

**HOLOCENE ENVIRONMENTAL CHANGES
DERIVED FROM A MONTANE POLLEN SEQUENCE
IN THE KWAZULU-NATAL MIDLANDS,
SOUTH AFRICA**

by
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Submitted in fulfilment of the academic requirements
for the degree of Master of Science in the Discipline of Geography
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April 2013



ABSTRACT

There is a limited understanding of the climatic history of summer rainfall regions of South Africa, especially the east coast, even though palaeo-research has become a popular technique used in southern Africa to determine past environmental and climatic changes. Sites such as wetlands and peatlands are ideal for palaeo-environmental research as they are of high organic content and enable pollen preservation. Dartmoor Vlei, situated at Mt. Gilboa, KwaZulu-Natal, is surrounded by Midlands Mistbelt grassland and in close proximity of the Karkloof Forest archipelago, rendering the site ideal for investigating grassland/forest dynamics. A minimally disturbed, 240 cm, organic rich sediment core was obtained from Dartmoor Vlei for analyses. A multi-proxy approach, *viz.* radiocarbon, charcoal, geochemical (carbon and nitrogen stable isotopes) and palynological analyses, was adopted to determine past environmental changes. Six samples were used for AMS radiocarbon dating, which indicates sediments date back *ca.* 12,200 cal yr BP at 144 cm. Environmental conditions at Dartmoor Vlei during the early Holocene are characterised by warmer, dry conditions, and arboreal pollen taxa are found in high concentrations between *ca.* 12,300 and 9000 cal yr BP. The mid-Holocene marks a period where systematic changes begin to occur at Dartmoor Vlei, as wetter conditions in accordance with the Holocene Altithermal are evident *ca.* 8000 cal yr BP. A period of locally drier conditions at *ca.* 6000 cal yr BP is followed by a decrease in arboreal taxa such as *Podocarpus*, Brassicaceae, Anacardiaceae and *Celtis* at *ca.* 5800 cal yr BP. The occurrence of *Zea mays* in the record at *ca.* 1600 cal yr BP, the increase in fire intensity and frequency, and subsequent decrease in some arboreal taxa is a robust indication of anthropogenic activity in the KwaZulu-Natal Midlands region, attributed to Iron Age settlers. Arboreal and grassland pollen signals indicate the existence of a mosaic of montane and sub-alpine grassland and montane forests in the region of Dartmoor Vlei throughout the Holocene, and at present.

PREFACE

The experimental work described in this dissertation was carried out in the School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg, from January 2010 to February 2013, under the supervision of Prof T.R. Hill and Dr J.M. Finch.

These studies represent original work by the author and have not otherwise been submitted in any form of degree or diploma to any University. Where use has been made of the work of others it is duly acknowledged in the text.



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ACKNOWLEDGEMENTS

To my supervisors, **Prof. Trevor Hill** and **Dr. Jemma Finch** a heartfelt thanks for sparking my interest in palaeo-research and for your time and continuous support, it is truly appreciated.

To my fellow pollen-man, **Jared Lodder**, for all your help and advice, you are a star, and to my friends, **Imke, Paul, Dom and Liandra**, who braved the great outdoors to help me with my fieldwork, you guys were amazing.

Thank you to the **Palaeontological Scientific Trust (PAST)** and the **SANBI Grasslands Programme** for the financial assistance which made this research possible.

To the **Electron Microscopy Unit (UKZN)** for the use of their facilities and the **Stable Light Isotope Laboratory (UCT)** for conducting the Stable Light Isotope Analysis. The **University of Waikato** and **Beta Analytic Laboratories** for conducting Radiocarbon Dating. To the **Grassland Science Department (UKZN)** for allowing me to use their laboratory facilities, and to the **Soil Science Department (UKZN)** for the use of their equipment. To **Astika Bhugeloo (UKZN)** for conducting charcoal counts. To **Desiree Lamoral** at the **Institute for Commercial Forestry Research Library** for her assistance with reference material. To **Colin Holmes, Victor Bangamwabo** and **Brice Gijsbertsen (UKZN)** for their assistance with GIS. To the **Van Zuydam family** of Dartmoor Vlei for allowing me to carry out the research on their property and allowing me access to the site.

And to family, thank you for your continuous support and encouragement throughout my work, without you this thesis would not have been possible.

TABLE OF CONTENTS

1. INTRODUCTION.....	1
1.1 Introduction.....	1
1.2 Aim and objectives.....	4
1.3 Thesis outline.....	5
2. REVIEW OF SOUTH AFRICAN PALAEO-ENVIRONMENTAL HISTORY.....	6
2.1 Drivers of climate change.....	6
2.2 The Holocene in South Africa.....	9
2.3 Conclusion.....	17
3. SITE DESCRIPTION.....	18
3.1 Introduction.....	18
3.2 Locality.....	19
3.2.1 Geology.....	20
3.2.2 Drainage.....	21
3.2.3 Land use.....	23
3.3 Indigenous forests and grasslands of South Africa.....	23
3.3.1 The forest biome.....	23
3.3.1.1 The Karkloof Forests.....	24
3.3.2 History of utilisation of indigenous forests in South Africa.....	27
3.3.2.1 Historical overview of human impacts on the Karkloof Catchment.....	28
3.3.3 The grassland biome.....	30
3.3.3.1 The Midlands Mistbelt Grasslands.....	31
4. THEORETICAL BACKGROUND.....	33
4.1 Introduction.....	33
4.2 Pollen analysis.....	33
4.2.1 General principles and limitations.....	34
4.2.2 Methodological considerations.....	36
4.2.2.1 Site selection.....	36

4.2.2.2 Field sampling.....	36
4.2.2.3 Laboratory processing.....	37
4.2.2.4 Counting.....	39
4.2.2.5 Data presentation.....	39
4.2.2.6 Palaeo-environmental reconstruction and interpretation.....	40
4.3 Charcoal analysis.....	40
4.4 Radiocarbon analysis.....	43
4.5 Troels-Smith sediment characterisation.....	45
4.6 Geochemical analysis.....	45
4.7 Conclusion.....	47
5. METHODS.....	48
5.1 Field techniques.....	48
5.1.1 Vegetation and pollen reference material.....	48
5.1.2 Vegetation survey.....	49
5.1.3 Core extraction.....	50
5.2 Laboratory techniques.....	51
5.2.1 Subsampling.....	52
5.2.2 Chronology.....	53
5.2.2.1 Radiocarbon dating.....	53
5.2.2.2 Time stratigraphic marker horizons.....	53
5.2.3 Stable light isotope analysis.....	54
5.2.4 Gravitational separation technique.....	54
5.2.5 Pollen counts.....	55
5.2.6 Pollen diagrams.....	55
6. RESULTS.....	57
6.1 Vegetation description.....	57
6.2 Troels-Smith stratigraphic description.....	58
6.3 Radiocarbon analysis.....	59
6.3.1 Age model.....	62

6.3.2 Sedimentation rates.....	63
6.4 Zonation of core material.....	63
6.5 Geochemical analysis.....	64
6.6 Pollen analysis.....	67
6.7 Charcoal analysis.....	72
7. DISCUSSION.....	75
7.1 Introduction.....	75
7.2 Palaeo-environmental changes at Dartmoor Vlei.....	75
7.2.1 Zone D1: 144-110 cm; <i>ca.</i> 12,100 - 9690 cal yr BP, Early Holocene.....	75
7.2.2 Zone D2: 110 - 83 cm; 9690 - 7970 cal yr BP, Mid-Holocene.....	77
7.2.3 Zone D3: 83 - 25 cm; 7970 - 550 cal yr BP, Late Holocene.....	78
7.2.4 Zone D4: 25 - 0 cm; 550 cal yr BP – present.....	80
8. CONCLUSION.....	82
8.1 Introduction.....	82
8.2 Review of aim and objectives.....	82
8.3 Synthesis.....	84
REFERENCES.....	88

LIST OF APPENDICES

Appendix A preparation procedure for reference material.....	i
Appendix B Characteristics of the modified Troels-Smith system of sediment description with original terms in brackets.....	iii
Appendix C Procedure for subsampling.....	iv
Appendix D Troels-Smith data sheets for sediment core DA2.....	v
Appendix E Swirling technique for pollen and charcoal extraction.....	vii
Appendix F Calibrated ages of individual samples.....	x
Appendix G Interpolated calibrated ages.....	xii
Appendix H Age-depth models.....	xv
Appendix I Vegetation survey – Dartmoor Vlei.....	xvii
Appendix J Geochemical data (UCT).....	xxviii
Appendix K Raw pollen count data.....	xxx i
Appendix L Pollen diagrams.....	xxxiv
Appendix M Raw charcoal data.....	xxxix
Appendix N Charcoal diagrams.....	xl
Appendix O Morphological, preservation and dispersal characteristics of major palynomorphs.....	xl iii
Appendix P Species list of Dartmoor Vlei.....	lxiv
Appendix Q Disclaimer.....	xciv

LIST OF FIGURES

Figure 2.1 Selected palynological sites in the summer rainfall region, South Africa.....	11
Figure 3.1 Location of Dartmoor Vlei, Mt Gilboa, KwaZulu-Natal in South Africa. Position of sediment cores (DA1; DA2) extracted from Dartmoor Vlei.....	20
Figure 3.2 Dartmoor Vlei topography and surrounding land uses.....	22
Figure 4.1: Radiocarbon decay curve.....	44
Figure 5.1 Location of Braun-Blanquet vegetation sampling quadrats in Dartmoor Vlei and immediate surroundings.....	50
Figure 5.3 Summary of analyses carried out on core DA2.....	52
Figure 6.1 Troels Smith stratigraphic description of core DA2, indicating cal yr BP.....	61
Figure 6.2 Calibrated linear interpolation age-depth model for Dartmoor Vlei	62
Figure 6.3 Zonation derived from CONISS, based on the regional pollen sum.....	64
Figure 6.4 Geochemical analysis	65
Figure 6.5 $\delta^{13}\text{C}$ versus C:N relationship	66
Figure 6.6 Regional pollen plotted against depth.....	69
Figure 6.7 Grassland and Indigenous forest taxa plotted against depth.....	70
Figure 6.8 Charcoal diagram for Dartmoor Vlei.....	73

LIST OF TABLES

Table 3.1: Landscape metrics describing indigenous forest patterns in the Karkloof-Balgowan region, KwaZulu-Natal, in 1944 and 1996.....	27
Table 4.1 Important variables to be considered when sampling peat deposits.....	36
Table 5.1: Conversion of Braun-Blanquet scale to % cover of individual species.....	48
Table 5.2 Radiocarbon dates.....	52
Table 6.1 Relative abundance of species recorded at Dartmoor Vlei.....	57
Table 6.2 Radiocarbon results for Dartmoor Vlei, indicating calibrated and uncalibrated ages.....	59
Table 6.3 Average sediment accumulation rates for Dartmoor Vlei.....	63
Table 6.4 Classification of taxa according to regional, local, arboreal and non-arboreal groupings.....	68
Table 8.1 Summary of key environmental changes which occurred at Dartmoor Vlei	85

LIST OF PLATES

Plate 3.1 Dartmoor Vlei, a valley bottom wetland surrounded by hill slopes.....	18
Plate 3.2 Dartmoor Vlei, surrounded by Midlands Mistbelt Grassland.....	19
Plate 3.3 Disused artificial drainage channels within Dartmoor Vlei.....	21
Plate 5.1 Examples of modern pollen reference slides: (a) <i>Eriocaulon dregei</i> (b) <i>Protea simplex</i> (c) <i>Acacia mearnsii</i> (d) <i>Podocarpus sp.</i>	48
Plate 5.2 Extraction of a sediment core at Dartmoor Vlei using a Russian peat corer.....	51
Plate 6.1 Sediment core DA2 extracted from Dartmoor Vlei.....	60

LIST OF ABBREVIATIONS

‰	Parts per million
$\delta^{13}\text{C}$	Ratio of ^{12}C / ^{13}C
^{12}C	Carbon-12 isotope
^{13}C	Carbon-13 isotope
^{14}C	Radiocarbon
$\delta^{15}\text{N}$	Ratio of ^{14}N / ^{15}N
^{14}N	Nitrogen-14 isotope
^{15}N	Nitrogen-15 isotope
AMS	Accelerated Mass Spectrometry
AP	Arboreal Pollen
BP	Before Present (starting at 1950)
C_3	Calvin-Benson metabolic carbon fixation pathway
C_4	Hatch-Slack metabolic carbon fixation pathway
<i>ca.</i>	Approximately
cal	Calibrated
CAM	Crassulacean acid metabolism
CLAM	Classic Age Modelling
CONISS	Constrained Incremental Sum of Squares
CO_2	Carbon dioxide
C/N	Carbon:Nitrogen ratio
DA2	Dartmoor Vlei, core number 2
IntCal	International Calibration curve
LGM	Last Glacial Maximum (23,000-18,000 cal yr BP)
m a.s.l.	Meters above sea level
NAP	Non-arboreal Pollen
SHCal	Southern Hemisphere Calibration curve
TN	Total Nitrogen
TOC	Total Organic Carbon
YD	Younger Dryas event (13,000-11,700 cal yr BP)
cal yr BP	Calibrated year before present
^{14}C yr BP	Uncalibrated ^{14}C dates

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

South Africa is described by Bamford and Grab (2005:1) as “a treasure trove for those whose mission it is to unlock the mysteries of the past environment”. A key to unlocking these mysteries lies in the understanding of past environmental conditions and the transformations associated with climatic change. Climate change is not a new phenomenon, but rather a continual process that has occurred throughout the history of the earth (Marchant, 2010). Interest in past climate change has grown considerably and as more palaeo-environmental data are collected, a clearer perspective on shifts in climatic conditions emerge (Zubakov and Borzenkova, 1990; Anderson *et al.*, 2007; Marchant, 2010). Uncertainties surrounding future climate shifts are tangible and justified, on both a global and regional scale (Zubakov and Borzenkova, 1990). Gaining perspective on climate predictions is achieved through: (i) observation of instrumental data collected over the past 100 years; (ii) the use of climate simulation models; and (iii) empirical reconstruction of past climates through hundreds or thousands of years. As information is gathered on past climates, an understanding of past environmental changes can be formulated at both a regional and international scale (Zubakov and Borzenkova, 1990). Thus, palaeo-environmental research has become a spatial and temporal tool for researchers from a multitude of disciplines to explore methods of palaeo-reconstruction through a diversity of proxies.

