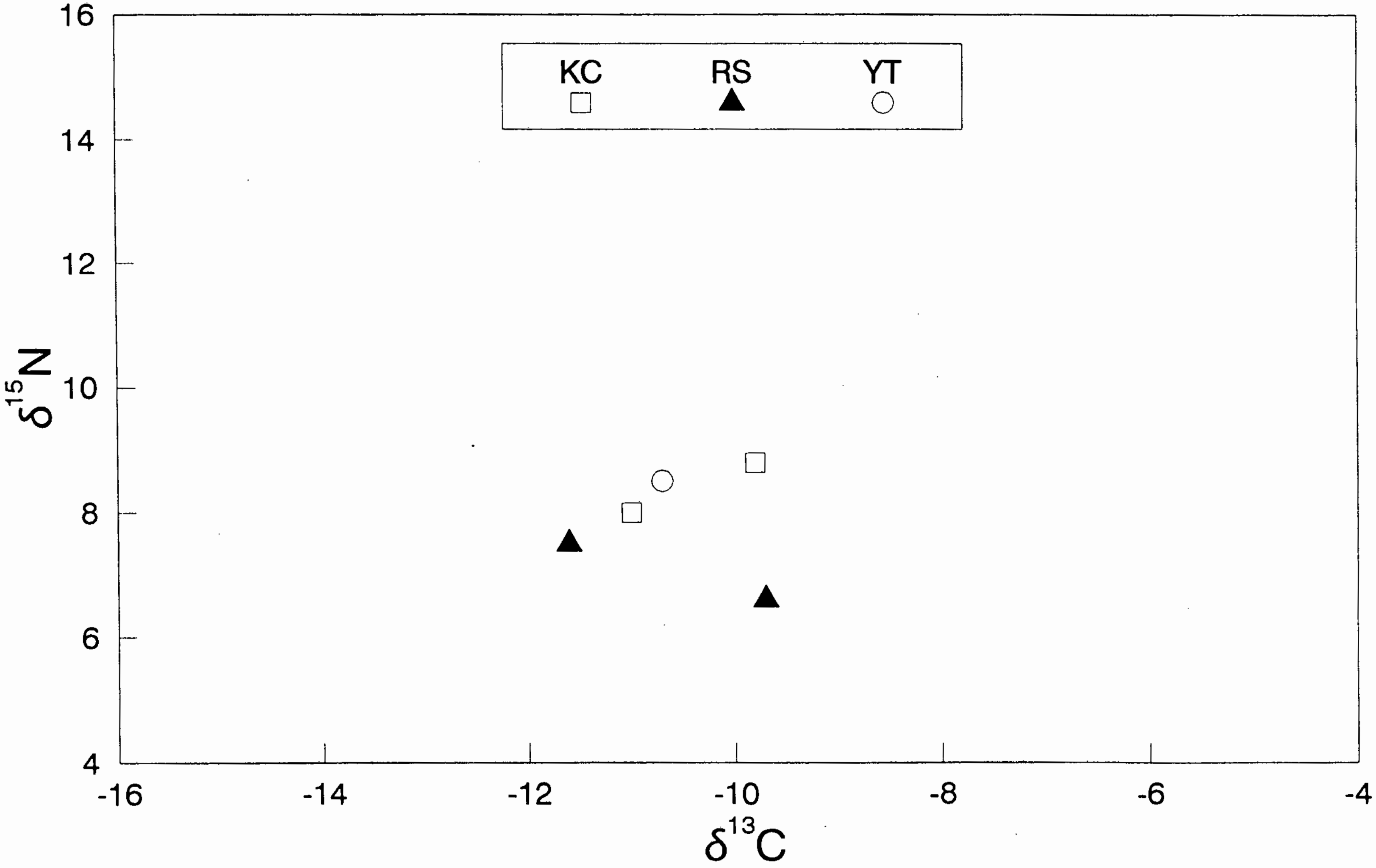
Site	Abv	x $\delta^{13}C$	s	Range	x $\delta^{15}N$	s	Range	#	Ref
Kaybar's Cave	KC	-10.4	±0.6	-10.8 to -11.	8.4	±0.4	8.0 to 8.8	2	CG
Robinson's shelter	RS	-10.6	±0.9	-11.6 to -9.7	7.0	±0.4	6.6 to 7.5	2	CG
Yellowtree	YT	-10.7			8.5				

Table 6.6: The x, s and range of $\delta^{13}C$ and $\delta^{15}N$ values for sites from the Natal grassland sub-biome.

Five individuals from three sites in the Drakensberg, Kaybar's Cave (KC), Robinson's Shelter (RS) and Yellowtree (YT), fall within the grassland region of Natal/Kwazulu. The averages, variability and range of $\delta^{13}C$ and $\delta^{15}N$ values for samples from this sub-biome, are presented in Table 6.6 .

A plot of the $\delta^{13}C$ and $\delta^{15}N$ values for these samples (Figure 5) shows that the skeletons fall out of the range of variation for Iron Age skeletons from the interior Northern Transvaal, PWV and North West savanna. The average $\delta^{13}C$ and $\delta^{15}N$ values for this sub-biome, are -10.6‰ and 7.9‰ respectively.

Figure 5: The $\delta^{13}C$ and $\delta^{15}N$ values of skeletons from the Natal grassland sub-biome



This appears to be very similar to sites such as Rooikrans and Nelspruit in the savanna sub-biome region. The sites represent a very recent period of Iron Age history as they have been attributed to Nguni speaking people who settled in the Drakensberg during the difaquane wars in the early 19th century. UCT 4917 from Robinson's shelter has the lowest $\delta^{15}N$ value for the entire data set (6.6‰). The overall low $\delta^{15}N$ average for these samples (7.9‰) would point towards a diet of minimal animal protein. The more negative average $\delta^{13}C$ value for the biome is likely to be a result of the larger amount of C_3 grass cover which occurs in the Drakensberg which is consumed by both wild and domestic grazers with a lower $\delta^{13}C$ values compared to the other biomes.

The trend in isotopic values through time

Comparison of the average isotopic results for the different biomes reveals a strong similarity in isotopic values between the grassland, savanna and savanna woodland biomes. This similarity suggests that no geographic or climatic factors are acting upon the isotopic results from these biomes. However the early second millennium skeletons from the dry savanna sub-biome and the very recent skeletons from the Natal grassland sub-biome have considerably different isotopic values. As there is no apparent environmental influence between the savanna biomes, it is unlikely that the difference in the results from the Natal grassland is a consequence of environmental factors.

This difference therefore prompted an examination of the change in $\delta^{13}C$ and $\delta^{15}N$ values during the Later Iron Age. Appendix 5 lists the isotopic results for all skeletons with relative dates. What is evident is that $\delta^{13}C$ values are more enriched in recent skeletal material. In order to determine the extent of the relationship, samples with relative dates were plotted against their corresponding $\delta^{13}C$ and $\delta^{15}N$ values (Figure 6 & 7). The average date for each sample was used for this comparison.

Figure 6 compares the $\delta^{13}C$ results of skeletons throughout the second millennium. This demonstrates a definite trend towards an increase in $\delta^{13}C$ values over the last millennium. The square symbols represent those values used in the calculation of the regression, while the triangular symbols represent samples which fall beyond the range of variation and were therefore not used in the regression calculation (Those samples whose isotopic values were identified earlier in this chapter as falling outside the range of variation namely KC, RS, RK, BM, MX). Regression analysis established a strong correlation between $\delta^{13}C$ and time. The correlation coefficient ($r = 0.84$) specifies a strong linear relationship between the independent ($\delta^{13}C$) and dependent (time) variables, while the coefficient of determination ($r2 = 0.7201$) indicates that 72% of the variation in $\delta^{13}C$ values is related to time.

Figure 6: A comparison of $\delta^{13}C$ from the second millennium

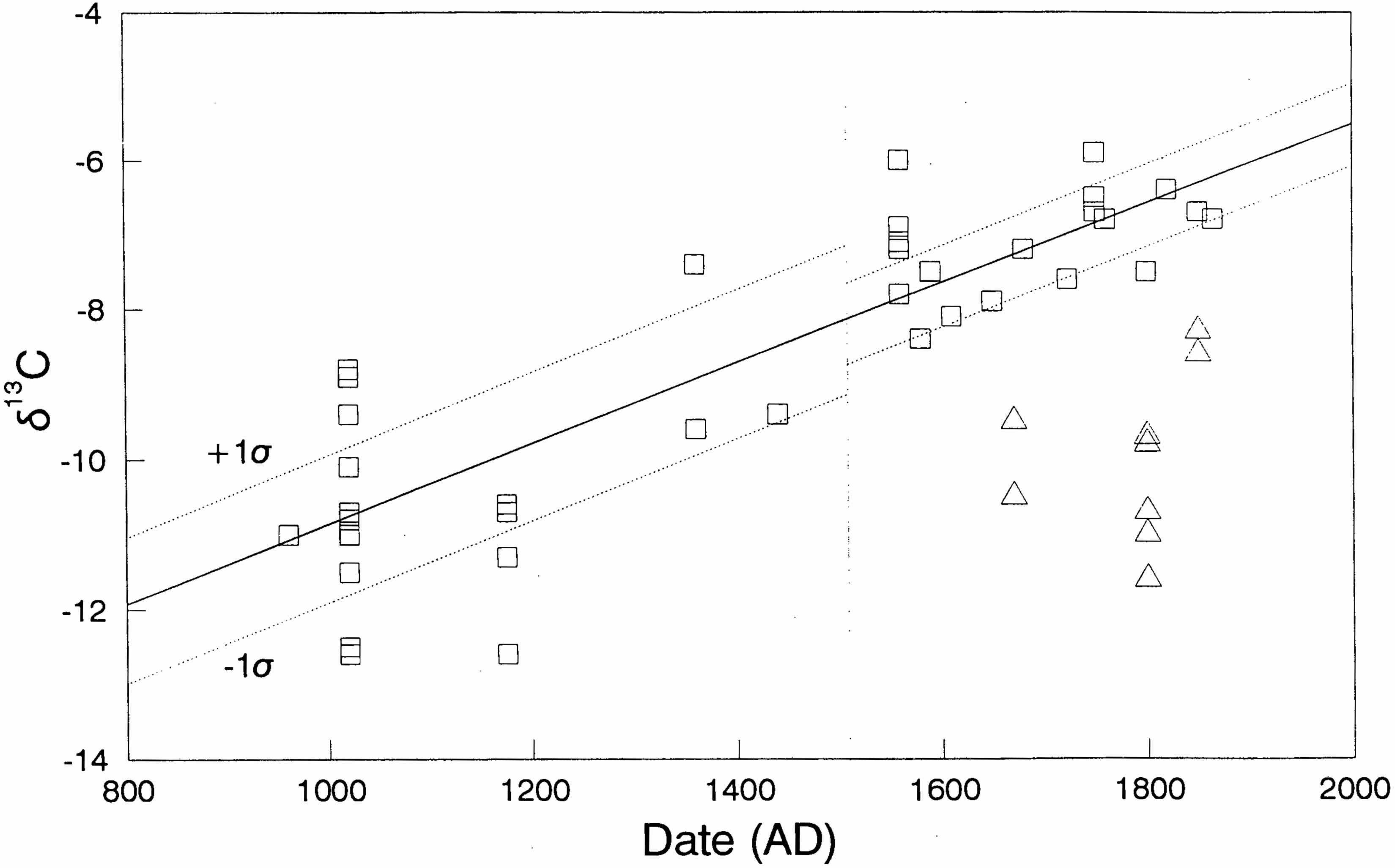
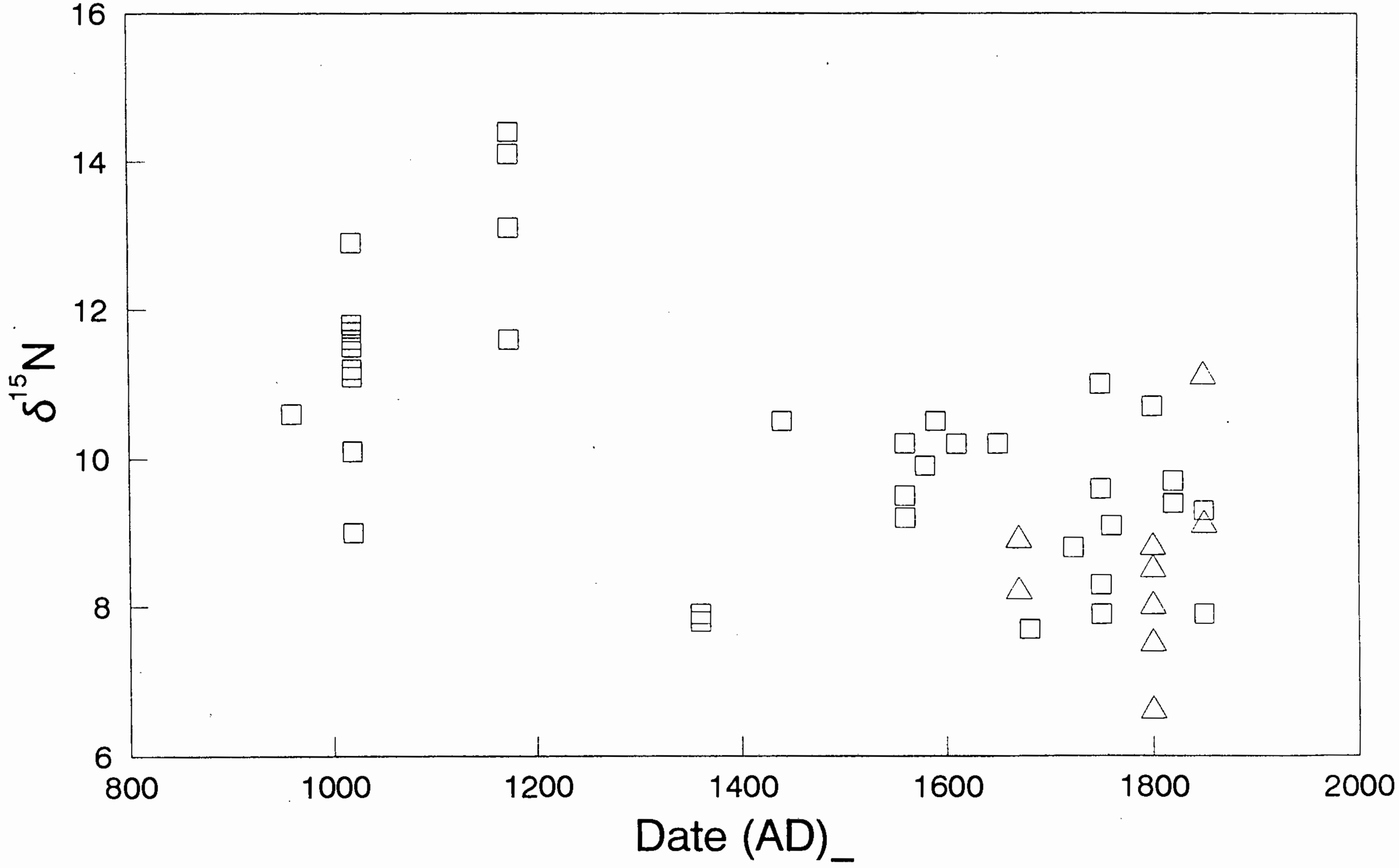


Figure 7: A comparison of $\delta^{15}N$ from the second millennium



Regression analysis of the relationship between $\delta^{15}N$ and time reveals only a moderate correlation (r= 0.6, r2= 0.3667). Although a general trend towards lower $\delta^{15}N$ values is apparent (Figure 7), there does not appear to be any relationship between the $\delta^{15}N$ and time. Comparison's need to be drawn with caution, as the sites from the early part of the second millennium (Bambandyanalo and Skutwater) are from the dry savanna biome, a region which receives under 400mm of rain per year. Thus the steady increase in $\delta^{13}C$ during the second millennium is not parallelled by a change in the $\delta^{15}N$ values, which remain relatively low throughout the later period.

A standard error or residual variation for the regression analysis of $\delta^{13}C$ values, was calculated using the below equation to be ± 1.08%

$sd^2 = (ya - ye)^2 / n$

This means there is a 68% chance that an observation will fall within 1 per mill of the regression line. The variation is in accordance with the standard deviations calculated for the $\delta^{13}C$ averages of each biome (Tables 6.1 to 6.6). However it is noted that the degree of variability decreases considerably in the later part of the second millennium (this supports the hypothesis of an increasing trend towards uniform diets). After 1499 AD, the calculated standard deviation is reduced by half. This change is reflected in Figure 6.

As a result of the strong correlation between $\delta^{13}C$ and time I decided to see if it was possible to use the $\delta^{13}C$ (y) value to predict the expected date of the x variable within the range of the residual variation.

x values can be estimated using the regression equation

$y = a + bx$ therefore $x = y - (-16.20637) / 0.0053817$

where (a) represents the point at which the regression line crosses the y axis and (b) defines the slope of the regression (Shennan 1988).

Table 6.7 contains the predicted dates for those samples whose archaeological context cannot place them in any specific time frame other than the Later Iron Age. The $\delta^{13}C$ value was used to estimate, according to the regression analysis, within what range of the timescale a particular sample would fall. The standard deviation of the calculated dates also decreases with time. After 1499 AD, a standard deviation of ±121 years was calculated using the above mentioned equations (falling to ±113 after 1699 AD).

UCT #	Site	$\delta^{13}C$	Calculated date	st dev	Average date
4942	Bainsvlei	-11.2	930 AD	± 176	10th century
4945	Nelspruit	-10.5	1050 AD	± 176	11th century
4941	Buispoort	-8.8	1380 AD	± 176	14th/15th century
4940	Rustenberg	-8.0	1520 AD	± 121	15th/16th century
4171	Nylsvlei	-7.9	1540 AD	± 121	16th century
4929	Wellington Estates	-7.8	1560 AD	± 121	16th century
4165	Derdepoort	-7.8	1560 AD	± 121	16th century
4930	Wellington Estates	-7.7	1570 AD	± 121	16th/17th century
4925	Wellington Estates	-7.2	1670 AD	± 121	17th/18th century
3691	Makgwareng	-7.2	1670 AD	± 113	17th/18th century
3705	Wellington Estates	-7.1	1690 AD	± 113	17th/18th century
3690	Makgwareng	-7.0	1700 AD	± 113	17th/18th century
3703	Wellington Estates	-6.8	1750 AD	± 113	18th century
4927	Wellington Estates	-6.8	1750AD	± 113	18th century
4928	Wellington Estates	-6.7	1760 AD	± 113	18th century
4921	Wellington Estates	-6.6	1780 AD	± 113	18th/19th century
3704	Wellington Estates	-6.2	1850 AD	± 113	19th century
4923	Wellington Estates	-6.1	1870AD	± 113	19th /20th century
4944	Vrede	-6.1	1870 AD	± 113	19th/20th century
4939	Frankfort	-5.8	1900 +AD	± 113	20th century
4938	Frankfort	-5.6	1900 +AD	± 113	20th century
3693	Klip River Valley	-5.5	1900 +AD	± 113	20th century

Table 6.7: Dates estimated according to the regression analysis

The results of this regression analysis are examined in conjunction with information derived from the archaeological context of the skeletons. The two individuals with $\delta^{13}C$ values similar to the Heilbron individual (from Bainsvlei and Nelspruit), have been estimated to fall in the early part of the second millennium AD. Archaeological information had not been able to place either of these skeletons in any particular context within the Later Iron Age. Certainly their isotopic signatures are significantly different from other Later Iron Age skeletons. Rustenberg, Nylsvlei and Derdepoort from the savanna biome were placed within the 16th century. Samples from Wellington Estates have been chronologically ordered according to their $\delta^{13}C$ values, to between 1550 AD and 1850 AD, (within the range of radiocarbon dating for the site). The individuals from Makgwareng, which had previously been dated to between 1520 AD to 1800 AD, has been more specifically placed in the late 17th/ early 18th century. The dates of those individuals from Frankfort, Klip River Valley and Vrede with highly enriched $\delta^{13}C$ values (-6.1‰to -5.5‰) have been predicted to fall within the 19th/early 20th century.

The increase in the consumption of C_4 food over the second millennium is evident in the majority of Later Iron Age individuals (with the exception of the Transvaal Ndebele and Nguni-speaking people in the Drakensberg). The reasons for this increase will be discussed in chapter 7, This trend is however not paralleled by a similar increase in $\delta^{15}N$ values suggesting that the increase is a result of a greater consumption of C_4 cultigens such as sorghum and maize.

The definitive trend in $\delta^{13}C$ values has been used to relatively order LIA skeletal material, thus providing a more direct method of establishing the archaeological context of LIA skeletons. The technique involves examining an individual's diet, as opposed to their association with stone walling or ceramics. This methodology will differentiate both between hunter gatherers and agriculturists living in South Africa during the LIA.

Part 2: Caries results

In this study, a total of 926 teeth from 44 individuals were examined for evidence of caries (an average of 21 teeth per mouth) (see Appendix 3). Included for comparison, is data on the incidence of caries from Bambandyanalo (Steyn 1993). The relative dates established for the skeletal material in Part 1, are also used in Part 2 in the discussion of the caries results. As the sample of individuals from most sites is small, the total percentage of carious teeth from each site will examined. It must be noted here, that as a consequence of the large number of exongeous factors which influence caries, inferences representative of a population, cannot be made by simply examining the dentition of an individual. The caries data for all the skeletons is then combined and the incidence of caries amongst males and females and between different age groups are then examined. A comparison of the change in the percentage of carious teeth over the second millennium is then made. The pattern of caries is then examined in order to identify individuals with a high carbohydrate diet.

The savanna biome

Biome	Site	# teeth	# carious teeth	% carious teeth	# Individuals	# Individuals with caries
Dry savanna	K2	-	-	19.1%	-	-
	SK	47	7	14.8%	2	2
Savanna	EM	37	3	8.1%	2	1
	FI	32	4	12%	1	1
	WE	224	10	4.4%	10	6
	NS	19	4	21%	1	1
	BM	25	4	16%	1	1
	RK	38	3	7.8%	2	2
Savanna woodland	OP	44	19	43%	3	3
	RB	6	1	16%	1	1
	BF	26	1	3.8%	1	1
	MG	31	0	-	1	-
	DP	13	0	-	1	-
	PK	15	0	-	1	-
	BP	12	0	-	1	-

Table 6.8: The incidence or caries in sites from the savanna biome.

Sub-biome: dry savanna

The incidence of caries in this biome is high (Table 6.8). At Bambandyanalo (K2), 19.1% of teeth were infected by caries (Steyn 1993), while at Skutwater (SK), the incidence of caries was 14.8%. Both of the individuals from Skutwater whose teeth were examined had more than one carious lesion, while 52% of the 23 adults examined from Bambandyanalo, had one or more carious lesions (Steyn 1993) (Table 6.8). Low fluorine levels were determined in the area surrounding Bambandyanalo (Steyn pers comm) (Map 7, page 124).. This may also hold true for Skutwater as both sites are situated close together in the Shashi-Limpopo river valley. The low fluorine content of the water may act as a factor for the elevated incidence of caries.

A sample bias, resulting from the poor preservation of teeth at Bambandyanalo, may also account for the high percentage of teeth with caries at this site, (the average number of teeth per individual was 11). The posterior teeth which are best preserved in the archaeological record are also the most cariogenic thus resulting in an elevation in the proportion of teeth with caries.

Sub-biome: savanna

Two individuals from the 14th century site of Ellerton Mine (EM), have 8.1% of teeth affected by caries. A high incidence of caries also occurs amongst individuals at the 16th century sites of Ficus (FI) and New Smitsdorp (NS), and during the 17th century at Bambo (BM) and Rooikrans (RK). The incidence of caries amongst individuals at Ficus, New Smitsdorp and Bambo is greater that amongst individuals from Ellerton Mine and Rooikrans. The sub-minimum levels of fluorine in the Pietersberg, Letaba districts of the Northern Transvaal (< 0.5‰) (Map 7, page 124) may partly account for the high caries at Bambo (BM), Ficus (FI) and Ellerton Mine (EM) (Table 6.8). Caries is moderate at Wellington Estates (WE) throughout the 16th and 19th centuries. The largest sample of skeletons comes from Wellington Estates (WE) where the teeth of 10 adults were examined. 60% of these individuals had one or more carious lesion.

Sub-biome: savanna woodland

Most of the sites throughout the 16th and 17th century in this sub-biome either have a low incidence of caries, or no caries at all. The individuals from Rustenberg (RB) and Boshoff's Farm (BF) have one tooth affected by caries while individuals from Magozastad (MS), Derdepoort (DP), Paardekraal (PK) and Buispoort (BP) do not display any sign of caries. However the 3 individuals from Oliphantspoort

(OP) exhibit the highest incidence of caries observed in this study (43%). Although caries is considerably more pronounced in the two individuals from the 19th century, the early 15th century skeleton also displays a highly elevated incidence of caries (Table 6.8). The ab-normal level of caries at Oliphantspoort (OP) could also be attributable to a lack of fluorine as studies of the natural fluorine content in regions of South Africa indicate that this site is within a low fluorine area (Map 7, pg 124)

The grassland biome

Biome	Site	# teeth	# carious teeth	% carious teeth	# Individuals	# Individuals with caries
Grassland	HB	21	1	4.7%	1	1
	BV	22	4	18%	1	1
	WL	32	1	3.1%	1	1
	MK	41	1	2.4%	2	1
	KRB	21	0		-	1
	VK	30	1	3.3%	1	1
	WG	4	0		-	1
	VR	27	4	14.8%	1	1
	FF	37	7	18.9%	2	2
Natal grassland	KC	40	3	7.5%	2	2
	RS	33	7	21%	2	1

Table 6.9: Incidence of caries from sites in the grassland biome

The highest incidence of caries in this biome occurs amongst the very early second millennium skeletons from Heilbron (HB) and Bainsvlei (BV) and the very late second millennium skeletons from Vrede (VR) and Frankfort (FF). Skeletons from sites in the 17th and 18th century either have a lower incidence of caries, or no caries at all. Caries occurs in individuals from Willow Glen (WG), Makgwareng (MK) and Vechtkop (VK) and does not occur in individuals from Klipriviersberg (KRB) and Welgegund (WL).

Sub-biome: Natal grassland

The percentage of carious teeth at Kaybar's Cave (KC) is less than that at Robinson's Shelter (RS). This high incidence of caries at Robinson's Shelter (RS), is as a result of the large number of carious teeth in one individual (43%) while the other individual from exhibits no caries at all (Table 6.9). The overall levels of fluorine in the water in the eastern foothills of the Drakensberg are low. A study of schoolchildren in this area also revealed a higher than "normal" incidence of caries as a result of the low fluorine (Ockerse 1959). This may have also effected Later Iron Age people living in the area.

A comparison of the overall distribution of caries in each biome demonstrates that the savanna sub-biome and grassland biome has a lower incidence of caries than the dry, woodland and Natal grassland sub-biomes. The higher incidence of caries in the dry savanna and Natal grassland biomes correlates with the higher incidence of caries in the pre 1500 AD and post 1800 AD periods (as both sites from the dry savanna biome date to the 11th and 12th centuries respectively, while all the individuals from the Natal grassland biome are dated to the 19th century). The elevated incidence of caries in the woodland savanna biome is related to the extremely high incidence of caries at Oliphantspoort (OP), which is not paralleled in any other individuals in the Later Iron Age.

Patterns of caries in the Later Iron Age

Age and Sex differences

The caries data for all the skeletons was combined and details on the incidence of caries in males and females and in different age groups were noted.

	# teeth	# carious teeth	% carious teeth	# Individuals	# Individuals wih caries	% Individuals with caries
Sex						
Male	275	16	5.8%	12	7	58%
Female	262	22	8.3%	12	9	75%
Age						
Young (18-25)	339	18	5.3%	17	7	41%
Middle (25-35)	438	49	11.1%	21	18	85%
Old (35-45)	131	18	13.7%	6	5	83%

Table 6.10 Age and Sex distribution of caries in the Later Iron Age

As is observed in most other populations, there is a marked differences in the incidence of caries between males and females (Table 6.10). The total percentage of carious teeth amongst females in the second millennium is 8.3% as opposed to 5.8% amongst males. This is consistent with other agricultural and mixed economy societies where the sexual division of labour results in women being responsible for the production and preparation of cereal foods thus resulting in an increase in the amount of carbohydrate consumption in women.

The trend toward an increase in caries with age is also noticeable amongst Later Iron Age food producers (Table 6.10).. Middle and older aged individuals have twice as many carious teeth as younger individuals. This is directly associated with the length of time to which teeth have been exposed to cariogenic bacteria.

Trends in the incidence of caries during the LIA

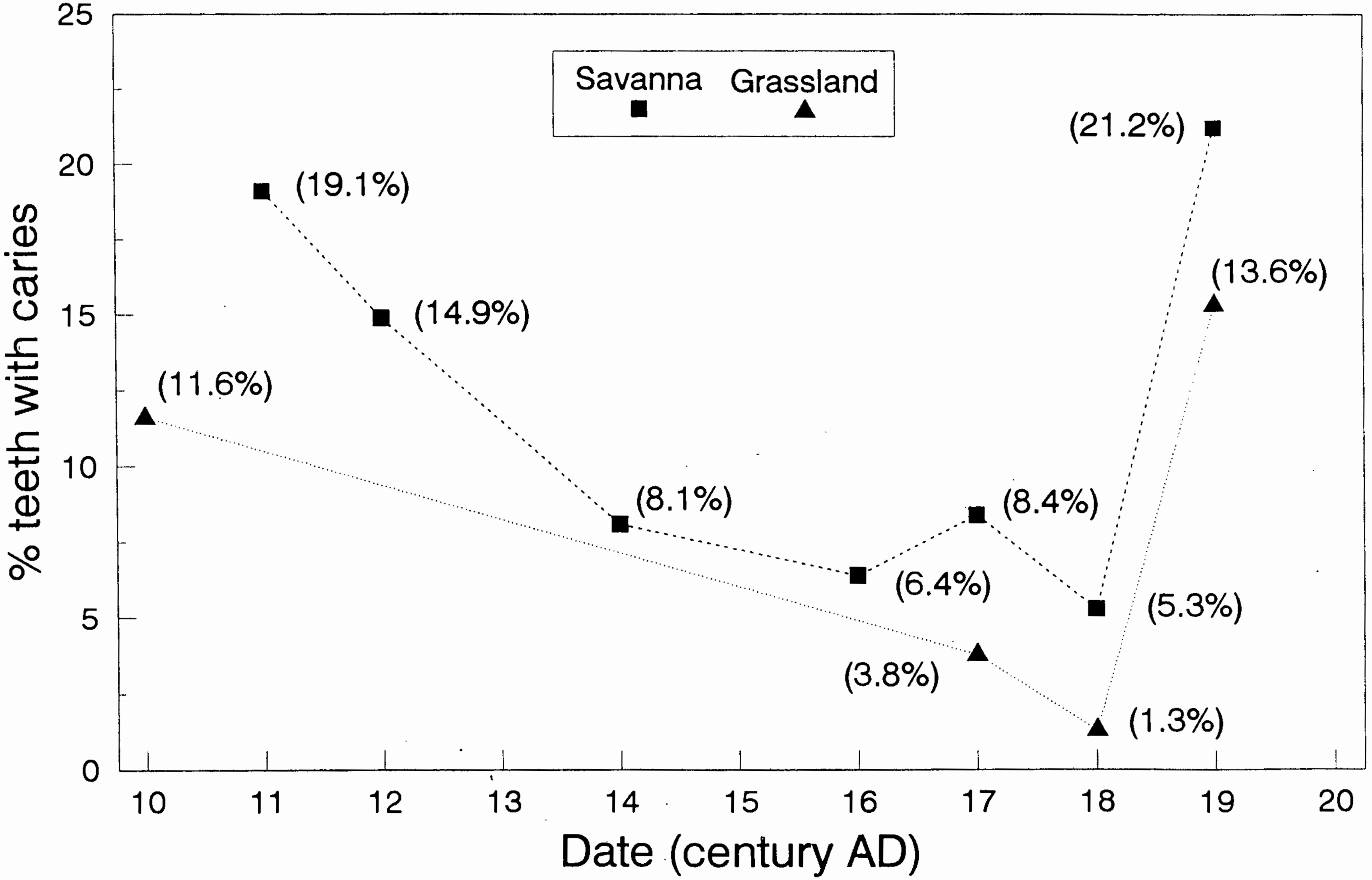
Biome	Date	# teeth	# carious teeth	% carious teeth	# Individuals	# Individuals with caries	% Individuals with caries
Dry Savanna	11th			19.1%			52%
	12th	47	7	14.8%	2	2	
Savanna	14th	37	3	8.1%	2	1	
	16th	108	9	8.3%	4	3	
	17th	11.8	10	8.4%	5	4	
	18th	56	3	5.3%	3	2	
	19th	87	3	3.4%	4	2	
Savanna woodland	16th	107	6	5.6%	6	3	
	18th	12	0		1		
	19th	38	15	39%	2	2	
Grassland	10th	43	5	11.6%	2	2	
	17th	52	2	3.8%	4	1	
	18th	76	1	1.3%	5	4	1
	19th	64	11	17.1%	3	3	
Natal grassland	19th	73	10	13.6%	4	3	

Table 6.11: Change in caries over time (by biome)

In order to increase the comparative sample size, the caries results are examined in groups. A comparison of the change in the percentage of carious teeth over the second millennium is presented in 100 year intervals for each biome (Figure 8) and sub-biome in Table 6.11. The elevated incidence of caries in the 11th and 12th centuries drops considerably during the 16th and 17th century (Figure 8). The gradual reduction of caries continues in both biomes until the late 18th and 19th centuries when it rises rapidly to 17.% and 14% respectively.