An array of proxies such as pollen, foraminifera, and diatoms are available to researchers in the field of palaeo-reconstruction (Birks, 1995; Burroughs, 2005; Anderson *et al.*, 2007). When direct evidence is lacking, proxies are used as a substitute measure of past environmental or climatic conditions (Anderson *et al.*, 2007). Depending on the location of the study site and the expected outcome of the research, a set of proxies can be selected to achieve the aim of the study. Palynology (pollen analysis) is one such technique available to palaeo-researchers, which provides a quantitative record of historical climate changes, and an effective tool for the reconstruction of vegetation transformation and response to shifting climatic conditions (Ortu *et al.*, 2006).

Palynology has become one of the most widely-used tools in vegetation reconstruction for long-term periods (Bunting, 2008). The primary aim is to study the morphology of modern and fossil pollen and spores, although the technique is applied in various fields of study: botany, archaeology, climatology and geology, and the interest in this tool has grown and evolved considerably (Traverse, 1999). The nature of pollen grains is such that they are easily dispersed and preserved due to their size and decay-resistant sporopollenin outer wall, respectively. Under anaerobic conditions, pollen grains may be preserved for hundreds or thousands of years, allowing for extraction, processing and interpretation of pollen signals in a sediment core (Bunting, 2008). Through the use of multi-proxy analyses, independent lines of evidence can be used to formulate an understanding of past environmental and climatic conditions (Eeley *et al.*, 1999; Duffin, 2008; Castañeda *et al.*, 2009).

Understanding natural variability and responses to environmental change, and how people and ecosystems have responded and adapted to change is vital (Marchant, 2010). Human activity has resulted in the transformation of ecosystems and the distribution of the earth's vegetation to varying degrees across the globe. However, the respective importance of humans and environmental factors is controversial when interpreting the distribution of vegetation patterns in the montane regions of Africa (Meadows and Linder, 1993). Some argue that current afro-montane grasslands exist as a result of recent anthropogenic forest clearing, while others contend that these grasslands have historically been a component of montane vegetation (Meadows and Linder, 1993).

Long-term history in southern Africa has shown changes in vegetation due to anthropogenic activities such as burning and vegetation clearing, even in the most remote regions of the continent. Chapman and White (1970) suggest that Afromontane grasslands originated, and expanded, due to anthropogenic impacts. These changes in vegetation, for example clearance of forests and increase in grasslands, have been attributed to the role and impacts of humans in the environment (Chapman and White, 1970; Meadows and Linder, 1993). Bredenkamp *et al.* (2002) attributes the distribution of grasslands to climatic changes during the Oligocene, and suggests that the current distribution of grasslands in southern Africa does not differ greatly in extent to the Holocene. Anthropogenic impacts such as agriculture and forest clearing did not affect the historical distribution of current grasslands, at least not until the

late Holocene (Bredenkamp, 2002). The nature and extent of these changes are worthy of research to appropriately manage these environments (Hamilton, 1981; Meadows *et al.*, 1987). An understanding of such environmental history, particularly in a region with such high diversity of flora and fauna, would be valuable in formulating conservation and management policies (Hamilton, 1981), particularly in regions such as the KwaZulu-Natal Midlands where a complex mosaic exists between the Midlands Mistbelt Grassland, the Karkloof forest, and human inhabitants.

In South Africa, information related to environmental changes has been constrained by a lack of researchers and funding and environmental limitations in terms of recovery of palaeo-environmental data (Chase and Meadows, 2007). Lake and peat sediments provide natural archives which are most likely to provide suitable pollen samples for analysis and inference of past conditions (Anderson *et al.*, 2006), however South Africa is predominantly an arid region, and therefore environmental conditions are seldom suitable for pollen preservation (Coetzee and van Zinderen Bakker, 1970; Nyakale and Scott, 2002). While southern African palaeo-records require extensive investigation, various studies conducted across the region have provided a growing collection of palaeo-ecological data. However, the KwaZulu-Natal Midlands region remains an area where minimal palaeo-ecological data are available. Although no empirical evidence exists to support the notion, Everard (1985) suggests that *Podocarpus* forest patches in the Natal Drakensberg were more extensive in the past. Due to changing environmental conditions and increase in fire frequency due to human intervention, the forest patches have significantly reduced and grasslands have expanded (Meadows and Linder, 1993). In the KwaZulu-Natal Midlands (Eeley *et al.*, 1999), the Midlands Mistbelt grasslands and forest are similarly under threat of degradation, highlighting the need for more research of historical change to be carried out in the region.

Dartmoor Vlei is a high altitude wetland situated near Mt. Gilboa in the KwaZulu-Natal Midlands, South Africa, and has potential to address the knowledge gap of palaeo-environmental history of the KwaZulu-Natal Midlands region. The area falls within a summer rainfall region (Begg, 1989), and the wetland is characterised by permanently waterlogged conditions and peat deposits (Edwards, 2009). The KwaZulu-Natal Midlands are characterised by a mosaic of Southern Mistbelt Forests and Midlands Mistbelt Grasslands

(Mucina and Rutherford, 2006), two vegetation units which are considered vulnerable (Scott-Shaw, 1999). Unaltered natural grassland surrounds the wetland, although commercial forestry plantations and annual crops are grown in the surrounds, and one of the largest indigenous forests remnants in KwaZulu-Natal, the Karkloof forest, is situated nearby (Rycroft, 1994), rendering Dartmoor Vlei an ideal site for grassland and forest investigation through palaeo-environmental research.

Across southern Africa, further analytical research is required to further our understanding of past environmental conditions (Scott, 1993). With the possibility of major environmental and climatic changes predicted for the near future, an understanding of the effect of past climatic conditions will provide a benchmark understanding of natural variability (Scott, 1993; Anderson *et al.*, 2006) and assist in formulating long-term management strategies for vulnerable natural resources (Willis and Birks, 2006; Watrin *et al.*, 2007; Bunting, 2008). The research presented in this thesis aims to provide just such an understanding of Holocene environmental conditions of the KwaZulu-Natal Midlands, using a sediment core extracted from Dartmoor Vlei.

1.2 AIM AND OBJECTIVES

To investigate Holocene palaeo-environmental change in the KwaZulu-Natal Midlands by applying multi-proxy analyses, *viz.* fossil pollen, charcoal, carbon and nitrogen isotope analyses, to a sedimentary record from Dartmoor Vlei, Mt. Gilboa. This will be achieved through the following objectives:

- (i) To survey, map and develop an inventory of the modern vegetation of the wetland and immediate surrounds;
- (ii) To develop a local modern pollen reference collection, as an aid to fossil pollen identification;
- (iii) To identify suitable coring locations and extract a series of minimally disturbed sediment cores from the wetland;

- (iv) To select samples from basal and intermediate sections of a selected core for AMS radiocarbon analysis to establish chronological control for the core; and create an age-depth model;
- (v) To identify and quantify fossil pollen along the length of the core to detect local and regional vegetation changes;
- (vi) To conduct geochemical (C and N isotope) analyses along the length of the core to detect changes in the relative proportion of C₃ and C₄, and aquatic and land plants inhabiting the wetland site;
- (vii) To reconstruct past Holocene environmental history of the KwaZulu-Natal Midlands.

1.3 THESIS OUTLINE

The aim of the introduction chapter is to familiarise the reader with the purpose, and importance of the research undertaken in the palaeo-environmental field. This chapter presents an outline of the aim and objectives of the research, and research approaches adopted in the study. A review of South African palaeo-environmental history is summarised in Chapter Two. To provide details of Dartmoor Vlei and insight into the background and surroundings of the Mt Gilboa region, an overview of the Karkloof forest and Midlands Mistbelt grasslands are provided in Chapter Three. Chapter Four provides a theoretical background to the methodologies adopted in the field of palaeo-research, and describes the methods used in pollen, charcoal, geochemical and radiocarbon analysis. Chapter Five describes the research methods, and Chapter Six depicts and describes the results. Chapter Seven provides a discussion and reconstruction of the palaeo-environmental conditions of the Mt. Gilboa region, as inferred from the results of the multi-proxy analysis conducted. In conclusion, the final chapter provides a synthesis of the palaeo-environmental changes at Mt Gilboa, KwaZulu-Natal Midlands.

CHAPTER TWO

REVIEW OF SOUTH AFRICAN PALAEO-ENVIRONMENTAL HISTORY

2.1 DRIVERS OF CLIMATE CHANGE

An understanding of drivers of climate change is valuable in interpreting historical climatic changes, as inherent curiosity not only leads us to question the extent of changes which occurred, but also the reasons behind such change. During the time which humans have inhabited the earth, there have been numerous environmental changes taking place at variable intensities (Anderson *et al.*, 2007) and timescales (Nash and Meadows, 2012), such as: climatic changes; sea level change; shifts in vegetation belts; animal populations; and soils and landforms (Anderson *et al.*, 2007). The causes of climate change have been hypothesised, although criticisms surrounding many major hypotheses remain. The main hypotheses relate to solar radiation; atmospheric transparency; the earth's geometry (orbital forcing, Milankovitch Cycles); changes in terrestrial geography; greenhouse gases and the feedback hypothesis. Detailed reviews of the drivers of climate change are provided by Goudie (1992), Burroughs (2005), Anderson *et al.* (2007) and Nash and Meadows (2012), and will be briefly discussed.

The theory of astronomical fluctuations was first introduced by Adhemar in 1842, and further developed by Croll and Milankovitch in the 1860s and 1920s respectively. The Croll-Milankovitch Cycle, or orbital forcing, is based on the notion that if the location and arrangement of the earth in relation to the sun was to change, then so might insolation from the sun. Three factors occurring at various timeframes have been identified to explain the occurrence of such change: a change in the eccentricity of the earth's orbital path (100,000 year cycle); the precession of the equinoxes (19-23,000 year cycle); and obliquity (41,000 year cycle), changes in the angle between the plane of the earth's orbit and the plane of its rotational equator (Goudie, 1992; Ruddiman, 2003; Anderson *et al.*, 2007; Nash and Meadows, 2012). Glacial periods are interrupted by interglacial periods when these three factors combine to maximise solar energy received during summer in the northern hemisphere, resulting in winter-snow melting. Similarly, when orbital parameters are such as the amount of solar energy is reduced, summer in the northern hemisphere is cooler resulting in less snow melting, thus allowing glaciers to expand (Goudie, 1992; Anderson *et al.*, 2007).

Climatic cycles have been greatly influenced by changes in solar radiation output, which changes in both quantity (as a result of phenomenon such as sunspots) and quality (changes in the ultraviolet range of the solar spectrum). Although criticised, the role of solar activity has been correlated with major characteristics of general atmospheric circulation (Goudie, 1992; Anderson *et al.*, 2007).