However closer examination of the change in caries in the savanna sub-biome after the 16th century reveal certain distinct differences (Figure 9). The incidence of caries decreases from approximately 8% in the 16th and 17th centuries to 5% in the 18th century and 3% in the 19th century. In contrast, the incidence of caries in the savanna woodland sub-biome increases from 5% in the 16th and 18th century to 39% in the 19th century. The Natal grassland sub-biome also demonstrates a contrasting high incidence of caries in the 19th century. This suggests that agriculture was a more viable subsistence prospect in the 14th and 16th/17th centuries in the savanna sub-biome while in the savanna woodland and grassland biome it was more viable during the 19th century.

Figure 8: The incidence of caries in the savanna and grassland biomes during the second millenium



Patterns of caries amongst agriculturists

One problem with interpreting the caries data by using the percentage of carious teeth as an indice, is that despite the comprehensive comparison of 64 different populations and 609 000 teeth used by Turner to establish the incidence of caries for different economies, there is a good deal of overlap between hunter gatherers, (0 to 5.3%), mixed economies (1 to 10.3%) and agriculturists (2.3 to 26.9%). Thus while an incidence of greater than 10% of carious teeth would apparently indicate a population with an agricultural economy, groups with less than 10% carious teeth could be either hunter-gatherers, mixed economists or agriculturists. Another problem is that factors other than diet may affect an individual susceptibility to caries (see chapter 5) and with the small sample size comparisons cannot easily be drawn.

In order to establish more definitively what type of economy is reflected by the caries data, a set of criteria (characteristic of agricultural populations consuming high carbohydrate foodstuffs), was devised using studies of the pattern of caries in different populations (chapter 4). This method provides a more suitable comparison because the pattern of a carious lesion is affected mainly by the type of food which is being eaten.

Criteria include: the type of tooth affected by caries, location of the carious lesion, percentage of teeth with advanced caries, and the number of teeth lost antemortem. These details were recorded for each case of caries (Appendix 8) and evaluated according to the criteria laid out below. They are classified as either primary factors (a characteristic which affects only agriculturists) or secondary factors (a characteristic which is unlikely to occur in hunter gatherer populations with caries).

- **Distribution of caries by tooth type**
  Primary criteria: I1, I2 or C affected by caries (I & C)
  Secondary criteria: P1, P2 (P1 & P2)
- **Location of carious lesions**
  Primary criteria: Caries on the buccal or lingual surfaces (B & L)
  Secondary criteria: Occlusal surface caries (O)
- **Antemortem tooth loss**
  Primary criteria: Age unknown - more than 6 teeth lost antemortem (Amp)
  Young adult - more than 3 teeth lost antemortem (Ams)
- **Advanced caries**
  Primary criteria: Over 50% of the carious lesions are advanced. (Ap)
  Secondary criteria: Any carious lesion in an advanced state (As)Table 6.12: The criteria used to determine an agricultural pattern of caries.

Table 6.12: The criteria used to determine an agriculturalists pattern of caries

In order to identify those individuals with a pattern of caries characteristic of a high carbohydrate diet, the presence of either 2 primary factors, 1 primary and 1 secondary factor or 3 secondary factors were required. This should identify those individuals with a staple cereal diet. Dentition's not meeting these requirements fall in the area of overlap between agriculturists and mixed farmers/hunter gatherers and cannot be positively identified as agriculturalists according to their pattern of caries.

Only 30 individuals, of the original 44 examined, had caries and were suitable for analysis according to the criteria outlined above. Of these, 12 met the requirements of high carbohydrate intake, 8 of which date to post 1800 AD (Table 6.13)

UCT #	Site	Date	# teeth with caries	Primary characteristics	Secondary characteristics
3682	SK	12th	3/23	I; AMp	O; As
3684	SK	12th		Ap; AMp	
4934	OP	15th	4/16		P1; P2; O; As;
4932	FC	16th	5/32		P1; P2; As
4914	KC	19th	2/25	B; L	P1
4915	KC	19th	1/15	B; C	
4917	RS	19th	7/16	B;	As
4926	WE	19th	2/16	AMp	P2; O; As
3710	OP	19th	9/14	C; B	P1; P2; O; As
4933	OP	19th	6/14	I; L;	P1; P2; O; Ams
4938	FF	19th	4/24	L; Ap	P2
4939	FF	19th	5/13	Ap; Amp	
4172	BM	17th	4/25	B	
4948	RK	17th	1/29	B	
4949	RK	17th	2/9	AMp	

Table 6.13: Samples with an agricultural caries pattern

Of the 4 individuals dated prior to 1800 AD, which display an agricultural pattern of caries, two are from Skutwater (SK), 1 is from Oliphantspoort (OP) and 1 is from Ficus (FI). Individuals dated post 1800 AD includes 2 individuals fro Kaybar's Cave (KC), 1 from Robinson's Shelter (RS), 2 from Oliphantspoort (OP), 1 from Wellington Estates (WE) and 2 from Frankfort (FF). Thus although the incidence of caries for 10 individuals from at Wellington Estates (WE) falls in the range between mixed farmers and agriculturists, at least one individual appears to have been from a definite agricultural subsistence base.

Individuals from the sites of Rooikrans (RK) and Bambo (BM) also exhibit a high incidence of caries comparable with agriculturalists. Each displays some of the characteristics of an agricultural population but not sufficient to fulfil the established criteria (although the presence of primary criteria, found only amongst agriculturists, indicates that it is highly likely that the caries resulted from the presence of agricultural carbohydrates in their diet). The main difference between individuals from these two sites and those individuals which display an agricultural pattern of caries is that the latter were probably consuming cereals as a staple food source.

Comparison of the number of carious teeth, together with the pattern of caries, indicate that populations/individuals were eating different proportions of agricultural carbohydrate. The sites from the early period had a high input of agricultural carbohydrates in their diet. The two individuals identified as hunter gatherers have a higher incidence of caries than one would expect, suggesting contact between hunter gatherers and agriculturists. This is consistent with historical records that observe the absorption of hunters gatherers into the society of cattle keepers and cultivators (Wilson 1969 a&b) Although all the sites from this period exhibit a high caries incidence, only Skutwater has both the pattern and incidence of caries associated with that of a staple agriculture. This emphasis on agriculture is continued in the Northern Transvaal savanna region during the 16th and 17th centuries. However intensive agricultural patterns of caries only become evident further south, in the savanna woodland and grassland biome, during the 19th century with Oliphantspoort being the exception.

Chapter 7
Discussion

Introduction

The results, which were presented in chapter 6, have outlined definite differences in the diet and subsistence patterns of Later Iron Age people. The distinction between the early and later second millennium skeletons points towards a definite difference in subsistence patterns during this period. This together with the increase in $\delta^{13}C$ values over the entire millennium, demonstrates a change in the subsistence of Later Iron Age people. While individuals from earlier sites have more negative $\delta^{13}C$ values, those from later sites are more enriched in $\delta^{13}C$. This change occurs gradually over the last 1000 years and has resulted in a strong linear relationship between $\delta^{13}C$ and time. Regression analysis has determined that 72% of all $\delta^{13}C$ values in the Later Iron Age are related to time. As a result, dietary signals can be used as a means of relatively ordering skeletal material. This establishes the context of the individual at the most basic level - by what they ate.

Examination of caries has revealed some variation in the amount of agricultural foods consumed. Establishment of a set of criteria reflective of the diet of agriculturists has differentiated between those individuals subsisting off a staple diet of cereals and those who were eating a mixed diet. Inter- and intra- site variation demonstrates that the diet of Later Iron Age people cannot be regarded as consistent. It is suggested in this discussion that the importance of cattle as a food source changed during the Later Iron Age, while that of agricultural cereals increased. The pronounced increase in caries during the 19th century is attributed to the introduction of maize.

This chapter will examine the differences evident in the isotopic and caries results, and seek to incorporate the information gained from this analyses of Later Iron Age people into the general framework of archaeological evidence

Theoretical framework

In the discussion of the economy of Later Iron Age people in chapter 2, it was determined that there was a wide range of foods available to people during the second millennium. These ranged from C_4 foods; ie the meat of grazing herbivores such as cattle and wild ungulates ($\delta^{13}C$ = -8.0‰), maize ($\delta^{13}C$ = -7.9‰ to -10.0‰) (Tieszen and Fagre1993), and millets and sorghums ($\delta^{13}C$ =-10.7‰ to -12.8‰), through to the meat of mixed feeders ie domestic sheep and goat and wild ungulates such as impala and springbok, ($\delta^{13}C$ values approximately = - 14‰), to C_3 foods ie the meat of pure browsers ($\delta^{13}C$ = approximately -20.0‰), and C_3 plant food such as nuts, berries, fruit, tubers, pumpkins, gourds ($\delta^{13}C$ = -20‰ and -36‰). Animal foods would be characterised by higher $\delta^{15}N$ values (ie 12.2‰) while plant foods would be characterised by lower $\delta^{15}N$ values(6.6‰). The main cariogenic foodstuffs would have been the C_4 cereals (maize and sorghum) and honey.

It has been determined (chapter 6), that the $\delta^{13}C$ signature of Later Iron Age people falls within the range of C_4 foods (-5.5‰ to -12.6‰). How then can we use $\delta^{13}C$, $\delta^{15}N$ and caries to elucidate more information about their diet?

Hypothetical framework

A more detailed examination of the $\delta^{13}C$ values of C_4 foodstuffs, reveals some subtle differences. If an individual was eating a diet consisting primarily of grazing herbivores, then we would expect their $\delta^{13}C$ bone collagen value to be -3‰. If they were eating a diet of pure maize, then their $\delta^{13}C$ bone collagen value would be -3.9‰. A diet of indigenous African cultigens would yield a $\delta^{13}C$ value of -6.7‰, mixed feeders would yield a $\delta^{13}C$ value of -9.0‰, browsers $\delta^{13}C$ = -15‰, and C_3 plants would average approximately -21.1‰. It therefore follows that those individuals with enriched $\delta^{13}C$ values would be subsisting from a primary C_4 base (which would have included domestic plants and stock), whereas those with depleted $\delta^{13}C$ values would be subsisting from a more varied diet which consisted of some proportion of C_3 foods.

For example; the diet of an individual with a $\delta^{13}C$ value of -10.5‰, and $\delta^{15}N$ value of 8.5‰ would be interpreted as having a predominantly C_4 diet, supplemented by some proportion of C_3 foods with a low consumption of animal protein. Alternately, an individual with a $\delta^{13}C$ value of -5.9‰ and a $\delta^{15}N$ value of 11.0 would indicate a dominant C_4 diet with a relatively high input of animal protein.

Caries results complement the isotopic evidence for diet by providing an indication of the amount of carbohydrate in the diet of an individual. The incidence of caries amongst individuals from agricultural populations is higher compared to those of mixed farmers and hunter gatherers. A set of criteria which outlines the pattern of caries characteristic of a high carbohydrate has been established providing additional evidence for the consumption of cereals. Individuals with caries have been classified (according to the criteria) as having a pattern of caries characteristic of agriculturalists. This is a preferable way of examining the caries data as it characterises caries by the pattern of the lesion and not the frequency of the occurrence (which can be affected by numerous other factors).

Thus by examining the isotopic and caries data I am able to draw inferences about the amount domestic cereals, livestock and wild foods, in the diet of food producing communities in South Africa.

Later Iron Age diet and subsistence patterns

Hunter gatherers

In this thesis, isotopic analyses has differentiated between hunting and gathering populations and Iron Age food producers living in the same biome. The two skeletons from the grassland biome, with negative $\delta^{13}C$ values and high $\delta^{15}N$ values, are isotopically different to the Iron Age skeletal material analysed in this study. One of these, UCT 3686 from Heilbron, has been dated to the beginning of the second millennium AD. As there is no archaeological evidence of Iron Age settlement in the grassland before the 15th century, it would appear that this individual was a hunter gatherer. The similarity in the isotopic results of Heilbron and Bainsvlei would suggest that the latter is also representative of a hunter gatherer. The $\delta^{13}C$ values for these individuals are similar to those of mixed subsistence bases from the early part of the second millennium. Both individuals exhibit an incidence of caries higher than is normally found amongst hunter gatherers. These factors point toward interaction between hunter gatherer communities and Iron Age food producers.

The Leopards Kopje tradition

Towards the end of the first millennium, a ceramic tradition called Leopards Kopje developed in the Shashi/Limpopo river valley. Archaeological evidence has identified Bambandyanalo as an important political centre within this tradition (Huffman 1986 a&b, Meyer 1984). The abandonment of Bambandyanalo coincided with the first occupation of Mapungubwe Hill, which developed into a state capital, linked with the Great Zimbabwe tradition. Villages such as Skutwater, are thought to have been second level authority sites allied to Mapungubwe, and were custodians of the royal herd (van Ewyk 1987).

A comparison of the carbon isotopic values of individuals from Bambandyanalo, Skutwater and other African populations show a strong similarity between the two Later Iron Age sites and the Kikuyu. The latter are a historic Bantu speaking group from the cool Kenyan highlands who consumed a mixed diet of; C_3 crops and legumes, C_4 grains, cattle, caprine, wild protein and wild C_3 plants ($\bar{x}$ δ^{13}C -11.6‰) (Ambrose 1986).

Despite the obvious importance of cattle, outlined both in the settlement pattern and faunal assemblage of these sites, neither Bambandyanalo nor Skutwater have δ^{15}N values as high as other African pastoralists who depend primarily on domestic stock as a food source. As interpretation of δ^{15}N results from arid areas needs to be made with caution comparisons between δ^{15}N values can only be drawn between individuals from similar hot, arid environments. Reported δ^{15}N results from Kenyan pastoral populations which lived in arid areas, such as the Pokot (14.2) and Turkana (13.9), reveal that the δ^{15}N for these groups, are only slightly more elevated than these early second millennium sites (Ambrose 1986). Their subsistence patterns cover a broad spectrum and include the meat and milk of cattle, sheep, goat and camel and exploitation of wild C_3 plants with C_4 grains contributing to the diet in a minor capacity. Despite the higher percentage of domestic stock at Bambandyanalo, δ^{15}N values from Skutwater indicate a higher consumption of animal protein.

The high incidence of caries at both Bambandyanalo and Skutwater would suggest a high consumption of cereals. This appears to contradict the isotopic results which indicate a mixed subsistence pattern. Low fluorine in the area could have played a part in increasing the incidence of caries (Ockerse 1947, Steyn pers comm). A preservational bias at Bambandyanalo may also account for the high incidence of caries at this site as posterior teeth which are best preserved, are also the most cariogenic. Skutwater on the other hand not only has a high incidence of caries but the carious lesions also have a very definite agricultural pattern. Another explanation could be that the high incidence of caries was a result of the consumption of honey. Although there is no way to test this hypothesis, it must be regarded as an viable option.

The high variation in the isotopic values amongst individuals from this period suggests that different people had differing access to the available foods. However without details on the status and sex of the individuals it is not possible to determine the specific nature of this variation. It is apparent that people, both within a large political centre Bambandyanalo, and from smaller villages (Skutwater), were affected by social differentiation in terms of their diet.

I would therefore conclude that Bambandyanalo and SK have a similar mixed diet to Kenyan pastoral groups and that the large herds of cattle kept on these sites lay beyond that of a basic subsistence need. Individuals at Bambandyanalo had a broad subsistence base that varied between individuals. Higher $\delta^{15}N$ results at Skutwater are associated with low negative $\delta^{13}C$ values which would suggest that the animal protein component was derived from browsing animals (this would include wild browsers as well as domestic caprines, especially goats). The high incidence of caries at Skutwater does suggest that C_4 grains were an important dietary component. If this was supplemented by the meat of C_3 browsers (as suggested), then the isotopic signature would fall more towards the negative range for C_4 diets, as it does. It is therefore my suggestion, that the population at Skutwater were eating mainly domestic cultigens together with the meat of domestic browsers and wild flora.