The effect of incoming solar radiation may be lessened by changes in atmospheric composition, for example volcanic dust, as backscattering is increased. Volcanic dust in the atmosphere may promote the formation of ice-crystals where atmospheric conditions are below freezing and air is saturated, and the presence of sulphur dioxide may result in acid droplets forming, thus reducing insolation. These factors are responsible for reduced atmospheric temperatures as less solar radiation is able to reach the earth's surface (Goudie, 1992; Anderson *et al.*, 2007). Although large volcanic activity is not a regular occurrence, the cooler climate of the Little Ice Age which followed the Medieval Warm Period, has been linked to volcanic activity between 600 and 1300 AD, and 1400 and 1985 AD (Anderson *et al.*, 2007) and cold, wet summers in Britain can be attributed to high volcanic dust concentrations in the atmosphere in (inter alia) 1695, 1725, 1816, 1879, 1903 and 1912 (Goudie, 1992; Anderson *et al.*, 2007). Further sources of high levels of dust in the atmosphere may be a result of elevated wind activity increasing surface material emplaced in the atmosphere, or from an influx of dust from outer space (Anderson *et al.*, 2007).

Although change in terrestrial geography would be considered long-term change, changes in the polar axis, and shifts in the position and uplift of continents, may be responsible for climatic changes in some parts of the world (Goudie, 1992; Anderson *et al.*, 2007). Considering extensive time periods, it may be possible that over thousands of years continental uplift will increase altitudes by several meters. As a result, marked temperature decrease at the summit and change in precipitation may be experienced (Goudie, 1992; Anderson *et al.*, 2007).

Ocean circulation can also be a driver of climate change, and may be due to natural or anthropogenic impacts. The Gulf Stream and the North Atlantic Drift currents are responsible for carrying warm, saline surface water from the oceans of the Gulf of Mexico to

Greenland, Iceland and Norway. As these waters move northwards, they cool, and sink due to an increase in density. This 'pull' action maintains the movement of the warm Gulf Stream, and is responsible for keeping winters in the British Isles milder than expected at such latitudes (Goudie, 1992; Burroughs, 2005; Anderson *et al.*, 2007). However, studies have shown that if an increase in freshwater were to occur (e.g. due to melting icecaps or from fresh water inland lakes) in the Arctic Sea, the deep-water production of the North Atlantic would cease. As the 'Atlantic Conveyor' system is disrupted by the dilution of this dense, saline ocean water, icecaps may form and prevent the circulation of the Gulf Stream (Goudie, 1992; Burroughs, 2005; Anderson *et al.*, 2007).

Atmospheric carbon dioxide (CO₂) levels have an effect on the global heat balance, as CO₂ does not impact on isolation but absorbs outgoing terrestrial radiation (Goudie, 1992; Anderson *et al.*, 2007; Nash and Meadows, 2012). As a result, heat cannot escape the atmosphere into space, causing temperatures to rise, a phenomenon known as the greenhouse-effect. Similarly, low levels of global CO₂ leads to climatic cooling, as indicated by analyses of CO₂ concentrations in bubbles trapped in ice cores (Goudie, 1992; Anderson *et al.*, 2007). Such analysis has shown a definitive correlation between climatic change and CO₂ concentrations in the atmosphere over the last 16 000 years, where glacial periods indicate low CO₂ levels and interglacial periods indicate high CO₂ levels (Goudie, 1992; Anderson *et al.*, 2007). Greenhouse gas concentrations are enhanced by anthropogenic activities, and it has been hypothesised that humans began altering greenhouse gas concentrations in the late-Holocene through agricultural practices (Vavrus *et al.*, 2008).

Minor environmental changes in landmasses, oceans, the atmosphere and ice may have a dramatic effect on climatic shifts (Goudie, 1992; Anderson *et al.*, 2007). Termed the 'feedback' hypothesis, it is suggested that these processes produce a larger or lesser climatic response than would have arisen without their involvement (Williams *et al.*, 1998). Factors such as albedo controls the extent to which insolation is reflected or absorbed, depending on conditions on the earth's surface, for example, dark volcanic ash will absorb insolation, whereas icecaps will reflect insolation. If such conditions persist over an extended period of time, it may result in regional or global climatic shifts (Goudie, 1992; Williams *et al.*, 1998; Anderson *et al.*, 2007).

Almost all changes in climate can be explained through natural variability in the global weather system, both on short timescales and over millennia. Occasionally, various components of climate systems may interact to produce major fluctuations (Burroughs, 2005). There has been hypothesised that current global warming as a result of anthropogenic activities may “push the climate into a more erratic mode” (Burroughs, 2005: 69), as an increase in average global temperatures since the mid-20th century can most likely be attributed to increased anthropogenic greenhouse gas concentrations (IPCC, 2007). Understanding the nature of past and present environmental change and drivers of climate change is vital in forming an understanding of challenges relating to climate change (Williams *et al.*, 1998; Burroughs, 2005). Holocene environmental research provides a unique historical perspective essential to long-term management (Williams *et al.*, 1998).

2.2 THE HOLOCENE IN SOUTH AFRICA

Historically, southern Africa lacked detailed data which could be used for palaeo-environmental reconstruction and a need for suitable deposits and pollen sequences hindered advancement in vegetation reconstruction for the region (Scott, 1984; Avery, 1993; Meadows, 2001). However, in recent years, palaeo-environmental research has progressed with researchers in various disciplines producing a growing number of datasets (Avery, 1993) through the use of alternate methods in palaeo-reconstruction, such as hyrax-middens, dendrochronology and speleothems (Goudie, 1992; Burroughs, 2005). With a growing body of knowledge and methods, it is important to establish a basis for comparison of various sites. For example, at Cold Air Cave in the Makapansgat Valley, a *ca.* 25,000 year old high resolution stalagmite record with excellent chronological control (particularly during the Holocene) has provided a basis for comparison of records for southern Africa (Holmgren *et al.*, 2003).

The transition from the glacial conditions of the Pleistocene to the warmer conditions of the Holocene is described by Abell and Plug (2000: 1) as “far from smooth”, and the climatic changes within the Holocene period do not differ greatly from this description. The Holocene is a time period during which many cultural and environmental changes had taken place (Roberts, 1998), and is generally understood to cover the last 11,500 years (Chase and Meadows, 2007). The Holocene can be divided into two broad time periods: the early

Holocene (*ca.* 11,700 to *ca.* 6000 cal yr BP) and late-Holocene (*ca.* 6000 cal yr BP to present). Holocene records suggest that climatic conditions in South Africa show a considerable variation between *ca.* 13,600 and 6100 cal yr BP (11,850 and 5400 ^{14}C yr BP; Scott *et al.*, 2005). The warmest period in the Holocene is represented by the Holocene Altithermal, broadly accepted to be approximately 8000 – 4000 cal yr BP although regional variability does occur (Chase and Meadows, 2007). Biological evidence indicates that the eastern region of South Africa experienced maximum warming between *ca.* 8800 and 5700 cal yr BP (8000 and 5000 ^{14}C yr BP; Partridge *et al.*, 1990), which is concordant with the Holocene Altithermal. A summary of the comparisons from multiple sites drawn from Holmgren *et al.* (2003) is provided. Due to the location of Dartmoor Vlei in the KwaZulu-Natal Midlands region, emphasis is placed on records from the summer rainfall region of South Africa.

At *ca.* 23,000 – 21,000, 19,500 – 17,500 and 15,000 – 13,500 $^{230}\text{Th}/^{234}\text{U}$ yr BP (calendar years before 2000 AD), $\delta^{18}\text{O}$ records indicate conditions were drier, temperatures lower and grass cover reduce in South Africa (Holmgren *et al.*, 2003). Records from Cold Air Cave (speleothem $\delta^{18}\text{O}$) and Wonderkrater (pollen-derived) show a period of rapid warming after a cold event at 17,500 $^{230}\text{Th}/^{234}\text{U}$ BP (before 2000 AD), cooling again at 15,000 $^{230}\text{Th}/^{234}\text{U}$ yr BP and warming at 13,500 $^{230}\text{Th}/^{234}\text{U}$ yr BP (before 2000 AD). A period of maximum cooling occurred at 17,500 $^{230}\text{Th}/^{234}\text{U}$ yr BP, indicating cool, dry conditions at this time (Holmgren *et al.*, 2003). The Wonderkrater pollen record indicates evaporative conditions, although not necessarily low rainfall, between 12,000 and 10,000 $^{230}\text{Th}/^{234}\text{U}$ yr BP (before 2000 AD), and both Cold Air Cave and Wonderkrater records indicate warm conditions between 10,000 and 6000 $^{230}\text{Th}/^{234}\text{U}$ yr BP (before 2000 AD). This period of warming precedes the generally acknowledged Holocene Altithermal timing in southern Africa by *ca.* 2000 $^{230}\text{Th}/^{234}\text{U}$ yr BP. At 9000 – 8400 $^{230}\text{Th}/^{234}\text{U}$ yr BP, $\delta^{13}\text{C}$ records at Cold Air Cave reaches its lowest point, indicating an abundance of C_3 woody vegetation and a sharp reduction in C_4 grass cover. After 8500 $^{230}\text{Th}/^{234}\text{U}$ yr BP, the Cold Air Cave record indicates an increase in grass cover, while conditions at Wonderkrater suggest dry, grassy vegetation (Holmgren *et al.*, 2003). A cool period is recorded at Cold Air Cave and Wonderkrater between 6000 and 3000 $^{230}\text{Th}/^{234}\text{U}$ yr BP, when conditions were predominantly dry, followed by cool, grassy environments between 3000 and 2000 $^{230}\text{Th}/^{234}\text{U}$ yr BP and warm wet conditions between 1200 and 600 ^{14}C yr BP (Holmgren *et al.*, 2003).

The Wonderkrater pollen record provides evidence of increasing temperatures at *ca.* 15,500 cal yr BP (13,000 yr BP; Scott *et al.*, 2003), however an increase in *Podocarpus* forests during the same period is interpreted as an indication of moist, cool conditions at Mfabeni (Finch and Hill, 2008). The Cathedral Peak pollen record indicates regionally cool, dry conditions at 15,490 cal yr BP, as indicated by the presence of *Amaranthaceae*, *Ericaceae* and *Tubiflorae*. Dominance of local pollen taxa in the record suggests that wetland vegetation was supported (Lodder, 2010). An increase in *Amaranthaceae* and *Chenopodiaceae* at Wonderkrater at *ca.* 14,900 cal yr BP (12,700 ^{14}C yr BP) suggests slightly cooler but evaporative conditions, although Scott *et al.* (2003) indicate drier conditions at the site at the Pleistocene/Holocene boundary.

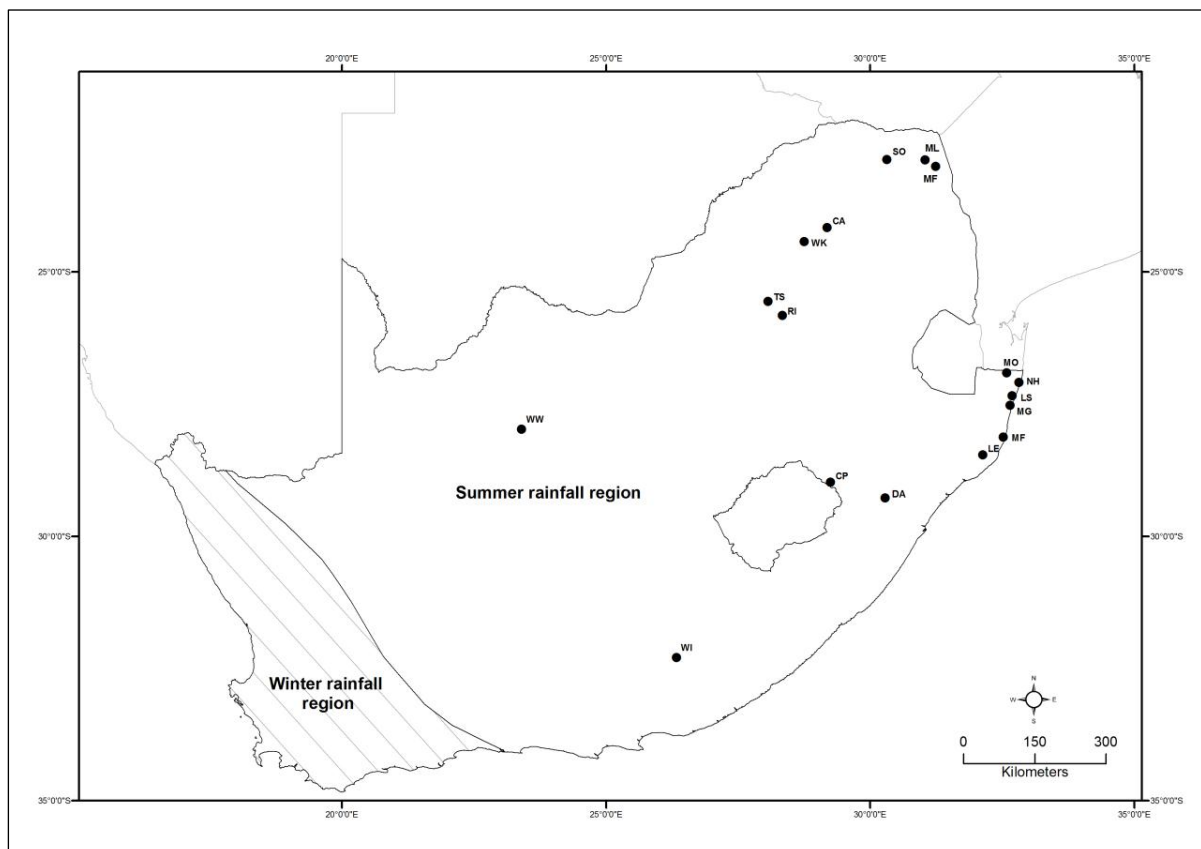


Figure 2.1 Selected palynological sites in the summer rainfall region, South Africa