The Letaba tradition

The area around the Soutpansberg has a history of occupation stretching back to the 12th century. Interaction between these Shona people and later Sotho/Tswana speaking people, resulted in the amalgamation of ceramic styles to form a new Letaba tradition, and the subsequent development of the Venda (chapter 2). Venda society has been noted ethnographically, to have a comparable social structure to that of the Shona. There is an unequal distribution of wealth ,and cattle ownership is restricted to the ruling class.

Two individuals from Ellerton Mine in the Northern Transvaal savanna, are dated to the early part of the second millennium. These individuals were formally buried, unattached to any settlement. Their low $\delta^{15}N$ values and enriched $\delta^{13}C$ values suggest a low component of dietary protein with an increased emphasis on C_4 foods. While their $\delta^{15}N$ values are almost identical, the $\delta^{13}C$ values differ by over 2‰ indicating a significant difference in the consumption of C_4 foods between these two individuals. The individuals with the more enriched $\delta^{13}C$ value has caries. The percentage of teeth affected by caries although comparable to that of agriculturists does not point towards a particularly high consumption of carbohydrates.

Another (slightly later) individual from Tavhutshwene (Venda), from the Northern Transvaal savanna also exhibits lower $\delta^{15}N$ values and enriched $\delta^{13}C$ values. The similar isotopic values between these individuals suggest that the skeletons from Ellerton Mine may have been part an early southern migration of Shona speaking people. Their diet would have been made up of largely wild and domestic plant food with a small component of hunting and snaring providing the protein component. This is consistent with the ethnographic evidence which notes that cattle were not available within the general community.

The Moloko Tradition

Towards the end of the 15th century, ancestral Sotho Tswana people move into the savanna woodland and grassland biomes of South Africa. The earliest occupants of these biomes had a mixed subsistence base. This is evidenced by the low $\delta^{13}C$ and $\delta^{15}N$ values from early sites in the savanna woodland (Oliphantspoort and Buispoort) and grassland (Welgegund and Klipriviersberg) biome. The incidence of caries amongst these early individuals is not particularly high, falling within the range for a mixed farming economy. An exception is the individual from Oliphantspoort which displays a high incidence of caries and a pattern of high carbohydrate consumption. Isotopic data would suggest that a high agricultural input in the diet (as evidenced from the caries data) was supplemented by low trophic level C_3 plant food together with a browsing animal component.

As the Sotho/Tswana became more settled in these new environments, the subsistence base changed. The $\delta^{13}C$ isotopic values from later individuals is remarkably similar to agro-pastoralists from Kenya namely, the Kalenjin, Savanna Pastoral (SPN) and Elmenteitan Neolithic (EM). groups. These populations relied on C_4 grains (millets and sorghum) and the meat, milk and blood of cattle and caprines to varying degrees (Ambrose 1986). This comparison indicates that, once established in the savanna woodland and grassland biomes, Sotho/Tswana people began living primarily on domesticated foods.

Although the $\delta^{15}N$ results for these established Sotho/Tswana populations are on the whole, lower than that of the agro-pastoralists from Kenya, some individuals do appear to be consuming at least equal amounts of animal protein and cereals. This is deduced from the similarity in the isotopic data of Later Iron Age Sotho/Tswana and the Kalenjin which are known, ethnographically, to have had a diet based on equal amounts of cereals and livestock.

Variable isotopic results during this period indicate that people were consuming different proportions of C_4 foods. This is however, not as pronounced amongst the ancestral Sotho/Tswana people as the Shona. This confirms my earlier suggestion that diet is more highly variable where the levels of hierarchy are more pronounced.

The pattern of caries in this period is also interesting. Between the 16th to 18th centuries, the incidence of caries is higher amongst individuals in the savanna biome than in individuals from the savanna woodland and grassland biomes. This appears to indicate that during the middle period of the Later Iron Age, people in the northern areas of South Africa were either eating a higher carbohydrate diet or preparing their food in a more refined manner, than their contempories further south.

Oliphantspoort is an exception to this hypothesis. Individuals from this site have an incredibly high incidence of caries which is manifest as an agricultural pattern in both the earlier and later samples (although higher in the later individuals with enriched $\delta^{13}C$). The high incidence of caries at Oliphantspoort may indicate increased supplementation of agricultural carbohydrate or perhaps a difference in the preparation of the carbohydrate. For example, sorghum beer is likely to be particularly cariogenic because of the texture and concentration of the carbohydrate. It is also possible that people at Oliphantspoort display a genetic susceptibility to cariogenic bacteria.

During the 18th/19th century, in the savanna woodland and grassland biomes, as the trend of increasing $\delta^{13}C$ continues, so does the incidence of caries. The pattern of caries in many of these later individuals indicates a diet with a high proportion of carbohydrates. This higher incidence and pattern of caries is also evident in 19th century individuals from Kaybar's Cave and Robinson's Shelter. Some of these individuals display the lowest $\delta^{15}N$ values of the entire Later Iron Age group suggesting a diet which is very low in animal protein and high in cereal carbohydrate. The depleted $\delta^{13}C$ values from the Drakensberg sites are most likely to be a result of the higher percentage of C_3 grasses which occur in equal quantity to C_4 grasses in this biome (van der Merwe and Vogel 1983). The $\delta^{13}C$ values would therefore reflect a higher C_3 consumption. It is not surprising that 19th century skeletons exhibit a high incidence of caries as in addition to the indigenous African cultigens of sorghum and millet, people would have had access to maize and sugarcane.

Transvaal Ndebele

The early phase of expansion of the Transvaal Ndebele, into the Waterberg is represented at Rooikrans. Although the presence of Moloko ceramics would normally have identified this site with the Sotho/Tswana, the pattern of settlement, and the fact that the ceramics were not made locally, outline the difference between Rooikrans and other surrounding sites. Low $\delta^{13}C$ and $\delta^{15}N$ results at Rooikrans suggest that, compared to the their contempories in the savanna woodland and grassland biomes, occupants at Rooikrans had a higher dietary component of wild fauna and flora. The high incidence of caries at Rooikrans reflects the importance of dietary carbohydrates. The isotopic results for individuals from Nylsvlei, Bambo, Ficus and Maxonwa (sites occupied by the Transvaal Ndebele during the 16th-19th centuries), are not as markedly depleted in $\delta^{13}C$ as Rooikrans, falling with in the range of isotopic values for the Sotho/Tswana. The incidence and pattern of caries of these individuals falls within the range expected of an agricultural economy.

Faunal assemblages and $\delta^{15}N$ results

While faunal assemblages can provide archaeologists with an indication of the relative proportions animal species on a site, $\delta^{15}N$ results can provide a reflection of how important animal protein was in the diet. It is interesting to compare the $\delta^{15}N$ results of individuals from sites with corresponding faunal analyses when available. In most cases, where domestic stock contribute largely to the faunal assemblage, such as Bambo, Ficus, Makgwareng, Wildebeestfontein and Buffelshoek, $\delta^{15}N$ results indicate a higher consumption of animal protein ($\bar{x}$ 10.4). At Rooikrans, Tavhutshwene and Klipriviersberg, the percentage of domestic stock in faunal assemblages is lower and individuals from these sites have lower $\delta^{15}N$ values ($\bar{x}$ 8.5). However, faunal analysis does not always represent the importance of animal food in the diets of people. At Bambandyanalo for example, domestic stock are dominant in the faunal assemblage, yet the $\delta^{15}N$ results suggest that individuals at Bambandyanalo were not eating particularly high proportions of meat. Thus the high percentage of domestic stock at Bambandyanalo was used for non-dietary purposes. It may be, that the meat of domestic stock was consumed mainly by visitors at important occasions or during court disputes, that cattle were sacrificed and not eaten, or possibly, that they died and eaten only at special occasions or that they were traded. Faunal assemblages are therefore not directly representative of amount of animal protein consumed by inhabitants of the site.

Introduction of maize

Maize was introduced on the east coast of Africa by the Portuguese probably as early as the late 16th century. There is some archaeological evidence for a growing dependency of this new cultigen during the 18th century (Maggs 1994, Huffman 1986). However it is not clear how and when maize spread across the country. The isotopic and caries results provide no evidence of particularly high cultigen consumption during the 16th and 17th centuries in the interior of South Africa. However highly enriched $\delta^{13}C$ values and low $\delta^{15}N$ values at the beginning of the 18th century indicate a staple C_4 diet with a low component of animal foods. This together with a sudden increase in the incidence of caries in the savanna woodland and grassland biomes during the 18th/19th century could well reflect the adoption of an new cultigen such as maize. The introduction of a new cereal would have resulted in more successful crop rotation and an increase in the yield of domestic grains thus increasing the overall consumption of agricultural grains.

This supports the scenario that as a result of increased trade with the Portuguese on the east coast, maize became more accessible to Later Iron Age people. It is my suggestion that given the isotopic and caries results together with the historical and ethnographic evidence for the introduction of maize (chapter 2) that maize was introduced to the eastern coastal regions and some parts of the interior of southern Africa by the Portuguese in the late 16th/early 17th centuries. With the development of a trade network between Delagoa Bay, and the interior of South Africa, maize could have spread across the interior of South Africa through the Eastern Transvaal to the savanna woodland sub-biome and then south to the grassland plateau, replacing sorghum and millet as the primary domesticated cereal.

Chapter 8
Conclusion

The aim of this thesis was to use stable carbon and nitrogen isotopic analysis together with the examination of tooth caries to test the validity of current theories of diet and subsistence patterns during the Later Iron Age in South Africa. In contrary to analysing the artefactual debris, I reviewed current archaeological perspectives by focusing on the examination of individual skeletal remains. Using the strong correlation between the change in $\delta^{13}C$ over time, I was able to relatively order previously undated skeletons. In addition, by formulating a set of criteria that outline a characteristic pattern of caries, people with a high carbohydrate consumption can be definitively distinguished from mixed farmers. With the context of skeletal material established, I was able to use the individual isotopic and caries results to draw conclusions indicative of subsistence change. Heterogeneity is clearly evidenced between individuals at one site and those at another, and between individuals at the same site, in the same period. However, the similar range in the isotopic results provides fundamental evidence that Later Iron Age people adapted communally, along the same lines, moving towards an acceptance of cultigens, while still pursuing individual lifestyles. With this increased dependence on cultigens, comes a change in individual perspective and utilisation of cattle.

At the outset of this thesis I was aware of the debate concerning the extent to which carbon collagen values are derived from protein. As a qualification, nitrogen ratios (which are indicative of trophic level), were also analysed. It would be expected that if an increase in $\delta^{13}C$ was primarily reflective of the increase in protein in the diet, that it would be paralleled by a similar increase in $\delta^{15}N$. As this does not seem to occur in this instance, we can assume that the increase in $\delta^{13}C$ is attributable to increasing carbohydrate consumption.

I was also aware of the possibility that if skeletal remains were found in association with the cattle byre/ dwelling or special significant locations within the settlement, it was likely to be an individual of high social class. This was not perceived to be a problem in the interpretation of the results as I would submit that the diet of the higher classes are still indicative of that of the population. Communities with a high social hierarchical and economic development exhibit a higher variance in diet in comparison to smaller family homesteads (as evidenced by the Shona).

The earliest skeletal remains analysed, were ancestors to the Shona from the Limpopo river valley. These people were living a sedentary lifestyle with periods of intense settlement in large centers with high social stratification, well developed trade networks and increasing wealth. Differences are evident between individuals living in main centers eg Bambandyanalo and those living in outlying villages eg Skutwater. Individuals at Skutwater appear to be consuming a high proportion of animal protein probably derived from domestic and wild browsers. A high incidence of caries at Skutwater indicates that the diet was also focused on cereal grains. In contrast, isotopic and caries data from Bambandyanalo is consistent with a more varied, variable diet which would have included a range of domestic and wild foods. Domestic cattle do not appear to have been consumed in large quantities. This is contrary to the archaeological evidence which provides evidence for large numbers of cattle at these sites. As a result, I conclude that cattle, which were owned by the ruling elite, were not utilised as a major source of food. Instead they were representative of wealth and political power within the community. This differential ownership of cattle also occurs amongst the Venda during the Later Iron Age and continues amongst some ethnic groups till the present day.

Other factors which may influence this economy and that of other hierarchical settlements are:

- Increasing economic specialisation.
- Increased production leading to a surplus beyond the basic subsistence needs.
- Increased demand as a consequence of dense population distribution and possible growth.
- Increased trade, leading to introduction of an increased variety of commodities, with some "fashionable" commodities perhaps becoming an additional form of bridewealth.
- Development of subsidiary villages, with distinct purposes; for example cattle keeping, agricultural and other economic production and defence.
- Spheres of influence of the economy which extend beyond the realm.
- Development of religious, quasi-religious beliefs.
- Selective burial patterns and techniques with high social class or senior individuals being buried in association with the central cattle byre or on hilltop settlements.

The dietary effect of these factors would be reflected in the variation of foodstuffs being consumed by different social classes, age groups and genders. This is demonstrated by the isotopic results.

Later in the millennia, from 1400 AD, the ancestors of the Sotho/Tswana speaking people had begun to migrate and settle in the savanna woodland and grassland of the North West, PWV and Orange Free State. Early Sotho/Tswana populations also existed off a mixed subsistence base, their diet consisting mainly of wild fauna and cultigens. With the occupation of areas of higher rainfall, their subsistence base changed, to an increased consumption of cultigens and an increasing utilisation of cattle as an allocative food source (sometimes replacing wild fauna and ovicaprines as the major dietary protein).

An exception is the Transvaal Ndebele, which maintained a greater proportion of wild resources and a higher carbohydrate consumption in their diet.

Towards the middle of the 18th century archaeological evidence indicates that populations in the grassland and savanna began to aggregate (perhaps for defensive purposes), forming larger communities with a more highly developed social structures. However isotopic evidence indicates that the level of dietary protein, including that of domestic cattle, does not increase. As postulated previously, concentration of people in towns increases economic production, demand, and opens up new markets for trade. The sudden ascendence of Delagoa Bay as a major trading port, between the 18th and 19th centuries, is a possible response to this demand. The suitable environmental conditions and the availability of maize at Delagoa Bay, may have led to a sudden acceptance of this C_4 cultigen, with it's rapid cultivation times and high yields, to fulfil the increased demand of the growing population. The productive, hierarchical communities developed and continued to exist, until the later 19th/early 20th centuries when decentralisation occurs. People moved away from the large centers into dispersed homesteads, taking with them cattle and the new cultigen, maize. This together with the disruption of the trade network, is likely to have led to an increased utilisation of cattle as the primary commercial commodity. Those homesteads with large numbers of cattle would have been more likely to be able to secure marriage alliances, thus increasing reproductive capacity. The effect of the growing population of the homestead is twofold; it increases the consumptive demand and provides a larger workforce. To supply the increased demand of this population, maize becomes the staple food source. This is graphically depicted by the sudden increase in caries during the 19th century and remains the scenario until the western influences somewhat erodes the tradition during the 20th century.

In summary, isotopic and caries analysis of Later Iron Age people has enabled a re-assessment of the faunal analysis and a re-examination of archaeological perspectives on the importance of domestic produce. It is clear from the strong correlation between $\delta^{13}C$ and time that the utilisation of domestic cultigens increases throughout the second millennium (this also allows for relative ordering of skeletal remains). Different ethnic and individual subsistence patterns demonstrate that the Later Iron Age was heterogeneous but with economic and social interaction influencing diet. Dental health is also indicative of diet, so by the analysis of caries it is possible to distinguish agricultural subsistence patterns from other dietary modes. This allowed for the establishment of a set of criteria that can be used to predict the degree of reliance on carbohydrates in an individuals diet. During the 19th century, a notable reduction in the dental health of the Sotho/Tswana populations is evidenced. Shortly prior to this, these people were aggregated in larger population centers and one can surmise that it was during this period with high demand and population growth that maize was adopted as a primary source of carbohydrate.

Finally, it would be extremely profitable to extend the data base of this study to include individuals from different levels of the social hierarchy, Early Iron Age material, and hunter gatherers from the savanna woodland and grassland biomes. This would further examine the variance in the diet of people from different social levels, the theory of continuity between the diets of Early and Later Iron Age people and provide evidence for the distinction between the diets of hunter gatherers and Iron Age people in C_4 areas. An increase in the number of skeletons analysed would further test the hypothesis made in this thesis and would determine to what extent peoples diets (the increasing dependence on cereals and the movement from a subsistence of mixed farming to one of agriculture) are changing as an ethnic group, community, or on an individual basis. Radiocarbon dating of skeletons, particularly those with very enriched $\delta^{13}C$ values would test the validity of using $\delta^{13}C$ values as an indicator of context of skeletal material in the LIA.

In conclusion, the aims of this thesis have been achieved and it is hoped that researchers in southern African Iron Age studies may benefit from this thesis.

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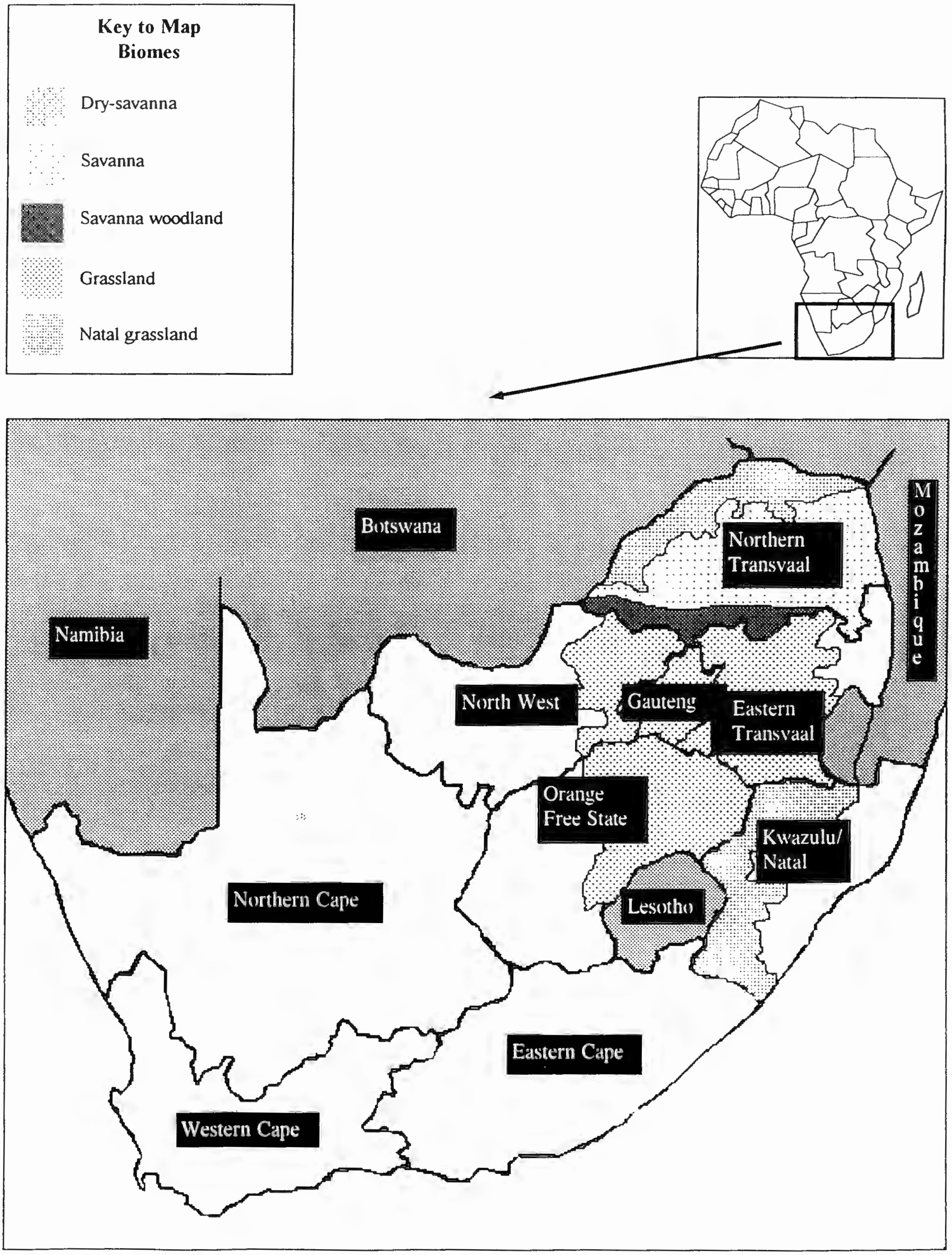
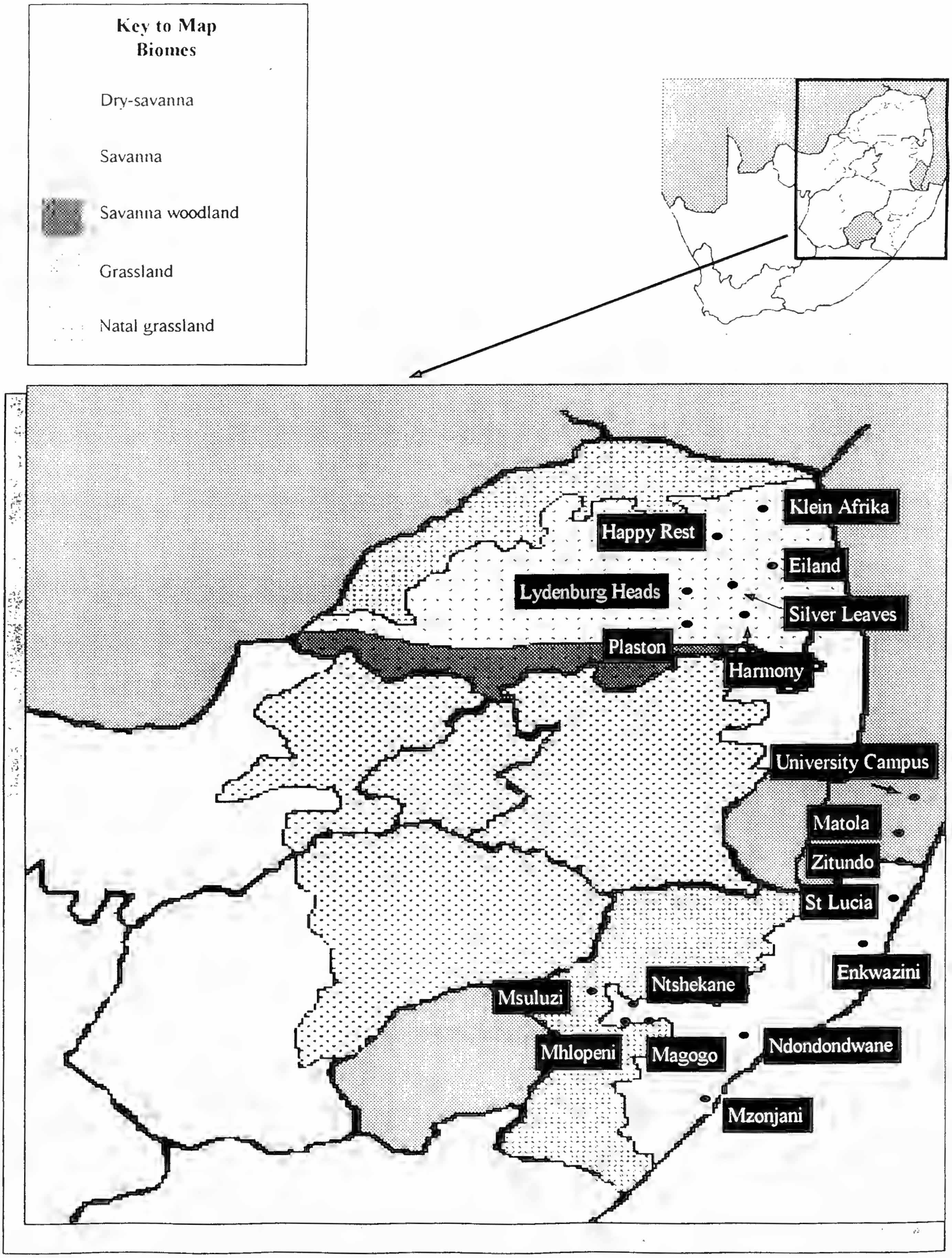
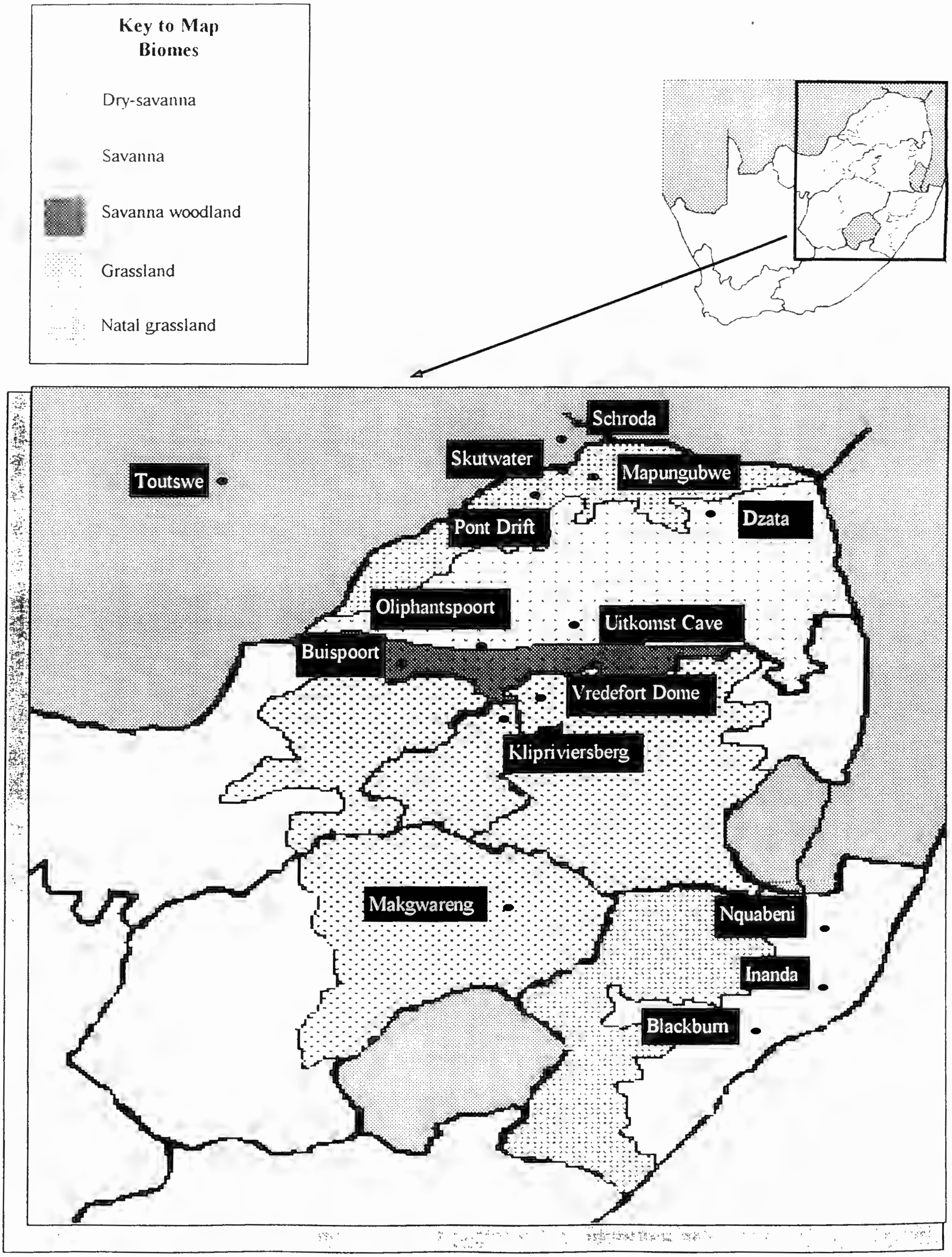
Map 1: The region of southern Africa and it's biomes



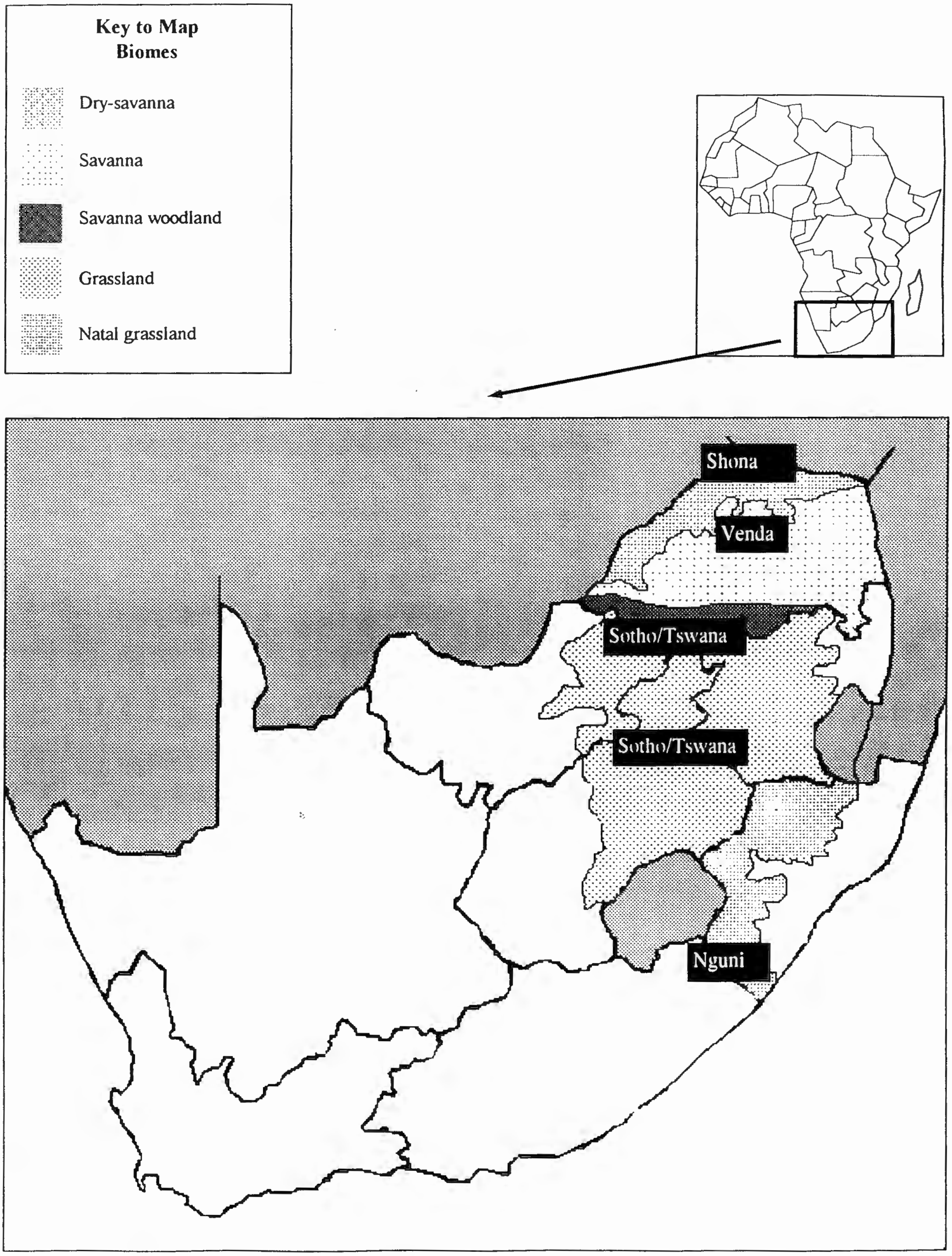
Map 2: The location of Early Iron Age site mentioned in the text