(Cathedral Peak: CP; Cold Air Cave: CA; Dartmoor Vlei: DA; Lake Eteza: LE; Lake Sibaya: LS; Mfabeni: MF; Mafayeni: MF; Malahlapanga: ML; Mgobezeleni: MG; Muzi-Oos: MO; Nhlangu: NH; Rietvlei Dam: RI; Soutpansberg: SO; Tswaing: TS; Winterberg: WI; Wonderkrater: WK; Wonderwerk: WW). *Rainfall regions adapted from Finch *et al.*, 2003

During the early Holocene there is a period of warm, dry climatic conditions (Scott, 1990; Partridge *et al.*, 1990), with more mesic types of woodland than evident during the late Pleistocene (Scott, 1982b) resulting in expansion of warm, semi-arid savannah. This is supported by evidence from the Soutpansberg, which records an increase in savanna vegetation at *ca.* 12,800 cal yr BP (11,000 ^{14}C yr BP; Scott, 1987). Meadows *et al.* (1987) indicate that although no marked changes occur in the Winterberg, cooler and possibly drier conditions prevail from *ca.* 14,600 cal yr BP (12,500 ^{14}C yr BP) into the early Holocene.

Grundling *et al.* (1998) conducted preliminary palynological investigations of major pollen taxa at Mfabeni (east-coast of South Africa), although the main focus of the work was relating to peat accumulation rates. The pollen record from Mfabeni peatland shows an expansion in hydromorphous forest, as indicated by an increase in *Podocarpus*, *Olea*, *Syzigium*, *Myrica* and *Celtis* at *ca.* 13,400 cal yr BP (11,570 ^{14}C yr BP). Contrasting records from Rietvlei Dam from 11,490 - 7730 cal yr BP indicate low arboreal and local pollen concentrations, indicating grasslands dominated the period under cool, temperate, dry, sub-humid conditions (Scott and Vogel, 1983). These conditions are supported at Wonderkrater where arboreal pollen (including *Podocarpus*) decreases, indicating a reduction in arboreal vegetation (Scott, 1982c). At Lake Eteza (east-coast of South Africa), arboreal pollen frequencies decrease in the region at *ca.* 10,500 cal yr BP (Neumann *et al.*, 2010). A period of noticeable warming is recorded in the Winterberg at *ca.* 10,000 cal yr BP (Scott *et al.*, 1995) and observed at Wonderkrater 700 years later, where a reduction in swamp vegetation and *Podocarpus* were observed (Scott, 1982c).

After *ca.* 10,700 cal yr BP (9500 ^{14}C yr BP), warmer conditions are indicated at Wonderkrater as proportions of Asteraceae and Combretaceae increase after *ca.* 10,700 cal yr BP (9500 ^{14}C yr BP), and Poaceae rapidly increases at *ca.* 9500 cal yr BP (8500 ^{14}C yr BP). (Scott and Vogel, 1978). However, Partridge *et al.* (1990) report a brief period of cooling between *ca.* 10,100 and 8800 cal yr BP (9000 and 8000 ^{14}C yr BP) at Lake Eteza. Tswaing (Gauteng) records indicate similar dry, moderately warm conditions at *ca.* 8800 cal yr BP (8000 ^{14}C yr BP), however this is followed by warm but wetter conditions at about *ca.* 7800 cal yr BP (7000 ^{14}C yr BP; Partridge *et al.*, 1993). Similarly, conditions at Winterberg remained dry until 8000 cal yr BP, as indicated by Asteraceae, Chenopodiaceae and Thymelaeaceae, however an increase in wetter conditions is indicated by Cyperaceae, an

indicator of more water-logged conditions (Meadows and Meadows, 1988). After 8000 cal yr BP, low concentrations of montane forest taxa appeared, and taxa associated with drier conditions decreased in the Winterberg pollen record, an indication of more moist conditions (Meadows and Meadows, 1988), followed by warmer conditions in the Transvaal Highveld after 7400 cal yr BP (Scott and Vogel, 1983). Records from Wonderkrater indicate a similar trend (Scott, 1982c).

Wetter conditions at Lake Eteza are indicated by high percentages of arboreal pollen and fern spores, and a higher water table is inferred until *ca.* 8500 cal yr BP. Poaceae frequencies increase at Lake Eteza between *ca.* 8000 and 7000 cal yr BP indicating grassy conditions, followed by a decrease at *ca.* 6800 cal yr BP (Neumann *et al.*, 2010). Similar conditions are experienced at Mfabeni, where an initial increase in grassland in the early Holocene is followed by the reestablishment of *Podocarpus*-abundant forests after *ca.* 8300 cal yr BP (7500 ¹⁴C yr BP; Finch and Hill, 2008). An increase in abundance and diversity of arboreal pollen taxa is recorded between *ca.* 8300 and 6800 cal yr BP (7500 and 6000 ¹⁴C yr BP) followed by a sharp decrease in arboreal pollen after *ca.* 6800 cal yr BP (6000 ¹⁴C yr BP). Cyperaceae decrease at this time, indicating local drying at Mfabeni (Finch and Hill, 2008). The pollen record from Lake Sibaya (Neumann *et al.*, 2008) is concordant with Mfabeni, with a high percentage of forest pollen taxa and relatively low Poaceae and herb percentages during the mid-Holocene.

Records from the former Transvaal show a similar period of increasing temperatures during the mid-Holocene between *ca.* 7800 and 6800 cal yr BP (7000 and 6000 ¹⁴C yr BP; Scott, 1990). The Wonderkrater pollen record provides evidence of warm, dry climatic conditions during the early Holocene, and wet and warm conditions during the mid-Holocene, which corresponds with records from sites in the former Transvaal (Scott, 1990).

Although mid-Holocene generally indicates warm, wet conditions, the late Holocene is characterised by cooler conditions (Scott, 1990) where semi-arid savannah is replaced by more broad-leafed woodland in the Transvaal (Scott, 1983). The Soutpansberg record, however, indicates that minimal environmental change has occurred since the mid-Holocene (Scott, 1982d). The Wonderkrater record indicates broad-leaf bushveld vegetation at *ca.*

6800 cal yr BP (6000 ^{14}C yr BP) which is associated with wetter conditions (Scott, 1982c), followed by a cooling trend from *ca.* 6800 cal yr BP (6000 ^{14}C yr BP) to the present (Scott *et al.*, 2003). The Lake Eteza pollen record shows a decrease in Poaceae percentages and an increase in arboreal pollen taxa at *ca.* 6500 cal yr BP (Neumann *et al.*, 2010). At 6500-6300 cal yr BP, Rosaceae and *Podocarpus* signals occur in high concentrations at Cathedral Peak, a possible indication of moist conditions. At 6200 cal yr BP, Rosaceae and *Podocarpus* signals are absent from the Cathedral Peak record, in spite of expectation that moist conditions are generally suited to montane forest expansion (Lodder, 2010). Locally, conditions at Cathedral Peak suggest that moisture levels decreased, thus becoming slightly drier between 6200 and 5760 cal yr BP (Lodder, 2010).

Mazus (1996) found that the record from Nhlangu (east-coast of South Africa) shows hydromorphous forests dominated by *Myrica* and *Syzygium*, followed by an increase in *Podocarpus* pollen and then a retreat in forest components from *ca.* 5800 cal yr BP (5100 ^{14}C yr BP). Similar trends are found by Grundling *et al.* (1998) at Mfabeni in the mid-Holocene. After *ca.* 6300 cal yr BP (5600 ^{14}C yr BP), an expansion on forests is recorded at Mfabeni as arboreal pollen increases (Finch and Hill, 2008), a trend paralleled by the Lake Eteza record (Neumann *et al.*, 2010) which indicates a peak in forest taxa at *ca.* 5500 cal yr BP. At 5700 cal yr BP, Gillson and Ekblom (2009) suggest that vegetation at Malahlapanga (Kruger National Park) was dominated by open grassland, where fire was rare or absent.

Arboreal pollen further increases at *ca.* 4500 ^{14}C yr BP, and with continuing cool, wet conditions at *ca.* 4400 cal yr BP (4000 ^{14}C yr BP) at Mfabeni (Finch and Hill, 2008). Conditions at Wonderwerk become cooler and wetter at *ca.* 4400 cal yr BP (4000 ^{14}C yr BP; Scott 1982c). Wonderkrater and Tswaing records suggest low temperatures and dry conditions at *ca.* 3100 cal yr BP (3000 ^{14}C yr BP; Scott *et al.*, 2003 and Scott 1990). The decrease in *Podocarpus* pollen at Muzi-Oos at *ca.* 4700 cal yr BP (4200 ^{14}C yr BP; Grundling *et al.*, 1998) and at Lake Eteza after *ca.* 5600 cal yr BP (3400 ^{14}C yr BP; Scott and Steenkamp, 1996) indicates a tendency towards drier conditions. Cooler, more temperate conditions are experienced at Wonderkrater between 4030 - 2090 cal yr BP, as indicated by the decrease in arboreal pollen in the record (Scott, 1982c).

At Lake Eteza, *Podocarpus* percentages reaches a maximum of >30% at 3700 cal yr BP, signalling moist subtropical conditions, although a rapid drop to approximately 8% is recorded at *ca.* 3500 cal yr BP. The decline in *Podocarpus* is accompanied by a decline in other forest elements (Neumann *et al.*, 2010). A decrease in forests at Mfabeni is recorded after *ca.* 3700 cal yr BP (3500 ¹⁴C yr BP; Finch and Hill, 2008), supported by records from Mfabeni by Grundling *et al.* (1998), from Nhlangu by Mazus (1996) and from Lake Eteza by Scott and Steenkamp (1996). *Podocarpus* concentrations peak at 3960 cal yr BP at Cathedral Peak, an indication of moist conditions (Lodder, 2010). The Transvaal shows slightly lower temperatures at *ca.* 3100 cal yr BP (3000 ¹⁴C yr BP; Scott, 1990). The Lake Eteza record indicates high percentages of Poaceae and Asteraceae, and low percentages of arboreal taxa, representing a relatively dry grassy environment between *ca.* 3600 and 2000 cal yr BP (Neumann *et al.*, 2010).

At *ca.* 1900 cal yr BP (2000 yr BP) conditions become warmer and drier (Scott and Vogel, 1978 and Scott, 1982c), and *ca.* 1300 cal yr BP (1500 ¹⁴C yr BP) record at Soutpansberg indicate a sharp decline in arboreal pollen taxa (Scott, 1987). The Wonderkrater record indicates that the modern climate of the Transvaal bushveld originated at *ca.* 1900 cal yr BP (2000 ¹⁴C yr BP; Scott, 1982c). The Lake Eteza record indicates a relative increase in arboreal pollen taxa at *ca.* 2000 cal yr BP (Neumann *et al.*, 2010). The Rietvlei record suggest a decrease in arboreal pollen taxa and Cyperaceae while there was an increase in Amaranthaceae, Asteraceae and Chenopodiaceae from 2240 cal yr BP onwards, indicating a shift towards grassland vegetation with cooler, moist, sub-humid temperatures (Scott and Vogel, 1983). However, at Wonderkrater, the occurrence of arboreal pollen taxa increases, indicating warmer conditions tending towards bushveld vegetation (Scott, 1982c).

The pollen record at Mafayeni (Kruger National Park) indicates a resilient savannah phase throughout the past *ca.* 1200 cal yr BP (1300 ¹⁴C yr BP), where no major phase changes are observed (Gillson and Ekblom, 2009), and attributed to water, fire and herbivory which limits tree density. At Malahlapanga (Gillson and Ekblom, 2009), a transition from open grassland to savannah occurs at the end of the 9th century A.D. (*ca.* 1100 cal yr BP). A relative increase in Cyperaceae, indicating wetter conditions, is recorded at Nhlangu after *ca.* 1300 cal yr BP (1390 ¹⁴C yr BP; Mazus, 1996) and an increase in swamp forest vegetation at Mgobezeleni is recorded after *ca.* 1200 cal yr BP (1300 ¹⁴C yr BP). The Mfabeni record (Grundling *et al.*,

1998) suggests the establishment of swamp forests dominated by *Syzigium*, *Myrica* and *Ficus* after ca. 570 cal yr BP (600 ¹⁴C yr BP). The Mfabeni record indicates a dominance of Poaceae, and low frequencies of arboreal taxa and Cyperaceae from ca. 860 cal yr BP (1000 ¹⁴C yr BP) to present. The pollen record indicates similar warm, dry, savannah-like conditions as experienced at present at Mfabeni (Finch and Hill, 2008). $\delta^{18}\text{O}$ records from Cold Air Cave reflects humid conditions at ca. 690 cal yr BP (800 ¹⁴C yr BP) followed by drier, cooler conditions after ca. 570 cal yr BP (600 ¹⁴C yr BP; Repinski *et al.*, 1999). At Winterberg, anthropogenic influences are suggested in the last 890 cal yr BP, indicated by a decrease in arboreal pollen taxa, and a relative increase in disturbance indicators such as *Anthospermum*, Ericaceae, Mimosoides and *Stoebe*. Exotic *Pinus*, indicative of timber plantations at Winterberg, are recorded in the last 150 years (Meadows and Meadows, 1988). Between 1900 and 860 cal yr BP (2000 and 1000 ¹⁴C yr BP) the eastern region of South Africa indicates wetter conditions than experienced at present (Partridge *et al.*, 1990).

Cool, moist conditions are inferred from the pollen record at Cathedral Peak until 1680 cal yr BP, after which conditions become moister and warmer. This is seen from the decrease of Ericaceae in the pollen record, and *Podocarpus* concentrations increase after 1200 cal yr BP, further supporting the notion of warmer, moist conditions (Lodder, 2010). *Podocarpus* concentrations at Cathedral Peak increase dramatically at about 1100 cal yr BP, suggesting that montane forests were expanding. *Leucosidea* and *Cordia*, present between 1880-1760 cal yr BP, suggest that forests occurred within the wetland region, surrounded by grassland (Lodder, 2010). Conditions at Cathedral Peak shift from slightly drier to slightly wetter at ca. 1000 cal yr BP, supported by evidence from the pollen records (Lodder, 2010). At Lake Sibaya, a decrease in *Podocarpus* pollen concentrations at ca. 1500 - 1250 cal yr BP is followed by an increase in cereal-type Poaceae, indicating human presence in the region (Neumann *et al.*, 2008). The Cathedral Peak pollen record indicates the appearance of *Pinus* and cereal-type Poaceae, an indication of human presence. Cereal-type Poaceae occurs from the first time at about 890 cal yr BP, and again in modern samples. *Pinus* appears at about 105 cal yr BP, although *Pinus* was first planted in Cathedral Peak in 1950 (Lodder, 2010). This discrepancy may be due to issues related to the chronology of the core. The Lake Eteza record indicates dramatic changes in the vegetation from ca. 700 cal yr BP. There is a sharp decline in arboreal and shrub taxa, and a relative increase in Poaceae to about 85%, indicating a shift towards drier conditions and a retreat in forest elements (Neumann *et al.*, 2010).

These changes may be attributed to pastoralism and crop cultivation, as Iron Age farming activities in the eastern parts of South Africa began at *ca.* 1400 cal yr BP (1600 ¹⁴C yr BP; Neumann *et al.*, 2010).

2.3 CONCLUSION

This chapter provides an understanding of the drivers of climate change, and summarised trends of environmental change which occurred at numerous sites during the Holocene in South Africa. The need for comparison between sites is essential in palaeo-environmental research, as a regional picture of environmental change emerges. Site specific responses are of significance, however where areas lack research, comparison of regional change becomes problematic. Ensuring research is conducted at a high resolution and obtaining solid chronological control, is vital to creating a broader understanding of environmental change. Although trends such as the Holocene Altithermal emerge from comparison of various sites, further palaeo-environmental research is key to producing reliable regional trends and fill in gaps in our understanding of specific regions such as Mt Gilboa, where a mosaic of grasslands and forests exist.

CHAPTER THREE

SITE DESCRIPTION

3.1 INTRODUCTION

The following chapter introduces the research site and surrounding environment, including details of geology, drainage and land use. The indigenous forest and grassland biomes of South Africa are discussed, with a focus on the patch-mosaic assemblage of the Karkloof Forest and Midlands Mistbelt Grasslands. Furthermore, a historical overview of human occupation in the Karkloof Catchment, and their land-use practices is provided.



Plate 3.1 Dartmoor Vlei, a valley bottom wetland surrounded by hill slopes

3.2 LOCALITY

KwaZulu-Natal is a province primarily covered by grasslands, savannah woodlands, bush thickets and forests (Fairbanks and Benn, 2000). The Midlands region of KwaZulu-Natal in particular is characterised by a mosaic of Southern Mistbelt Forests and Midlands Mistbelt Grasslands (Mucina and Rutherford, 2006), of which a prominent area is the Karkloof forest.

Dartmoor Vlei is a valley-bottom wetland (Edwards, 2009) situated at Mount Gilboa in the KwaZulu-Natal Midlands, South Africa, (29.2857°S; 30.2559°E; Figure 3.1). This 42 ha wetland is located at an altitude of 1563 m, on the headwaters of the Myamvubu River, a tributary of the Mooi River (Edwards, 2009). The area falls within a summer rainfall region, where the catchment receives an average annual rainfall of 1000 mm (Moll, 1978; Begg, 1989), occasional snowfalls, and heavy frost (Begg, 1989). Dartmoor Vlei is characterised by an array of small, discontinuous meandering channels, a lack of classic floodplain features (e.g. backswamps, alluvial ridges, oxbow lakes and levees), predominantly diffuse flow and permanently waterlogged conditions, and organic rich deposits (Edwards, 2009).



Plate 3.2 Dartmoor Vlei, surrounded by Midlands Mistbelt Grassland

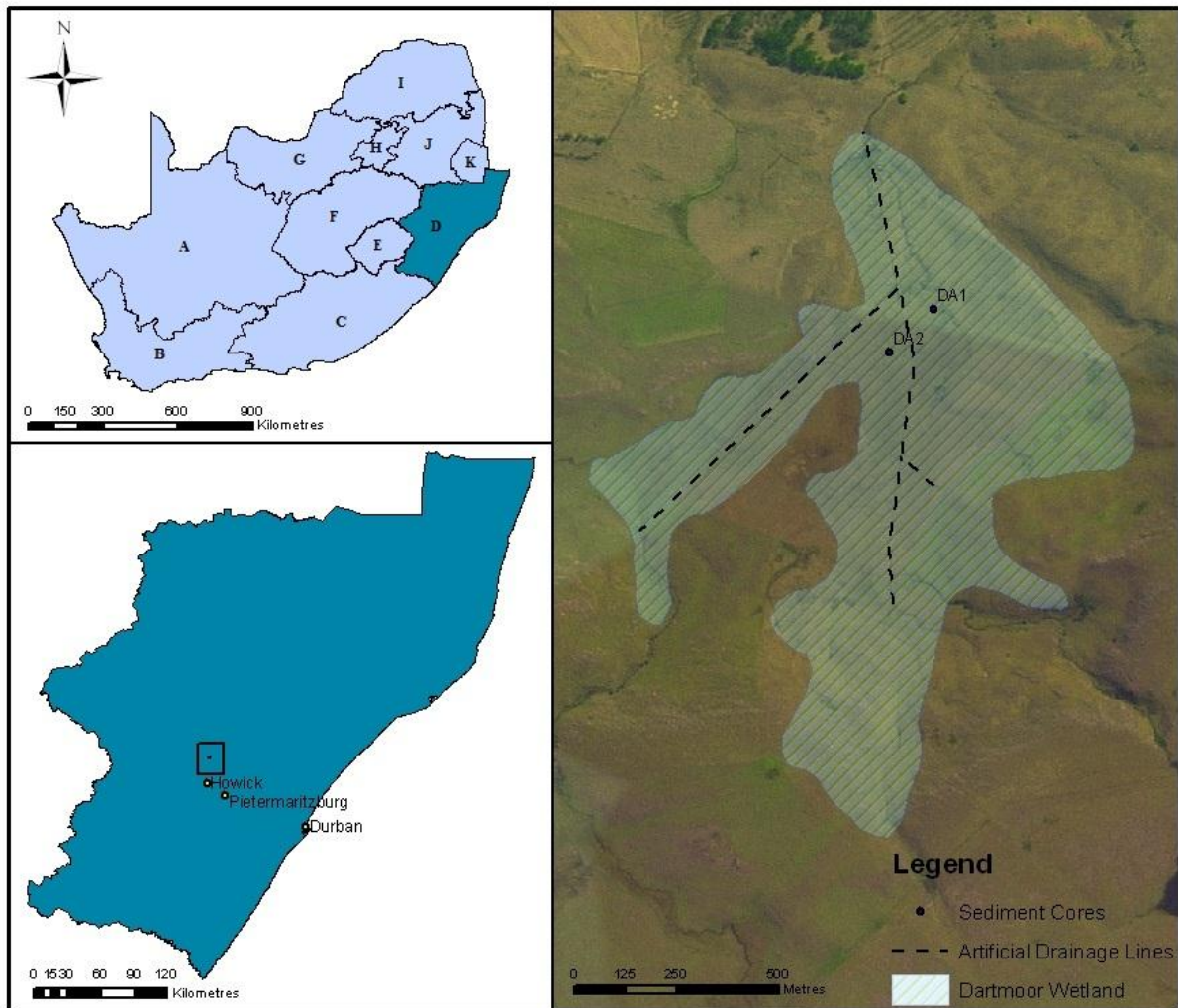


Figure 3.1 Location of Dartmoor Vlei, Mt Gilboa, KwaZulu-Natal in South Africa. Position of sediment cores (DA1; DA2) extracted from Dartmoor Vlei. (A: Western Cape; B:Northern Cape; C: Eastern Cape; D: KwaZulu-Natal; E: Lesotho; F: Freestate; G: North West; H: Gauteng; I: Limpopo; J: Mpumalanga; K:Swaziland)

3.2.1 Geology

The Karkloof Plateau is underlain by shale, siltstone and sandstone which have been intruded by Jurassic dolerite sills and dykes. Although the dolerite dykes are highly resistant and show little sign of weathering, the dolerite sill capping the plateau has been subject to chemical weathering, resulting in some lower lying valley bottom basins (including Dartmoor Vlei) comprising of residual saprolite in excess of 7 m in depth (Begg, 1989; Edwards, 2009).

3.2.2 Drainage

Dartmoor Vlei is located within a gently sloping valley (Figure 3.2) which terminates against a dolerite dyke at the toe of the wetland. The wetland is surrounded by dolerite ridge outcrops which extend upwards from broad terrestrial planation surfaces (flat areas created by fluvial action) (Edwards, 2009). Two mountain streams enter the wetland at the southern boundary and are diverted into artificial channels that were excavated throughout the length of the wetland.

The wetland has been impacted on by artificial drainage channels (Figure 3.1; Plate 3.3) which were put in place several decades ago to improve drainage for agricultural use (Kotze *et al*, 2009). In 2004, rehabilitation interventions were carried out on behalf of Working for Wetlands to improve the general health of the wetland. Interventions included: plugging the drainage channels, raising the water table by reducing water-loss from the wetland, and dispersal of water flow across the wetland (Kotze *et al*, 2009). These measures were in the form of nine weirs placed on the artificial drains, and have proved effective based on individual assessments of the weirs (Kotze *et al*, 2009).