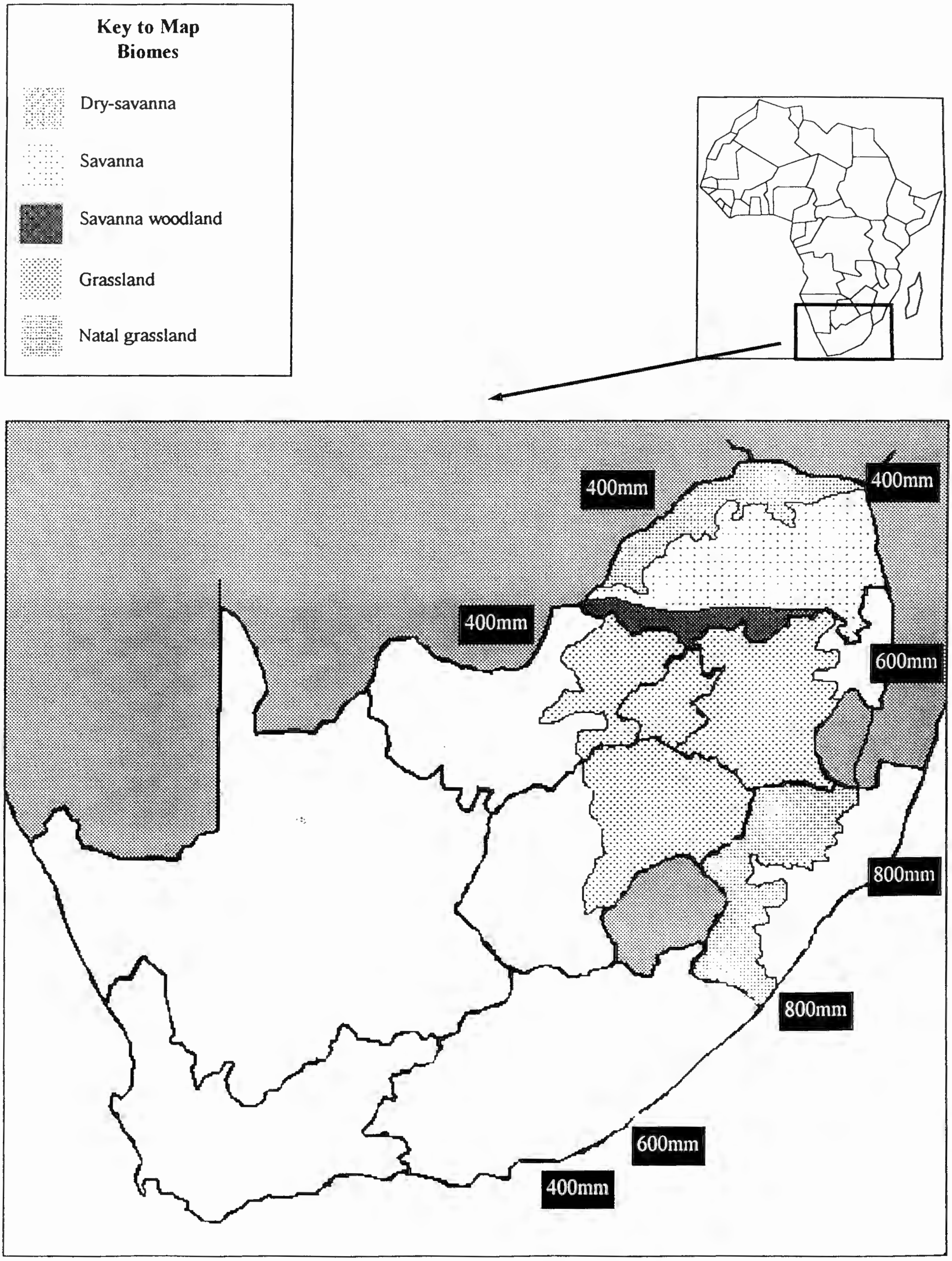
Map 3: The location of Later Iron Age sites mentioned in the text



Map 4: The distribution of ethnic groups in South Africa (1945 AD)
(adapted from Wilson 1969 a&b)



Map 5: Rainfall in South Africa: The distribution of the 400mm and 600mm isohyets



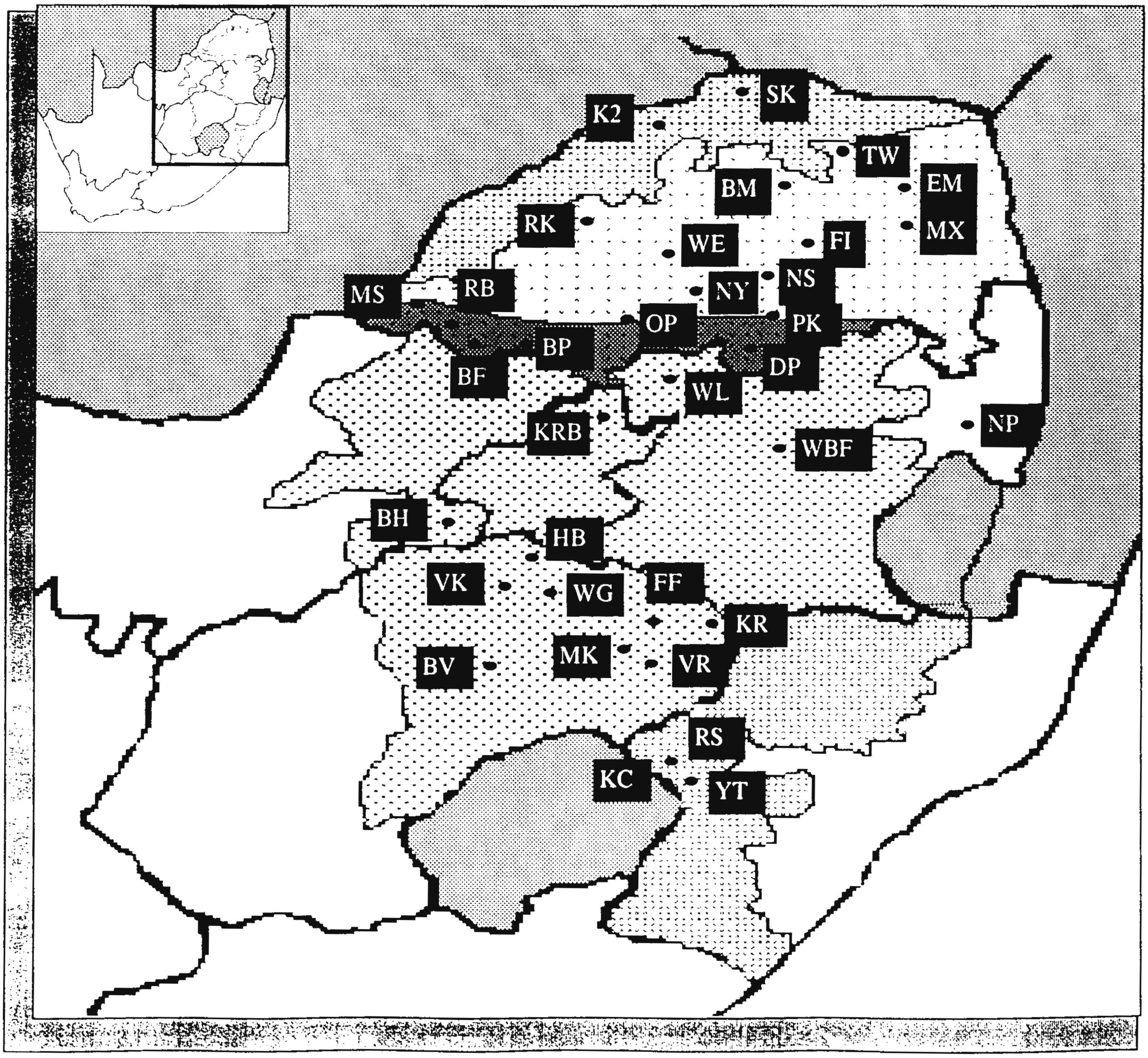
Map 6: The location of sites from which the sample were selected

Key to Map
Biomes

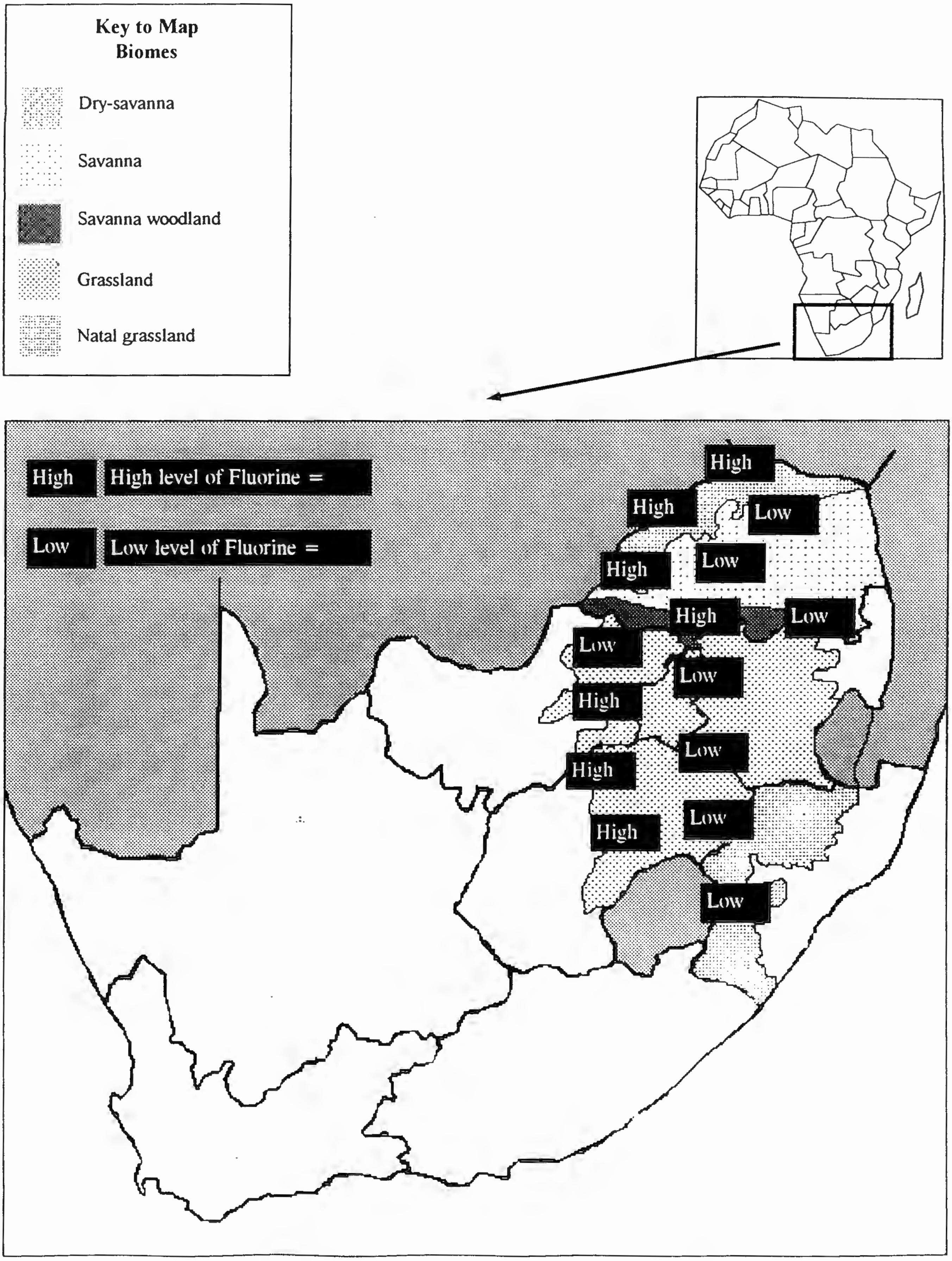
- ░ Dry-savanna
- ⬚ Savanna
- ▩ Savanna woodland
- ▒ Grassland
- ░ Natal grassland

Key to Sites

BF	Boshoff's Farm
BH	Buffelshoek
BM	Bambo
BP	Buispoort
BV	Bainsvlei
DP	Derdepoort
EM	Ellerton Mine
FC	Ficus
FF	Frankfort
HL	Heilbron
K2	Bambandyanalo
KC	Kaybars Cave
KRB	Klipriviersberg
KRV	Klip River Valley
MK	Makgwareng
MS	Magozastad
MX	Maxonwa
NP	Nelspruit
NS	New Smitsdorp
NY	Nylsvlei
OP	Oliphantspoort
PK	Paardekraal
RB	Rustenburg
RK	Rooikrans
RS	Robinson's Shelter
SK	Skutwater
TW	Tauhutswana
VK	Vechtkop
VR	Vrede
WBF	Wildebeestfontein
WE	Wellington Estates
WG	Willow Glen
WL	Welgegund
YT	Yellowtree



Map 7: The distribution of Fluorine in South Africa (adapted from Ockerse 1947)



Appendix 1

UCT #	SITE	ABV	BM	xDATE	δ13C	δ15N	REF
4162	Yellowtree	YT	SN	19th	-10.7	8.5	CG
4170	Wildebeestfontein	WBF	G	19th	-6.8	9.7	CG
4173	Buffelshoek	BH	G	19th	-6.4	9.4	CG
4913	Vechtkop	VK	G	18th	-6.5	9.6	CG
4914	Kaybar's Cave	KC	GN	19th	-9.8	8.8	CG
4915	Kaybar's Cave	KC	GN	19th	-11.0	8.0	CG
4916	Robinson's shelter	RS	GN	19th	-11.6	7.5	CG
4917	Robinson's shelter	RS	GN	19th	-9.7	6.6	CG
4918	Willow Glen	WG	G	18th	-5.9	8.3	CG
1919	Ellerton Mine	EM	S	14th	-9.6	7.8	CG
4920	Ellerton Mine	EM	S	14th	-7.4	7.9	CG
4921	Wellington Estates	WE	S	LIA	-6.6	8.4	CG
4922	Boshoff's Farm	BF	SW	16th	-6.0	9.2	CG
4923	Wellington Estates	WE	S	LIA	-6.1	11.7	CG
4924	Wellington Estates	WE	S	16th	-6.9	9.5	CG
4925	Wellington Estates	WE	S	LIA	-7.2	10.8	CG
4926	Wellington Estates	WE	S	19th	-7.5	10.7	CG
4927	Wellington Estates	WE	S	LIA	-6.8	10.3	CG
4928	Wellington Estates	WE	S	LIA	-6.7	12.2	CG
4929	Wellington Estates	WE	S	LIA	-7.8	9.5	CG
4930	Wellington Estates	WE	S	LIA	-7.7	11.0	CG
4932	Ficus	FC	S	16th	-7.1	10.2	CG
4933	Oliphantspoort	OP	SW	19th	-7.2	10.5	CG
4934	Oliphantspoort	OP	SW	15th	-9.4	7.9	CG
4935	Klipriviersberg	KRB	G	18th	-7.6	8.8	CG
4937	Magozastad	MS	SW	16th	-7.2	9.2	CG
4938	Frankfort	FF	G	LIA	-5.6	10.0	CG
4939	Frankfort	FF	G	LIA	-5.8	8.3	CG
4940	Rustenburg	RB	SW	LIA	-8.0	9.6	CG
4941	Buispoort	BP	SW	LIA	-8.8	8.7	CG
4942	Bainsvlei	BV	G	LIA	-11.2	9.2	CG
4944	Vrede	VR	G	LIA	-6.1	10.2	CG
4945	Nelspruit	NP	S	LIA	-10.5	7.4	CG
4946	Welgegund	WL	G	17th	-7.2	7.7	CG
4948	Rooikrans	RK	S	17th	-9.5	8.2	CG
4949	Rooikrans	RK	S	17th	-9.5	8.9	CG

Appendix 2

UCT #	SITE	ABV	BM	xDATE	δ13C	δ15N	REF
3290	Makgwareng	MK	G	LIA	-7.0	11.3	JLT
3682	Skutwater	SK	SD	12th	-12.6	14.1	JLT
3683	Skutwater	SK	SD	12th	-10.7	14.4	JLT
3684	Skutwater	SK	SD	12th	-10.6	11.6	JLT
3685	Skutwater	SK	SD	12th	-11.3	13.1	JLT
3686	Heilbron	HB	G	10th	-11.0	10.6	JLT
3687	Willow Glen	WG	G	18th	-6.7	11.0	JLT
3691	Makgwareng	MK	G	LIA	-7.2	10.4	JLT
3693	Klip River Valley	KRV	G	LIA	-5.5	10.4	JLT
3696	New Smitsdorp	NS	S	16th	-8.4	9.9	JLT
3703	Wellington Estate	WE	S	LIA	-6.8	10.0	JLT
3704	Wellington Estate	WE	S	LIA	-6.2	10.5	JLT
3705	Wellington Estate	WE	S	LIA	-7.1	12.2	JLT
3709	Paardekraal	PK	SW	16th	-7.5	10.5	JLT
3710	Oliphantspoort	OP	SW	19th	-6.7	9.3	JLT
3713	Buispoort	BP	SW	18th	-6.8	9.1	JLT
4165	Derdepoort	DP	SW	16th	-7.8	10.2	JLT
4167	Welgegund	WL	G	17th	-8.1	10.2	JLT
4171	Nylsvlei	NY	S	16th	-7.9	10.3	JLT
4172	Bambo 9A	BM	S	17th	-7.9	10.2	JLT
4178	Bambandyanalo	K2	SD	11th	-10.1	9.0	JLT
4180	Bambandyanalo	K2	SD	11th	-10.7	11.2	JLT
4182	Bambandyanalo	K2	SD	11th	-12.5	10.1	JLT
4187	Bambandyanalo	K2	SD	11th	-9.1	11.5	JLT
4191	Bambandyanalo	K2	SD	11th	-8.9	11.6	JLT
4192	Bambandyanalo	K2	SD	11th	-11.0	11.1	JLT
4194	Bambandyanalo	K2	SD	11th	-10.7	11.2	JLT
4205	Bambandyanalo	K2	SD	11th	-11.5	11.7	JLT
4207	Bambandyanalo	K2	SD	11th	-12.6	10.1	JLT
4209	Bambandyanalo	K2	SD	11th	-9.4	12.9	JLT
4210	Bambandyanalo	K2	SD	11th	-8.8	12.9	JLT
4211	Bambandyanalo	K2	SD	11th	-8.9	11.8	JLT
4213	Bambandyanalo	K2	SD	11th	-10.8	11.6	JLT
	Tauhatswana # 2	TW	S	16th	-7.8	8.3	SA
	Bambo 9C	BM	S	19th	-8.6	11.1	SA
	Maxonwa	MX	S	19th	-8.3	9.1	SA

Appendix 3:

UCT #	SITE	ABV	BM	xDATE	# T	# C	AGE	SEX
4913	Vechtkop	VK	G	18th	30	1	M	
4914	Kaybar's Cave	KC	GN	19th	25	2	Y	M
4915	Kaybar's Cave	KC	GN	19th	15	1	M	F
4916	Robinson's shelter	RS	GN	19th	17	0	Y	M
4917	Robinson's shelter	RS	GN	19th	16	7	M	M
4918	Willow Glen	WG	G	18th	4	0	Y	
4919	Ellerton Mine	EM	S	14th	14	0	Y	
4920	Ellerton Mine	EM	S	14th	23	3	Y	F
4921	Wellington Estates	WE	S	LIA	25	0	Y	M
4922	Boshoff's Farm	BF	SW	16th	26	1	M	M
4923	Wellington Estates	WE	S	LIA	24	0	O	M
4924	Wellington Estates	WE	S	16th	26	1	M	M
4925	Wellington Estates	WE	S	LIA	23	3	Y	F
4926	Wellington Estates	WE	S	19th	16	2	M	M
4928	Wellington Estates	WE	S	LIA	23	1	Y	
4930	Wellington Estates	WE	S	LIA	32	0	M	
4932	Ficus	FC	S	16th	32	4	M	F
4933	Oliphantspoort	OP	SW	19th	14	6	M	
4934	Oliphantspoort	OP	SW	15th	16	4	M	F
4935	Klipriviersberg	KRB	G	18th	21	0	Y	F
4937	Magozastad	MS	SW	16th	31	0	Y	M
4938	Frankfort	FF	G	LIA	24	2	M	
4939	Frankfort	FF	G	LIA	13	5	O	
4940	Rustenburg	RB	SW	LIA	6	1	M	
4942	Bainsvlei	BV	G	LIA	22	4	O	
4944	Vrede	VR	G	LIA	27	4	Y	
4948	Rooikrans	RK	S	17th	29	1	O	M
4949	Rooikrans	RK	S	17th	9	2	M	M
3290	Makgwareng	MK	G	LIA	21	0	Y	F
3682	Skutwater	SK	SD	12th	23	3	M	
3684	Skutwater	SK	SD	12th	24	4	O	
3686	Heilbron	HB	G	10th	21	1	M	
3691	Makgwareng	MG	G	LIA	20	1	Y	F
3696	New Smitsdorp	NS	S	16th	19	4	O	
3703	Wellington Estate	WE	S	LIA	15	0	Y	
3704	Wellington Estate	WE	S	LIA	22	1	M	F
3705	Wellington Estate	WE	S	LIA	18	2	M	
3709	Paardekraal	PK	SW	16th	15	0	M	
3710	Oliphantspoort	OP	SW	19th	14	9	M	
3713	Buispoort	BP	SW	18th	12	0	Y	F
4165	Derdepoort	DP	SW	16th	13	0	Y	
4167	Welgegund	WL	G	17th	32	1	M	F
4171	Nylsvlei	NY	S	16th	31	0	M	M
4172	Bambo 9A	BM	S	17th	25	4	Y	F

Appendix 4:

Savanna

Sub-Biome:	**Dry savanna - Map 6**

Site:	**Bambandyanalo** (K2)
Date:	970 - 1070 AD
Context of date:	Radiocarbon dates on ashheap and burials
Average date:	1020 AD
# of skeletons:	13
UCT #:	4178; 4180; 4182; 4197; 4191; 4192; 4194; 4205; 4207; 4209; 4210; 4211; 4213
Settlement pattern:	Pole and daga huts, clustered around a cattle byre, which moved elsewhere when intensive trade and occupation caused a large increase in the size of the central midden.
Ceramics:	Leopards Kopje A
Economy:	Mixed farmers; The remains of millets, sorghum and beans were found as well as the seeds of wild fruit. Domestic stock contributed to 96% of the total meat content of the diet.
Burials:	Large number of burials at this site, some buried with the bovid bones
Reference:	Huffman 1986, Morris 1992a, Lee-Thorp et al 1993,

Site:	**Skutwater** (SK)
Date:	1150 ± 40 AD
Context of date:	Radiocarbon dates on dung layers
Average date:	1150 AD
# of skeletons:	4
UCT #:	3682; 3683; 3684; 3685
Settlement pattern:	Central cattle byre with huts arranged around concentrically around the byre.
Ceramics:	Mapungubwe
Economy:	Fauna - domestic stock contibute to 74% of the total meat in the diet with wild fauna contibuting significantly to the diet. Cultigen - carbonised seeds of millets and sorghum together with the seeds from 14 different wild plant species.
Burials:	Buried in Central cattle byre, flexed on RHS except for 3684 which was buried in the habitation area.
Reference:	Van Ewyk 1987, Morris 1992a, Lee-Thorp et al 1993.

Sub-Biome:	**Savanna - Map 6**

Site:	**Bambo** (BM)
Date:	9A - 17th century; 9C - 110 ± 50 (Wits 934)
Context of date:	Ceramics and settlement pattern; Radiocarbon date on dung layer
Average date:	1650 AD; 1850 AD
# of skeletons:	2
UCT #:	4172; 9C
Settlement pattern:	9A - hilltop settlements occur prior to 1650 AD (ie before Group 2 settlement pattern); 9C - Recent 19th century terraced walling in Group 3 pattern
Ceramics:	9A - Moloko ceramics which appear in the central Northern Transvaal during the 15th/16th century and are not found after 1600 AD
Economy:	Fauna - predominantly cattle and ovicaprines, some wild fauna; Cultigens - the presence of grain pits and iron hoes provides evidence for agriculture
Burials:	9A - Burial 1 - shallow burial in stone wall hilltop settlement, flexed LHS, facing east, interred after formation of compact dung layer. 9C - Burial in central cattle kraal on stone terrace, south side of hilltop settlement.
Reference:	Morris 1992a; Loubser 1981, Lee-Thorp et al 1993, Ambrose 1986.

Site:	**Ellerton Mine** (EM)
Date:	600 ± 50 BP
Context of date:	Radiocarbon date on skeleton 4920
Average date:	1350 AD
# of skeletons:	2
UCT #:	4919; 4920
Settlement pattern:	
Ceramics:	
Economy:	4920 - Buried with three clay pots, glass, textiles and animal bone
Burials:	4920 - Buried 3 feet deep in calcite, flexed. Masses of coiled copper wire anklets (similar to that worn by Venda today) ensheathed the legs. 4919 buried 2 feet deep, presumably next to 4920
Reference:	Morris 1992a

Site:	**Ficus** (FC)
Date:	1560 ± 50 AD
Context of date:	Radiocarbon date of dung layer
Average date:	1560
# of skeletons:	1
UCT #:	4932
Settlement pattern:	Terraced open hilltop site
Ceramics:	Similar to Buispoort
Economy:	Fauna - domestic animals contribute to 83% of the meat in the diet, wild fauna inlclude large ungulates and small buck; Cultigens - grain bins provide evidence for agriculture
Burials:	Buried in the foundations of the kraal, flexed on LHS facing east.
Reference:	Moore 1981, Morris 1992a.

Site:	**Nelspruit** (NP)
Date:	Later Iron Age
Context of date:	Stone walling
Average date:	
# of skeletons:	1
UCT #:	4945
Settlement pattern:	
Ceramics:	
Economy:	
Burials:	Buried 60cm bemow the surface on a stone koppie near stone walling
Reference:	Morris 1992a

Site:	**Nylsvlei (NY)**
Date:	14th/15th century
Context of date:	Settlement patterns
Average date:	
# of skeletons:	1
UCT #:	4171
Settlement pattern:	Pre stone walling, central cattle kraal evidecnt in settlement pattern.
Ceramics:	Moloko
Economy:	
Burials:	Buried in an Iron Age settlement in a grove of trees
Reference:	Huffman 1986, Morris 1992a, Ambrose 1986, Lee-Thorp et al 1993.

Site:	**Paardekraal** (PK)
Date:	370 ± 50 BP
Context of date:	Radiocarbon date on skeleton
Average date:	1590
# of skeletons:	1
UCT #:	3709
Settlement pattern:	
Ceramics:	
Economy:	
Burials:	
Reference:	Morris 1992a, Lee-Thorp et al 1993.

Site:	**Rooikrans** (RK)
Date:	1670 ± 50 AD
Context of date:	Radiocarbon date on dung layer
Average date:	1670
# of skeletons:	2
UCT #:	4948, 4949
Settlement pattern:	Hilltop site with primary enclosures, surrounded by secondary walling. Different to other settlement patterns in the area.
Ceramics:	Moloko
Economy:	Fauna - livestock contribute to 60% of the meat in the diet, wild fauna very important; Cutigens - grindstones and iron ore
Burials:	4948 - flexed on LHS facing west; 4949 - flexed on LHS, facing west, buried under two pots.
Reference:	Hall 1984, Plug 1984.

Site: **Tauhatswana** (TW)
Date: 1580 ± 80 (Wits 1549); 1600 ± 80 (Wits 1460).
Context of date: Radiocarbon dates on dung layers
Average date: 1600 (Loubser says 1500 - calibrated)
# of skeletons: 1
UCT #: TW # 2
Settlement pattern:
Ceramics:
Economy:
Burials: Burial in dung mound and ashheap, flexed
Reference: Morris 1992a, Ambrose 1986, Loubser 1989.

Site: **Maxonwa** (MX)
Date: Late 19th century
Context of date: Ethnographic
Average date: 1850
# of skeletons: 1
UCT #:
Settlement pattern:
Ceramics:
Economy:
Burials: Buried in a shallow grave, beside the central cattle byre in the residence of a 19th century Ndebele headman
Reference: Morris 1992a, Ambrose 1986.

Site: **Wellington Estates** (WE)
Date: 400 ± 40; 160 ± 50
Context of date: Various radiocarbon dates from skeletons
Average date:
# of skeletons: 12
UCT #: 3703; 3704; 3705; 4921; 4923; 4924; 4925; 4926; 4927; 4928; 4929; 4930
Settlement pattern:
Ceramics:
Economy:
Burials: Burials uncovered by ploughing and erosion. SOme of the interments do not appear to be intentional; 3703 - was buried in the sitting position 20 cm deep; 3704 - buired 10cm deep facind southwest.
Reference: Myers 1958, Fichardt 1960, Morris 1992a, Lee-Thorp et al 1993

Site: **New Smitsdorp** (NS)
Date: 380 ± 30 BP
Context of date: Radiocarbon date on skeletons
Average date: 1580
# of skeletons: 1
UCT #: 3696
Settlement pattern:
Ceramics:
Economy:
Burials: No sign of a grave, suggested natural interment, grave goods included BaVenda type ceramics, and bone whistle
Reference: Berry 1935, Morris 1992a, Lee-Thorp et al 1993

Sub-Biome:	**Savanna woodland - Map 6**

Site:	**Buispoort** (BP)
Date:	Between 16th to 19th centuries; 200 ± 45
Context of date:	Settlement patterns and ceramics, 18th century radiocarbon date on skeleton 3713
Average date:	1760 AD
# of skeletons:	2
UCT #:	3713; 4941
Settlement pattern:	Stone walled settlement with stone beehive huts
Ceramics:	Moloko - Buispoort ceramics western regional varient of Uitkomst
Economy:	Cultigens - storage platforms, large grinding stones and iron working provides evidence for agriculture
Burials:	Buried in the fissures of rocks, 3713 - in half sitting position, 4941 - 1 of 2 graves on the northwestern side of the site
Reference:	Van Hoeppen and Hoffman 1935, Morris 1992a, Lee-Thorp 1993.

Site:	**Derdepoort** (DP)
Date:	post 1500
Context of date:	Stone walling
Average date:	
# of skeletons:	1
UCT #:	4165
Settlement pattern:	
Ceramics:	Buried with clay pot
Economy:	Buried with animal bone
Burials:	Buried in the ash-heap at the entrance to old stone kraal ruins. Flexed in sitting position
Reference:	Morris 1992a, Lee-Thorp et al 1993

Site:	**Magozastad** (MS)
Date:	400 ± 45
Context of date:	Radiocarbon date from charcoal inhearth
Average date:	1560
# of skeletons:	1
UCT #:	4937
Settlement pattern:	Stone wall site
Ceramics:	Moloko
Economy:	Fauna - livestock dominant, only one wild animal in faunal sample.
Burials:	
Reference:	Plug unpub

Site:	**Oliphantspoort** (OP)
Date:	1440 ± 90 AD; 19th century
Context of date:	Radiocarbon dates on ashheaps,
Average date:	1440; 1850
# of skeletons:	3
UCT #:	3710; 4933; 4934
Settlement pattern:	Earliest dated stone wall settlement
Ceramics:	Oori (Moloko)
Economy:	Fauna - 88% of meat consumed at the site was from domestic stock, age profiles indicate large herds of cattle; Cultigens - pollen samples of sorghum found, grindstones and grain bins.
Burials:	3710 - buried in recent ashheap flexed on LHS; 4933 - buried in same ashheap against stone wall, flexed on LHS, facing south; 4934 - buried in earlier ashheap, dated to 15th century, against stone wall, flexed on LHS.
Reference:	Mason 1986, Morris 1992a, Lee-Thorp et al 1993.

Site:	**Rustenberg** (RB)
Date:	1600 - 1800 AD
Context of date:	Historical/Ethnographic
Average date:	1700
# of skeletons:	1
UCT #:	4940
Settlement pattern:	Selonskraal - similar to Type Z
Ceramics:	Moloko
Economy:	Fauna - livestock contibuted to 79% of the meat in the diet, hunting practised to any large extent; Cultigens - grinding stones and elevated grain bins
Burials:	Probably from Selonskraal stone wall site
Reference:	Morris 1992a

Site:	**Boshoff's Farm** (BF)
Date:	400 ± 45
Context of date:	Radiocarbon date on skeleton
Average date:	1560
# of skeletons:	1
UCT #:	4922
Settlement pattern:	
Ceramics:	
Economy:	
Burials:	
Reference:	Morris 1992a

Biome:	**Grassland - Map 6**

Site:	**Bainsvlei** (BV)
Date:	Thought to be historic burials
Context of date:	
Average date:	
# of skeletons:	1
UCT #:	4942
Settlement pattern:	
Ceramics:	
Economy:	
Burials:	
Reference:	Morris 1993

Site:	**Buffelshoek** (BH)
Date:	early 19th century, probably occupied during the difaquane
Context of date:	Ethnographic/historical accounts
Average date:	1820 AD
# of skeletons:	1
UCT #:	4173
Settlement pattern:	Similar to Type Z pattern and Bambo Group 3 (Taylor 1979). Both represent 19th century phases of occupation.
Ceramics:	Moloko
Economy:	Fauna - predominantly cattle and ovicaprines,with a small hunted and snared assemblage; Cultigens - the presence of grindstones, iron implements and stone grain bins provude evidence for agriculture.
Burials:	
Reference:	Morris 1992a, Taylor 1979, Loubser 1988

Site:	**Frankfort** (FF)
Date:	Later Iron Age - post 1500
Context of date:	Settlement pattern
Average date:	
# of skeletons:	2
UCT #:	4938; 4939
Settlement pattern:	Type N
Ceramics:	
Economy:	
Burials:	Found near stone circles in old kraal
Reference:	Maggs 1976, Morris 1992a

Site:	**Heilbron** (HB)
Date:	1000 ± 60 BP
Context of date:	Radiocarbon date on skeleton
Average date:	960 AD
# of skeletons:	1
UCT #:	3686
Settlement pattern:	
Ceramics:	
Economy:	
Burials:	Possibly found near Willow Glen and Vegkop
Reference:	Laidler 1935, Morris 1992a, Lee-Thorp et al 1993.