Plate 3.3 Disused artificial drainage channels within Dartmoor Vlei

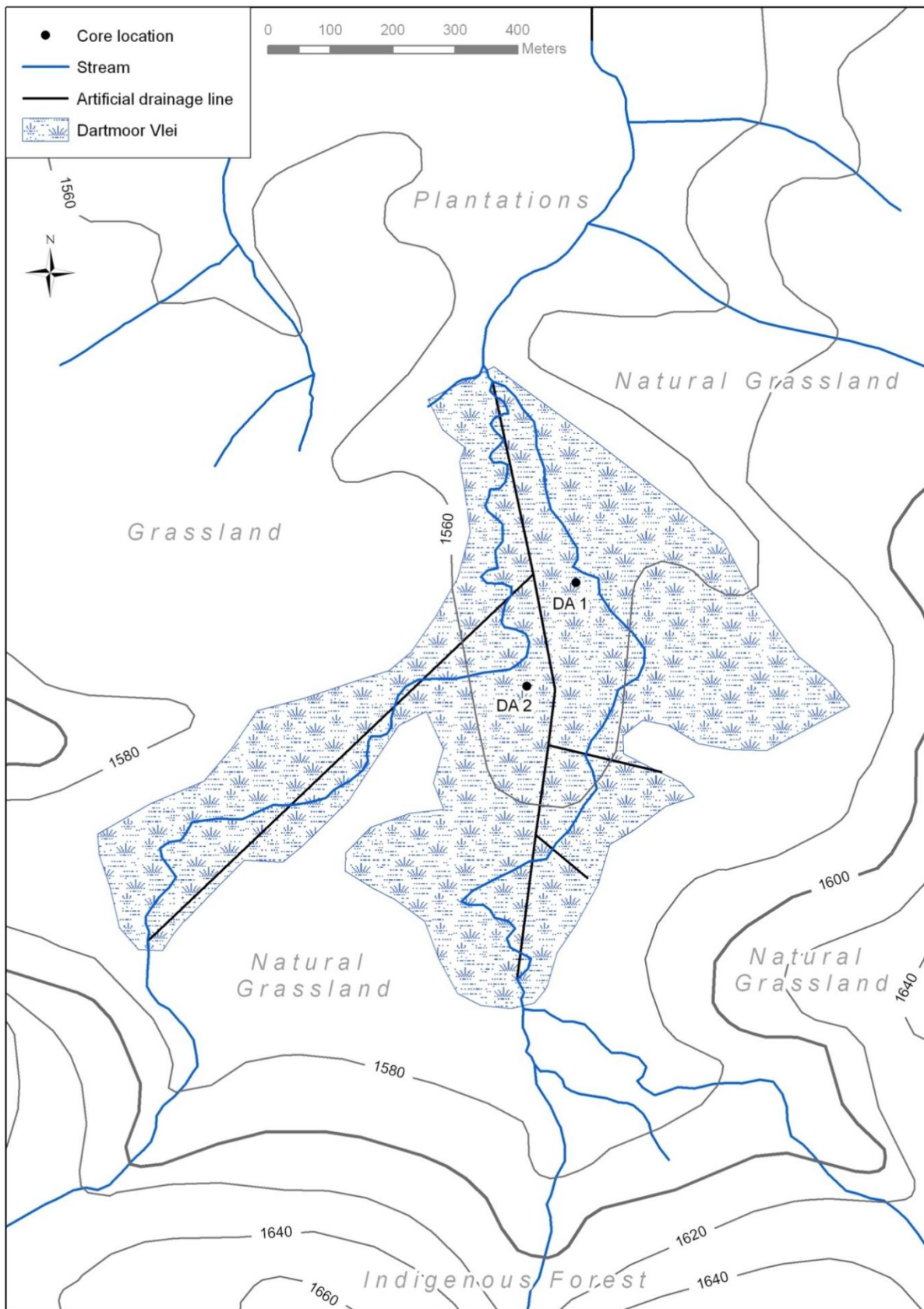


Figure 3.2 Dartmoor Vlei topography and surrounding land uses

3.2.3 Land use

Dartmoor Farm was under private ownership until July 2010 (McCann *pers. com.*, 2012), when Wildlands Conservation Trust purchased the 780 ha. property. Although the surrounding catchment was previously under the administration of Ezemvelo KwaZulu-Natal Wildlife (Edwards, 2009), domestic livestock, mostly cattle, grazed on the slopes surrounding the wetland. Dartmoor Farm officially became part of the Karkloof Nature Reserve in August 2012 after being declared a nature reserve and assigned to Ezemvelo KZN Wildlife as the management authority (KwaZulu-Natal Province Provincial Gazette, 2012).

The dominant vegetation type surrounding the wetland is natural grassland, although commercial forestry plantations (pine and wattle) and annual crops (predominantly rye grass) are located to the north of the wetland, and the Karkloof Forest Archipelago to the south (Figure 3.2). There are numerous wetlands located in the area, including Gilboa and Melmoth Vlei. The vegetation surrounding Dartmoor Vlei is classified by Mucina and Rutherford (2006) as Southern Mistbelt Forest, Midlands Mistbelt Grassland and Drakensberg Foothill Moist Grassland.

3.3 INDIGENOUS FORESTS AND GRASSLANDS OF SOUTH AFRICA

Indigenous forests and grasslands are introduced in a broad context to provide an overview of these biomes in South Africa. The Karkloof forest and Midlands Mistbelt grasslands are discussed as they constitute the patch-mosaic vegetation of Mt. Gilboa, and a historical overview of human impacts in the Karkloof catchment is provided.

3.3.1 The forest biome

Although previously more extensive, the forest biome currently covers approximately 0.56% of the total land area of South Africa (Low and Rebelo, 1996; Lawes *et al.*, 2004), a very small proportion considering its biodiversity value and conservation priority. It is therefore essential that conservation and management of these systems are well executed (Low and Rebelo, 1996; Lawes *et al.*, 2004). Indigenous forests are defined as “a generally multi-layered vegetation unit dominated by trees (largely evergreen or semi-deciduous), whose combined strata have overlapping crowns (i.e. the crown cover is 75% or more), and where

graminoids in the herbaceous stratum (if present) are generally rare” (Mucina and Rutherford, 2006: 586). All indigenous forests in South Africa are evergreen, and scattered along the eastern and southern margins of the country, typically in small patches. There are, however, a few large forests, of which the Knysna forest complex in the western Cape, the Amathole forest complex in the eastern Cape, the Dukuduku forest in KwaZulu-Natal and the Woodbush-De Hoek forest along the Northern Escarpment are renowned (Mucina and Rutherford, 2006). Forests in KwaZulu-Natal can be divided into eight categories (Mucina and Rutherford, 2006), namely Northern Afrotemperate forests, Southern Mistbelt forests, Scarp forests, Northern Coastal forests, Sand forests, Lowveld Riverine Forests, Swamp forests and Mangrove forests.

3.3.1.1 The Karkloof Forest

The Karkloof forest is situated in the KwaZulu-Natal Midlands, and was described by Rycroft (1944: 14) as “the largest remnant of indigenous forest in Natal”. Defined as Afromontane Mistbelt Mixed *Podocarpus* Forest, it occurs on steep slopes at an altitude of 1000 to 1500 m.a.s.l. (Moll, 1978; Macfarlane, 2000) and consists of a few large patches and numerous smaller fragmented forest pockets. The surrounding area is dominated by natural grassland, and this forest-grassland mosaic pattern is considered the natural, historic condition of the landscape (Lawes *et al.*, 2004).

The forest lies within the Mistbelt region of KwaZulu-Natal, and runs along an almost continuous belt along the Karkloof mountain range (Rycroft, 1944; Macfarlane, 2000). Thick mist assists in maintaining saturated conditions in the air for prolonged periods of time and results in high soil-moisture levels. Within the forest, cool and moist air and windless conditions are prevalent (Rycroft, 1944; Von Maltitz *et al.*, 2003). The forest canopy is evergreen to semi-deciduous depending on the moisture and nutrient content of the site (Macfarlane, 2000). Complex plant associations exist as a result of a successional development from simpler pioneer plant communities. According to Rycroft (1944), the entire south to south-east region of the Karkloof range has the environmental potential to support forests, but complete succession may take centuries.

In 1880, the Forest Commission of the Colony of Natal estimated the area covered by the Karkloof forest to be 32 376 ha. By 1942, the forest was thought to have decreased to a quarter of its former area, mainly as a result of commercial logging of indigenous timber (Lawes *et al.*, 2004). Although many of these figures are estimates, and Rycroft (1942) proposed that original figures were overestimated, he does suggest that there has been a reduction in the forest area of up to 80% in 60 years (prior to 1942). Lawes *et al.*, (2004), indicates a 5.6% decrease in forest area between 1944 and 1996 (Table 3.1).

Table 3.1 Landscape metrics describing indigenous forest patterns in the Karkloof-Balgowan region, KwaZulu-Natal, in 1944 and 1996 (Adapted from (Lawes *et al.*, 2004: 616)

	1944	1996	% change
Forest area (ha)	7143	6739	– 5.66 %
Number of patches	2063	1277	– 38.1%
Median patch size (ha)	0.18	0.29	+ 61.11%
Total edge (m)	1546000	1234000	– 20.18%
Median nearest neighbour distance (m)	28	40	+ 42.86%

More recently (post-1996), the Karkloof forest archipelago was estimated to be 7551 ha, which suggests that there has been very little change in the forest area since harvesting of indigenous timber ceased in 1940 (Macfarlane, 2000; Lawes *et al.*, 2004). Macfarlane (2000) argues that estimates prior to 1944 were grossly exaggerated, possibly due to inaccurate mapping of the Karkloof forest boundaries, although such arguments are difficult to substantiate in the absence of empirical evidence.

In many respects, the Karkloof forest composition is very similar to other indigenous forests found in KwaZulu-Natal and the Eastern Cape, with minor floristic differences (Rycroft, 1944). Taylor (1961) made a broad differentiation of forest types within the Karkloof forest, namely: Mixed-Dominant Forest; Stream Forest and Stinkwood Forest. The following species are listed as representative of the tree layer in the Mixed-Dominant Forest (for updated vegetation list see Appendix P), which occupies the majority of steep ridges:

Podocarpus falcatus, *Celtis africana*, *Combretum kraussii*, *Cryptocarya woodii*, *Ekebergia capensis*, *Fagara davyi*, *Kiggelaria africana*, *Ptaeroxylon obliquum*, *Podocarpus latifolius*, *Scolopia mundii*, *Scolopia zeyheri*, *Xymalos monospora* and *Halleria lucida*. Regeneration of seedlings occurs on the forest floor where the tree canopy remains intact and includes the species: *Carissa arduina*, *Celtis africana*, *Clausena anisata*, *Cnestis natalensis*, *Cussonia chartaceae*, *Dovyalis rhamnoides*, *Gardenia* sp., *Grewia occidentalis*, *Gymnosporia harveyana*, *Olea* spp., *Peddiea africana*, *Popowia caffra*, *Ptaeroxylon obliquum*, *Rinorea natalensis*, *Royena lucida*, *Trichalysia* sp. and *Trimeria grandifolia* (Rycroft, 1944; Taylor, 1961) Where the tree canopy is unbroken, seedling growth rate appears to decrease and few advance beyond the seedling stage, especially where cattle grazing is permitted (Taylor, 1961). Stream Forest can be described as largely a mixed-dominant forest; however the key difference is the presence in varying densities of lower layers beneath the tree canopy (Taylor, 1961). In this forest type, moisture-loving species such as *Ilex mitis* and *Pygeum africanum* are present (Taylor, 1961). Taylor (1961) describes the Stinkwood forest type as that which occurs on the upper parts of the Karkloof forest where conditions are cooler and moister than on the lower slopes. Although this type has a simplified tree layer and a poorly developed shrub layer, it has a marked ground layer. This forest type consists of a very similar composition to the previous type; however there is a fair distribution of *Ocotea bullata*, *Podocarpus henkelii*, *Calodendrum capensis* and *Kiggelaria africana* in the tree layer. The ground layer consists of the species *Selaginella kraussiana*, *Asparagus* spp., *Plectranthus* spp. and a variety of ferns (Taylor, 1961).

Fire plays a vital role in limiting forest patches on a local and regional scale (Eeley *et al.*, 1999), as regeneration of forest patches takes place after fire. After burning of portions of the forest, *Helichrysum foetidum* often form communities along with bracken (*Pteridium aquilinum*), and the forest is likely to regenerate. Coppice shoots are produced from trees which have not been completely destroyed and a variety of shrubs are able to grow in the *Helichrysum* community. Over time, a closed canopy may be formed, and the forest is gradually reconstructed. However, if fire occurs at more regular intervals, regeneration will not take place. The *Helichrysum* communities will be replaced by grasses such as *Cymbopogon* spp., *Setaria* spp. and *Eragrostis* spp. and if overgrazing takes place *Aristida* spp. are likely to occur. This disturbance will result in the land gradually being reduced to poor grassveld (Rycroft, 1944).

As a result of fire, over-exploitation, grazing, cultivation and afforestation, total forest area in the KwaZulu-Natal Midlands has reduced significantly (Rycroft, 1944; Taylor, 1961; Macfarlane, 2000), and conservation concerns are therefore justified. Clearing forest areas for commercial plantations and timber use results in fragmentation of forest patches, changes in ecosystem function and modification of forest structure and composition. Removal of large trees from a forest will allow more light to penetrate the forest canopy, resulting in altered structures and species composition of the forest floor vegetation (Lawes *et al.*, 2007). Ultimately, decrease in forest area will result in a change in biotic and abiotic processes that are responsible for generating and maintaining biodiversity (Macfarlane, 2000). Indigenous forests are declining systematically throughout southern Africa, and it is essential to understand the history of both natural and anthropogenic impacts and disturbances to understand their ecology and ensure management of this biome (Lawes *et al.*, 2007).

3.3.2 History of utilisation of indigenous forests in South Africa

Although forests may have been utilised by earlier inhabitants, there is no empirical evidence to provide detail of this. Colonial settlers began to exploit the forests on the slopes of Table Mountain shortly after the establishment of a supply post at the Cape of Good Hope in 1652 (Ferguson and Huisamen, undated; Owen and van der Zel, 2000). By the late 1670s the supply had been exhausted, which meant that timber had to be imported from Europe and the East (Ferguson and Huisamen, undated). Thus the early history of forests was one of uncontrolled exploitation and devastation (Owen and van der Zel, 2000). As European colonists in South Africa moved eastwards from Cape Town along the south coast, they discovered the largest expanses of forests in the region of George, Knysna and Tsitsikamma, which fuelled the development of many timber-based industries. By 1820, the British began to arrive in the Eastern Cape and KwaZulu-Natal, and after colonising in 1836, woodlands gained economic significance (Owen and van der Zel, 2000). It was only in the 1700s that an attempt was made to protect forests in the south-western Cape, and only in the 1800s that this was achieved through conservation strategies implemented in the Eastern Cape. After the appointment of a formally trained forest officer in 1880, the Cape Colony introduced the first Forest Act in 1888 in an attempt to protect indigenous forests in the region (Owen and van der Zel, 2000).

In South Africa, the type and quality of forest management is determined by land ownership. National and provincial governments and statutory bodies manage and control large portions of forests, but only small portions of these are owned privately or are under communal land. Forests under conservation in South Africa may be on private or tribal land, designated as conservancies, heritage sites, nature reserves or wilderness areas (Mucina and Rutherford, 2006). There are a number of forests outside the designated conservation areas which are well conserved, however their conservation status remains insecure (Mucina and Rutherford, 2006). Threats and pressures facing forests in South Africa remain: an increase in human needs; high intensity farming; economic pressures; mining and development of infrastructure are all matters that need to be addressed when implementing conservation measures to protect the country's indigenous forests (Mucina and Rutherford, 2006). The type of forest and forest management is therefor critical to the conservation of forests.

3.3.2.1 Historical overview of human impacts in the Karkloof Catchment

Although few surveys have been conducted in the area, early, middle and late Stone Age sites have been recorded in the region, and it is thought that there are many more still to be revealed. Stone Age people were hunter gatherers and lived primarily off indigenous plants and animals, and the exploitation of certain favoured food types becomes apparent (Mazel, 1989). It has been hypothesised that due to seasonal migration of some large animals, exploitation of certain food types occurred on a periodic basis (Mazel, 1989; Partridge *et al.*, 2004). Due to the movement of these people from the coastal regions in winter, to the Drakensberg in summer, the Midlands region would have been traversed along the ridges rather than the valleys (Mazel, 1989). Moll (1976) argues that the effect on woody plants and forested areas were as a result of intentional fires set by people to maintain open grasslands and to assist in hunting.

Archaeological evidence from the KwaZulu-Natal Midlands region suggests that this area became inhabited by the Iron Age people approximately 2000 – 1500 years ago. Iron Age people began to settle in villages instead of living nomadic lifestyles and began to keep domestic livestock such as sheep, cattle and goats, and cultivate crops. Their food sources were supplemented by hunting, fishing, and gathering of wild plants, and wood would have been required as a source of fuel and building material. Burning grasslands to encourage

green growth for their livestock to graze on would have resulted in a change in species composition of the grasslands, and it is suggested that *Themeda triandra* was replaced by *Aristida junciformis* (Moll, 1976). Clearing of natural vegetation for crop production would have altered the vegetation composition. With prolonged periods of cultivation of small patches soil fertility would decrease, resulting in further areas of land to be cleared for cultivation and *T. triandra* further being replaced by *A. junciformis*, *Eragrostis curvula* and *Hyparrhenia hirta* (Moll, 1976).

In 1837, the Boers settled in KwaZulu-Natal and after subdividing the land, private tenure was established and private owners were able to exploit natural resources. Timber was used for building material and fuel, game was hunted for meat and vegetation was cleared for subsistence crops. Most Boers were involved in cattle farming, which resulted in natural vegetation being burnt on a regular basis to provide suitable grazing for their livestock (Ellis, 1998 cited in Weyer, 2000) however political unrest caused them to dispose of their land (Scott-Shaw, 1971). Approximately 5000 settlers from Britain arrived between 1849 and 1854 (Scott-Shaw, 1971). A number of attempts were made at various activities including: hunting; subsistence farming; exports of butter, ivory and various animal hides; stone quarrying; lime burning; and sawing of timber from forests in the Karkloof, Dargle and Pietermaritzburg district. Farmers found it difficult to subsist during this period, as soil and climatic conditions differed greatly from the environments which they had come from. During this time of colonisation, the number of game decreased significantly and many farming attempts were futile (Weyer, 2000). However, by 1860 experimental attempts at various farming techniques began to pay off, and between 1860 and 1900 farmers discovered that the Natal Midlands Mistbelt was suitable for grazing of cattle and sheep, dairy farming, and maize cultivation (Ballard and Lenta, 1985 cited in Weyer, 2000).

Although *Acacia mearnsii* (Black Wattle) was first introduced to South Africa from Australia by John van der Plank in 1864 (Sherry, 1968; Owen and van der Zel, 2000), plantations were only established in the Karkloof in 1876 on the farm Everdon (Sherry, 1968). The Karkloof Catchment, in particular in the vicinity of the Karkloof forest, was considered to be suitable for wattle plantations, as altitude and rainfall conditions were ideal (Scott-Shaw, 1971). By 1904, a wattle belt emerged in the Midlands area and by the late- to mid-1920s the wattle

bark and extract industry rapidly expanding (Hurwitz, 1957 cited in Weyer, 2000).

The Karkloof area is considered to be an important farming area due to the arable soils and high and reliable rainfall, and is thus suitable for growth of a variety of crops and timber. It is also an area with a high diversity of flora and fauna and in terms of the natural habitat it is highly valued (Macfarlane, 2000). Currently, timber plantations, dairy and beef farming and crops, remain an essential part of the Karkloof economy, and tourism, particularly eco-tourism, plays a significant role in the Karkloof. In 1997, the Karkloof Conservancy was established with the aim of environmental education and monitoring of wildlife populations, and forest companies such as Sappi Forests (Pty) Ltd and Mondi (Ltd), and local farmers, have membership of the conservancy. The success of the conservancy is evident in the increase of wildlife populations, and the occurrence of fewer uncontrolled forest and veld fires (Weyer, 2000).

3.3.3 The grassland biome

Globally, the conservation status of the grassland biome is of great concern (Neke and du Plessis, 2004), but considering human dependence on this biome (Van Oudtshoorn, 1999) its conservation efforts are grossly neglected. The grassland biome covers a large proportion of South Africa's land surface, with estimates varying from approximately 66% of the vegetation of South Africa (Breman *et al.*, 2011), to 16.5% (Neke and du Plessis, 2004), with distribution controlled primarily by climate and fire.

Based on habitat loss, degree of fragmentation and possible future threats, South African grasslands have been identified as critically endangered, and it is therefore not surprising that this biome is in need of urgent conservation attention (Neke and du Plessis, 2004). Grasslands contain several rare plant species and are home to a variety of severely threatened and endemic mammal species and grassland birds. The conservation status of these species is a reflection of the habitat loss and destruction, transformation, and loss of functionality of the grassland biome (Neke and du Plessis, 2004).

A number of threats to the grassland biome in South Africa have been identified, although some are less tangible than others. A loss in vegetation cover due to over-grazing and poorly managed fire-regimes may result in soil erosion, which could exacerbate vegetation loss. Exotic and invasive plant species (e.g. *Rubus cuneifolius* and *Acacia mearnsii*) have the ability to successfully invade grasslands, especially in areas which have been disturbed. This loss of natural vegetation, due to competition from invasive alien species, has the ability to do much damage to this biome. Furthermore, most mining activities are situated in grassland area and this has an effect not only on the immediate location, but also on the surrounding region. However, in spite of all these pressures, global climate change remains one of the most severe threats. Models to predict the impact of climate change on grasslands indicate that grasslands will be replaced by woody savannah plants, until merely north-south strips remain. It should not be assumed that the grasslands historical range will be suitable in the future, as additional threats to the grassland biome may arise as climate change results in habitat fragmentation (Neke and du Plessis, 2004).

3.3.3.1 The Midlands Mistbelt Grasslands

The grasslands of the KwaZulu-Natal Midlands have been identified as a centre of endemism, and of particular importance in this region are the Midlands Mistbelt Grasslands. These grasslands are found over a large area at altitudes ranging from 760-1400 m and large areas in regions surrounding the Meloth-Babanango area, Kranskop and Greytown, Howick, Lions River, Karkloof, Balgowan, Cedara, Edendale, Hilton, Richmond, the Ixopo-Highflats area, Mount Malowe and the Harding-Weza area (Mucina and Rutherford, 2006). The Midlands Mistbelt Grasslands are one of the most threatened vegetation types in KwaZulu-Natal and its conservation status is listed as endangered. Disturbingly, only a small fraction (0.5%) of these grasslands is under low-level conservation in reserves such as Queen Elizabeth Park, Blinkwater Reserve and Karkloof Reserve (Mucina and Rutherford, 2006), where several threatened plant species occur (Scott-Shaw, 1999). The Midlands Mistbelt grasslands are also home to several insect, bird and animal species of conservation importance, such as the Karkloof Blue butterfly (*Orachrysops Ariadne*; Lu and Samways, 2002), Oribi antelope (*Ourebia ourebi*; Samways, 2007), Blue Swallow (*Hirundo atrocaerulea*) and Wattled Crane (*Buggeranus carunculatus*; Wakelin and Hill, 2007). Most of the Midlands Mistbelt Grasslands have been transformed for plantations, cultivation and urban sprawl and further threats include uncontrolled fire, poorly managed grazing regimes, the spread of alien

invasive vegetation which competes for resources and medicinal plant collection (Scott-Shaw, 1999; Mucina and Rutherford, 2006). Alarminglly, only 1% of the original extent of the Midlands Mistbelt grasslands remains in a near-pristine state (Scott-Shaw, 1999).

CHAPTER FOUR

BACKGROUND TO PALAEOENVIRONMENTAL METHODS

4.1 INTRODUCTION

This chapter provides a description and assessment of the methodologies applied in this research. This includes the following proxies: pollen and charcoal analysis; radiocarbon dating; stratigraphic description and geochemical analysis. As pollen analysis is the principle proxy, details regarding key principles, advantages and limitations of this proxy are discussed in greater detail.

4.2 POLLEN ANALYSIS

Palynology, or pollen analysis, is defined by Faegri and Iverson (1989) as a technique to reconstruct former vegetation types through the study of the unique pollen grains produced and is able to demonstrate how various plant species respond to climatic changes (Williams *et al.*, 1998; Watrin *et al.*, 2007). The first quantitative pollen diagrams were published by Von Post in 1916 (Anderson *et al.*, 2007) and the method has become a universally applied technique in reconstructing regional vegetation and climate trends at different timescales (Willarda *et al.*, 2001; Bunting, 2008). This provides an understanding of the relationships between vegetation and climate and the ability to predict future changes in plant migration, dynamics of plants within an ecosystem and the distribution of various biomes (Watrin *et al.*, 2007).

Pollen analysis has proven to be a versatile tool in resolving vegetation dynamics at both a fine spatial scale and at continental scale (Bradshaw, 2008), and can provide a description of the vegetation changes occurring, however it may be difficult to identify the drivers which result in these changes. Although anthropogenic impacts are often identified, these have only escalated recently (Bradshaw, 2008). Behre (1988) reviewed various pollen types as indicators to anthropogenic changes, which is a method widely used to detect human impact, and the proportion of non-arboreal pollen types in landscapes which were potentially forested. This may provide evidence of the extent and scale of forest clearance as a result of human impacts (Bradshaw, 2008).