Site: **Vechtkop** (VK)
Date: 1650 to 1850 AD
Context of date: Ethnography - Laideler believes the burial predates the midden and dates it to the late 17th century while van Riet Lowe, dates the settlement to circa the Leghoya migrations of 1787.
Average date: 1750 AD
# of skeletons: 1
UCT #: 4913
Settlement pattern: Type V pattern
Ceramics:
Economy: Cultigens - grindstones, stone crucibles and iron implements provide evidence for agriculture
Burials: Buried near stone wall settlement, flexed on LHS, facing East
Reference: Laidler 1935, Morris 1992a

Site: **Klipriviersberg** (KRB)
Date: 1723 ± 46 AD
Context of date: Radiocarbon date on ashheap
Average date: 1720 AD
# of skeletons: 1
UCT #: 4935
Settlement pattern: Type N
Ceramics: Moloko
Economy: Fauna - livestock contribute to 79% of the total meat contentof the diet, wild launs also make a considerable contibution to the diet; Cultigens - Iron implements and granary bases
Burials: Buried in ashheap, flexed on LHS, facing east, northeast
Reference: Mason 1986, Morris 1992a

Site: **Makgwareng** site 001 (MG)
Date: 140 ± 50; 140 ± 60; 230 ± 50
Context of date: Radiocarbon dates of dung layers
Average date:
# of skeletons: 2
UCT #: 3290; 3291
Settlement pattern: Type V
Ceramics: Similar to Buispoort and Moor Park
Economy: Fauna - domestic stock dominated the assemblage with some wild fauna; Cultigens - seed impression of sorghum and cucurbit,two handed grindstones.
Burials: 3690 - buried in a pit marked by a layer of stones in the stone enclosure, flexed upright, facing north/east; 3291 - buriedin cairn nest to enclosure, flexed on RHS facing west.
Reference: Maggs 1976, Morris 1992a, Lee-Thorp et al 1993.

Site: **Klip River Valley** (KRV)
Date: postdates AD 1495
Context of date: Radiocarbon date on underlying midden
Average date:
# of skeletons: 1
UCT #: 3693
Settlement pattern: Type N
Ceramics:
Economy: Fauna - dominated by domestic stock with some wild fauna present.
Burials: Unmarked grave, disturbed, flexed upright
Reference: Maggs 1976, Morris 1992a, Lee-Thorp et al 1993.

Site:	**Vrede** (VR)
Date:	Later Iron Age - post 1500 AD
Context of date:	Settlement pattern
Average date:	
# of skeletons:	1
UCT #:	4944
Settlement pattern:	
Ceramics:	
Economy:	
Burials:	Buried near corbelled huts, sitting in a pit with flat stones over the head.
Reference:	Morris 1992a

Site:	**Welgegund** (WL)
Date:	350 ± 40 BP (Pta 1316) ; 280 ± 50 BP (Pta 548)
Context of date:	Radiocarbon dates on skeletons
Average Date	1610; 1680
# of skeletons:	2
UCT #:	4167; 4946
Settlement pattern:	Stone wall enlcosure with disjointed sections of walling.
Ceramics:	Similar to Uitkomst
Economy:	Fauna - bone fragmentary, mainly bovid.
Burials:	4946 - buried inside stone circle in pit, flexed on LHS, facing north.
Reference:	Voight 1973, Morris 1992a, Lee-Thorp et al 1993.

Site:	**Wildebeestfontein** (WBF)
Date:	1865 ± 50 BP
Context of date:	Radiocarbon date on skeleton
Average date:	1865
# of skeletons:	1
UCT #:	4170
Settlement pattern:	Type V although there are differences
Ceramics:	Moloko
Economy:	Fauna - mostly livestock; Cultigens - grindstones found.
Burials:	Buried in a pit cut into the bedrock, flexed upright, facing south
Reference:	Taylor 1979 , Morris 1992a.

Site:	**Willow Glen** (WG)
Date:	1650 - 1850
Context of date:	Ethnographic evidence - same as Vechtkop
Average date:	1750
# of skeletons:	2
UCT #:	3687; 4918
Settlement pattern:	Similar to type V
Ceramics:	
Economy:	
Burials:	Buried in the midden of a stone wall site
Reference:	Laidler 1935, Morris 1992a, Lee-Thorp et al 1993.

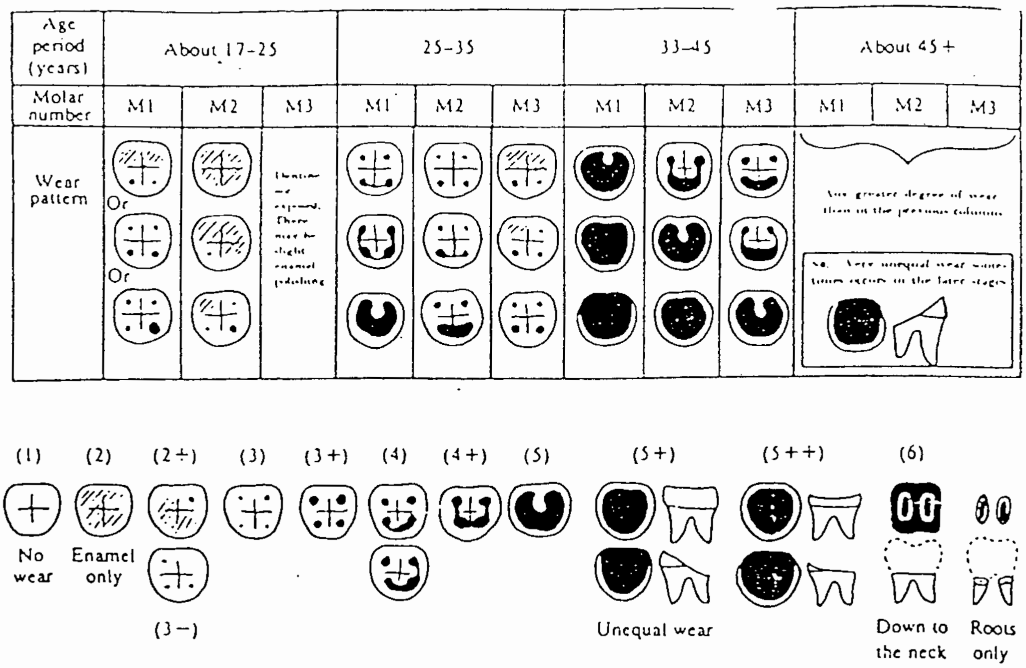
Sub-Biome:	**Natal grassland - Map 6**

Site:	**Kaybar's Cave** (KC)
Date:	early 19th century
Context of date:	Ethnography - the first Nguni people to occupy the foothills of the Drakensberg were the Amazizi, they moved there to escape confrontation.
Average date:	1820
# of skeletons:	2
UCT #:	4914; 4915;
Settlement pattern:	
Ceramics:	
Economy:	Cultigens - maize cobs and grinding stones recoverd from caves.
Burials:	Purposefull interments in caves in the Cathkin Park region, buried in graves lined with stone slabs and covered by a cobelled dome; 4915 - skull and hands found removed from body;
Reference:	Wells 1933, Morris 1992a

Site:	**Robinson's Shelter** (RS),
Date:	same as Kaybar's Cave
Context of date:	
Average date:	1820
# of skeletons:	2
UCT #:	4916; 4917;
Settlement pattern:	
Ceramics:	
Economy:	
Burials:	
Reference:	

Site:	**Yellowtree** (YT)
Date:	Same as Kaybar's Cave
Context of date:	
Average date:	1820
# of skeletons:	1
UCT #:	4162
Settlement pattern:	
Ceramics:	
Economy:	
Burials:	4162 - missing skull and mandible.
Reference:	

Appendix 5: Chart of wear patterns (Brothwell 1981)



Appendix 6: Example of the data sheet used in dental analysis

SPECIMEN NO. ____________

CATALOGUE NO. ______ ___ ______

DENTAL OBSERVATIONS

coding: CONDITION (1)absent (2)present (3)unerupted (4)erupting (5)socket resorbed (6)socket broken

WEAR (1)no wear (2)enamel only (3)slight wear (4)moderate wear (5)heavy wear (6)extreme wear

CARIES (1)interprox.slight (2)interprox. advanced (3)buccal slight (4)buccal advanced (5)lingual slight (6)lingual advanced (7)occlusal slight (8)occlusal advanced (9)none

Mandibular

	Condition	Wear	Caries
RL I_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RL I_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RL C	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RL P_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RL P_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RL M_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RL M_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RL M_3	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LL I_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LL I_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LL C	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LL P_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LL P_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LL M_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LL M_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LL M_3	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9

Maxillary

	Condition	Wear	Caries
RU I_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RU I_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RU C	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RU P_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RU P_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RU M_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RU M_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
RU M_3	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LU I_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LU I_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LU C	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LU P_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LU P_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LU M_1	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LU M_2	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9
LU M_3	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6 7 8 9

Appendix 7

UCT #	SITE	ABV	BM	xDATE	δ13C	δ15N	REF
3686	Heilbron	HL	G	10th	-11.0	10.6	JLT
4178	Bambandyanalo	K2	SD	11th	-10.1	9.0	JLT
4180	Bambandyanalo	K2	SD	11th	-10.7	11.2	JLT
4182	Bambandyanalo	K2	SD	11th	-12.5	10.1	JLT
4187	Bambandyanalo	K2	SD	11th	-9.1	11.5	JLT
4191	Bambandyanalo	K2	SD	11th	-8.9	11.6	JLT
4192	Bambandyanalo	K2	SD	11th	-11.0	11.1	JLT
4194	Bambandyanalo	K2	SD	11th	-10.7	11.2	JLT
4205	Bambandyanalo	K2	SD	11th	-11.5	11.7	JLT
4207	Bambandyanalo	K2	SD	11th	-12.6	10.1	JLT
4209	Bambandyanalo	K2	SD	11th	-9.4	12.9	JLT
4210	Bambandyanalo	K2	SD	11th	-8.8	12.9	JLT
4211	Bambandyanalo	K2	SD	11th	-8.9	11.8	JLT
4213	Bambandyanalo	K2	SD	11th	-10.8	11.6	JLT
3682	Skutwater	SK	SD	12th	-12.6	14.1	JLT
3683	Skutwater	SK	SD	12th	-10.7	14.4	JLT
3684	Skutwater	SK	SD	12th	-10.6	11.6	JLT
3685	Skutwater	SK	SD	12th	-11.3	13.1	JLT
4919	Ellerton Mine	EM	S	14th	-9.6	7.8	CG
4920	Ellerton Mine	EM	S	14th	-7.4	7.9	CG
4934	Oliphantspoort	OP	SW	15th	-9.4	7.9	CG
4922	Boshoff's Farm	BF	SW	16th	-6.0	9.2	CG
4924	Wellington Estates	WE	S	16th	-6.9	9.5	CG
4932	Ficus	FC	S	16th	-7.1	10.2	CG
4937	Magozastad	MS	SW	16th	-7.2	9.2	CG
3696	New Smitsdorp	NS	S	16th	-8.4	9.9	JLT
3709	Paardekraal	PK	SW	16th	-7.5	10.5	JLT
4171	Nylsvlei	NY	S	16th	-7.9	10.3	JLT
4165	Derdepoort	DP	SW	16th	-7.8	10.2	JLT
	Tauhatswana # 2	TV	S	16th	-7.8	8.3	SA
4946	Welgegund	WL	G	17th	-7.2	7.7	CG
4948	Rooikrans	RK	S	17th	-9.5	8.2	CG
4949	Rooikrans	RK	S	17th	-9.5	8.9	CG
4167	Welgegund	WL	G	17th	-8.1	10.2	JLT
4172	Bambo 9A	BM	S	17th	-7.9	10.2	JLT
3687	Willow Glen	WG	G	18th	-6.7	11.0	JLT
3713	Buispoort	BP	SW	18th	-6.8	9.1	JLT
4935	Klipriviersberg	KRB	G	18th	-7.6	8.8	CG
4913	Vechtkop	VK	G	18th	-6.5	9.6	CG
4918	Willow Glen	WG	G	18th	-5.9	8.3	CG
4926	Wellington Estates	WE	S	19th	-7.5	10.7	CG
4933	Oliphantspoort	OP	SW	19th	-7.2	10.5	CG
3710	Oliphantspoort	OP	SW	19th	-6.7	9.3	JLT
	Bambo 9C	BM	S	19th	-8.6	11.1	SA
	Maxonwa	MX	S	19th	-8.3	9.1	SA
4162	Yellowtree	YT	GN	19th	-10.7	8.5	CG
4170	Wildebeestfontein	WBF	G	19th	-6.8	9.7	CG
4173	Buffelshoek	BH	G	19th	-6.4	9.4	CG
4914	Kaybar's Cave	KC	GN	19th	-9.8	8.8	CG
4915	Kaybar's Cave	KC	GN	19th	-11.0	8.0	CG
4916	Robinson's shelter	RS	GN	19th	-11.6	7.5	CG
4917	Robinson's shelter	RS	GN	19th	-9.7	6.6	CG

Appendix 8:

UCT #	Site	ABV	BM	DATE	TL	EW	WX	I1	I2	C	P1	P2	M1	M2	M3	IP	B	L	O	A
4913	Vechtkop	VK	G	18th	-	1	3.3	-	-	-	-	-	-	-	1	-	1	-	-	-
4914	Kaybar's Cave	KC	GN	19th	-	-	2.6	-	-	-	1	-	-	-	1	-	1	1	-	-
4915	Kaybar's Cave	KC	GN	19th	2	-	3.0	-	-	1	-	-	-	-	-	-	1	-	-	-
4917	Robinson's shelter	RS	GN	19th	-	-	3.5	-	-	-	-	-	4	2	1	6	1	-	-	-
4920	Ellerton Mine	EM	S	14th	-	-	1.6	-	-	-	-	-	-	-	3	-	-	-	3	-
4922	Boshoff's Farm	BF	SW	16th	-	-	2.7	-	-	-	-	-	1	-	-	1	-	-	-	1
4924	Wellington Estates	WE	S	16th	1	-	3.1	-	-	-	-	-	1	-	1	-	-	-	-	-
4925	Wellington Estates	WE	S	LIA	-	-	1.7	-	-	-	-	-	-	1	2	-	-	-	3	-
4926	Wellington Estates	WE	S	19th	14	3	3.9	-	-	-	-	1	1	-	-	-	-	-	2	9
4928	Wellington Estates	WE	S	LIA	-	-	1.0	-	-	-	1	-	-	-	-	-	-	1	-	-
4932	Ficus	FC	S	16th	-	-	2.6	-	-	-	1	1	2	1	-	5	-	-	-	1
4933	Oliphantspoort	OP	SW	19th	4	-	3.6	1	-	-	2	1	1	-	1	2	-	1	3	4
4934	Oliphantspoort	OP	SW	15th	4	-	3.3	-	-	-	1	2	1	-	-	3	-	-	1	1
4938	Frankfort	FF	G	LIA	-	-	2.9	-	-	-	-	1	3	-	-	3	-	1	-	2
4939	Frankfort	FF	G	LIA	9	5	4.3	-	-	-	1	-	1	2	1	5	-	-	-	4
4940	Rustenburg	RB	SW	LIA	-	-	3.0	-	-	-	-	-	1	-	-	1	-	-	-	-
4942	Bainsvlei	BV	G	LIA	3	9	4.5	-	-	-	-	-	1	2	1	4	-	-	-	-
4944	Vrede	VR	G	LIA	-	-	2.6	-	-	-	-	-	1	2	1	4	-	-	-	-
4948	Rooikrans	RK	S	17th	-	-	3.0	-	-	-	-	-	-	1	-	-	-	1	-	-
4949	Rooikrans	RK	S	17th	7	-	4.0	-	-	-	-	-	-	-	2	2	-	-	-	-
3682	Skutwater	SK	SD	12th	8	5	3.6	-	1	-	-	-	-	-	2	-	-	-	3	1
3684	Skutwater	SK	SD	12th	7	5	4.3	-	-	-	-	-	1	1	2	4	-	-	-	2
3686	Heilbron	HL	G	10th	1	2	3.5	-	-	-	-	1	-	-	-	1	-	-	-	-
3691	Makwareng	MG	G	LIA	-	-	2.7	-	-	-	-	-	1	-	-	1	-	-	-	-
3696	New Smitsdorp	NS	S	16th	-	1	3.3	-	-	-	-	-	2	2	-	4	-	-	-	-
3704	Wellington Estate	WE	S	LIA	3	2	3.3	-	-	-	-	-	-	1	-	-	-	-	1	9
3705	Wellington Estate	WE	S	LIA	-	2	3.7	-	-	-	-	-	1	1	-	-	-	-	2	2
3710	Oliphantspoort	OP	SW	19th	1	4	3.6	-	-	2	1	2	2	1	1	3	3	-	4	4
4167	Welgegund	WL	G	17th	-	-	2.9	-	-	-	-	-	-	1	-	-	1	-	-	-
4172	Bambo 9A	BM	S	17th	1	-	1.6	-	-	-	-	-	1	2	1	3	1	-	-	-