4.2.1 General principles and Limitations

Basic principles of pollen analysis have been discussed by numerous authors (Moore and Webb, 1978; Birks and Birks, 1980), and a number of points have been outlined by Birks and Gordon (1985). There are however several limitations which are discussed.

1. It is assumed that all flowering plants produce pollen in relative abundance during the reproductive stage, and pollen grains are dispersed via wind and water.
2. Pollen released into the air is subjected to turbulence in the atmosphere and hydrological dynamics, which results in a more or less uniform pollen rain ultimately reaching the area of deposition.
3. Pollen grains comprise of organic compounds, which begin to decay under the process of biological decomposition. However, if pollen grains are deposited in an area which is permanently waterlogged, acidic and anaerobic (such as bogs, fens and lake bottoms), decomposition is inhibited and the exine of the pollen grains is preserved.
4. Fossilised pollen grains may be extracted from sediment, and through morphological variations pollen grains can be identified down to family/genus/species level.
5. The composition of fossilised pollen within a sediment sample is a reflection of the composition of pollen rain, which in turn is a reflection of the local and regional vegetation at that location at a particular period in the past.
6. If pollen in a sediment samples is preserved under suitable conditions, concentrations of pollen grains in 1 cm³ of sediment sample may be in excess of 10⁵ grains. This means that a very small sediment sample is required for analysis (usually less than 1 g), to ensure an adequate sample population. This illustrates the practicality of pollen analysis, as other fossil types such as seeds, insects and vertebrates require much larger samples to be examined.
7. If stratified pollen assemblages are analysed, the results should reveal a punctuated sequence of progressive vegetation development of the site over a period represented by the sediment record.
8. If a number of pollen assemblages are analysed from various locations, it is possible to make a comparison of the pollen spectra and to detect similarities and differences in the vegetation through time and space.

Faegri (1966) raises three problems relating to the representivity of pollen analysis. The first being how well the pollen spectrum represents the actual composition of the pollen present in the sample being analysed? Second, how well does the pollen in a sample represent the vegetation around the area under investigation? And third, does the actual flora represent the potential vegetation cover in its climax aspect?

Identification of pollen is achieved by comparison between fossil pollen material and modern pollen reference material, which is collected from plants of known identity. However, identification of fossil pollen is often problematic and can sometimes only be achieved to family taxonomic level. In some instances, pollen may be deteriorated beyond the point where identification is possible (Birks and Gordon, 1985; Anderson *et al.*, 2007). There is little advancement in the identification of common pollen types such as Poaceae and Cyperaceae, which is a limiting factor in interpretation of wetland and grassland systems as these are common taxa in such ecosystems. Although the use of Scanning Electron Microscopy (SEM) has increased the resolution of pollen for identification, the practicality of using SEM for the identification of thousands of pollen grains is not feasible. The use of identification keys and high-quality image databases (e.g. the African Pollen Database), facilitates the identification of fossil pollen (S  ppa and Bennett, 2003).

Jacobson and Bradshaw (1981) define local pollen as pollen which originated from plants growing within 20 m of the edge of the sampling basin, and regional pollen as pollen which comes from greater distances. Consideration must be given to the mode of pollination of varying types of plants. Plants may be anemophilous (wind-pollinated), zoophilous (animal-pollinated) or entomophilous (insect-pollinated), and plants will produce various amounts of pollen depending on the mode of pollination. Anemophilous taxa will produce large quantities of pollen which are evenly and widely dispersed, whilst zoophilous and entomophilous taxa produce smaller quantities of pollen, often in sticky clumps, which are transported short distances from the parent plant. Zoophilous or entomophilous taxa may not provide an accurate representation of the species, as the pollen counted is a function of the size of the pollen clump, rather than an indication of the species (Faegri, 1966), resulting in an over-representation of certain taxa (Anderson *et al.*, 2007). Pollen production of a species

is controlled by various factors, such as climate, exposure, competition and cultivation measures, and some plants are more effective in methods of pollen transport, which leads one to question the extent to which modern pollen rain is a representation of the vegetation (Hill, 1992). Prentice (1988) argues that modern pollen studies provide an indication of pollen assemblages which are representative of vegetation types, for example forests. Modern pollen studies by Meadows and Meadows (1988) in the Winterberg and Hill (1992) in the KwaZulu-Natal Drakensberg, suggest that contemporary pollen rain is a fair reflection of parent vegetation communities.

4.2.2 Methodological considerations

4.2.2.1 Site selection

Peat deposits contain the best pollen records for palaeo-climatic and palaeo-vegetational reconstruction (Jacobson and Bradshaw, 1981; Williams *et al.*, 1998; Anderson *et al.*, 2007). When sampling a peat deposit, consideration needs to be given to a number of variables (Table 4.1) such as basic characteristics, sedimentation processes and the local environment (Jacobson and Bradshaw, 1981).

4.2.2.2 Field sampling

A range of corers such as the Hiller, Russian, piston and vibracore, are available for the extraction of sediment samples, and various advantages and limitations of the equipment needs to be understood (Gastaldo, 1999). When coring peat, the use of side-filling samplers such as Hiller and Russian samplers are recommended by Feagri and Iverson (1989). The sediment cores are extracted in chambers which are inserted into the sediment, turned to cut the core, and extracted. The Russian corer produces a semi-circular core, which is cut without any disturbance to the stratigraphy. Cores are taken in an overlapping sequence from two closely situated holes, and several chamber lengths may be required when coring deeper sediment. Field instruments should be kept clean at all times to avoid contamination (Faegri and Iverson, 1989; Gastaldo, 1999).

Table 4.1 Important variables to be considered when sampling peat deposits (Jacobson and Bradshaw, 1981: 89)

Basin Characteristics
location size of area not covered by tree canopy extent of water movement through peat basin morphology
Sedimentation Processes
time period covered by deposit continuity of the record – recurrence surfaces extent of bioturbation/human disturbance postdepositional pollen movement redeposition of peat that has broken loose from floating mat
Local environments
present vegetation of peat surface pH and ionic content of percolating water hydrology fire frequency prevailing winds

4.2.2.3 Laboratory processing

Laboratory processing is comprised of three stages: subsampling; chemical and physical processing; and mounting of samples.

Subsampling of the sediment core should, if possible, be conducted in a controlled environment such as a sterile laboratory, as contamination of pollen from the environment may occur if subsampled outdoors. The surface of the sample should be cleaned with a knife or scalpel parallel to the strata of the core, to remove contaminated material. The resolution at which subsamples are taken depends on the data resolution which is required for the study, and on factors such as sedimentation rate (Williams *et al.*, 1993). It is suggested by Faegri and Iverson (1989) that subsamples are taken at a fine resolution, even if samples will not be analysed at this resolution. This prevents contamination on the exposed surface of the sediment core. For relative analyses, 1 cm³ of sample is sufficient (Birks and Gordon, 1985; Faegri and Iverson, 1989).

The swirling technique developed by Hunt (1985) was used to separate particles of different specific gravity, as they have different settling rates in water (Pearsall, 1989; Hunt and Rushworth, 2005; Wheeler, 2007) and is based on the panning principle (Funkhouser and Evitt, 1959). Particles are separated based on size, weight, shape and specific gravity, and the technique is effective in concentrating particles in a dilute suspension. Ensuring that a dispersing agent is used before swirling is essential, as failure to do so will result in particles flocculating and forming a heterogeneous mass. The general effect of the swirling motion is to separate lighter particles, such as pollen, and to keep them in suspension in the solution. The separated fossils can be concentrated further prior to making slides (Funkhouser and Evitt, 1959). The use of the gravitational separation technique is advantageous in that it is safer than the conventional use of HF digestion, as it does not rely on the use of hazardous chemicals. Staining of pollen in a sample is one of personal choice. Staining enhances the structural details of the pollen grain, and in some instances allows for variation between pollen grains and other palynomorphs of similar form to be differentiated. It is also possible to identify pollen grains which are damaged, as they may otherwise be overlooked and not taken into consideration (Faegri and Iverson, 1989).

When mounting pollen samples, the intended use of the slides must be clear before deciding on the mounting method used. If pollen slides are intended to be use temporarily, requirements for mounting will differ from those used as permanent slides (Batten, 1999; Faegri and Iverson, 1989). Various mounting agents can be used, including glycerine jelly, glycerol and silicon oil (Williams *et al.*, 1993; Baxter, 1996; Williams *et al.*, 1998). For permanent mounts, water-free glycerol may be used. If the slides are sealed with nail varnish they could last for several years (Faegri and Iverson, 1989; Batten, 1999), which is ideal for reference samples. When choosing a mounting medium, it is advised that the refractive index be considered, as this may ease the counting process (Faegri and Iverson, 1989; Batten, 1999). The method of mounting allows for later identification of pollen grains, as individual grains can be photographed, and co-ordinates of individual grains on the slide be recorded for re-examination where required.

4.2.2.4 Counting

Pollen counts are conducted on a light microscope at a set magnification, along evenly spaced transects on the microscope slide. The number of grains counted depends on the aim of the research. To obtain reliable estimates, a sufficient number of pollen grains should be counted (Birks and Gordon, 1985; Williams *et al.*, 1998). Birks and Gordon (1985) recommend that a total of 300 to 500 pollen grains are counted per sample, however some studies may require 1000 or more grains to be counted to obtain maximum precision. Research from the KwaZulu-Natal Drakensberg by Hill (1996) argues that there is no significant difference in the representativity of counts of 250 or 1000 pollen grains. Pollen types and counts are expressed as a percentage of the pollen sum, and a count of 250 pollen grains will suffice in representing various vegetation communities. To avoid issues surrounding non-random distribution of pollen grains on the slide, complete slides or transects should be counted (Birks and Gordon, 1985). Another method for determination of absolute pollen counts is through the use of *Lycopodium clavatum* spores, an exotic marker spore added in tablet form to the sample to determine abundance of pollen grains relative to the marker spores (Stockmarr, 1971). Pollen grains and spores are identified from morphological features on the exine, which enables identification to family, genus or species level (Williams *et al.*, 1998).

4.2.2.5 Data presentation

Once pollen counts have been obtained, pollen data is represented in a manner that is simplified and easy to visualise. This may be achieved through a series of graphs and diagrams, known as pollen diagrams, through the use of specialised programmes designed for this purpose, for example two of the most commonly used programmes are Psimpoll (Bennett, 2005) and Tilia (Grimm, 1992). A series of pollen diagrams are plotted from relative proportions of pollen and spore counts, and care should be taken not to represent too much information on one diagram but rather the data relevant to the objective of the investigation (Birks and Gordon, 1985; Faegri and Iversen, 1989). The diagrams should include the stratigraphy and chronology of the sediment core to ensure ease of referencing. Pollen diagrams are then further divided into zones (minor stratigraphic intervals), as it enables one to examine internal variations of diagrams, correlations between diagrams (Faegri and Iversen, 1989) and to aid in interpretation (Williams *et al.*, 1998). Zones can be

derived from the Constrained Incremental Sum of Squares (CONISS) function in Psimpoll (Bennett, 2005).

4.2.2.6 Palaeo-environmental reconstruction and interpretation

Much evidence used for palaeo-environmental reconstruction is stratigraphic in nature, and therefore clues regarding environmental conditions at specific time periods are investigated. Changes in the stratigraphic sequence over an extended period of time are used to infer changes which occurred in the environment (Anderson *et al.*, 2007). There are two general interpretative approaches that may be taken: an individualistic approach and an assemblage approach. The use of the assemblage approach has more strength in fossil pollen analysis as assemblages of fossils are used for comparison, whereas the individualistic approach is better suited to plant macrofossils that can be identified to species level (Birks and Birks, 2005). When interpreting pollen diagrams, it is important to consider the contemporary vegetation composition, as this is key to explaining vegetation patterns and changes, and may be achieved by collecting modern pollen samples of known vegetation communities (Williams *et al.*, 1998). Fossil pollen assemblages can then be compared with known ecological tolerances, to reconstruct past environments (Birks and Birks, 2005).

A factor complicating the interpretation of pollen assemblages is the impact of humans in the recent past. Although anthropogenic impacts may be observed in pollen assemblages and provide insight regarding historical human activity, some vegetation assemblages reflect human interference rather than climatic change. It is essential that an understanding of such influences is gained before interpretation is attempted (Williams *et al.*, 1998).

4.3 CHARCOAL ANALYSIS

Fire has played a significant role in the development of vegetation (Scott, 2002; Carcaillet *et al.*, 2001; Scott *et al.*, 2000), and hence the study of micro-charcoal fragments together with pollen analysis has become a widely used proxy in palaeo-reconstruction techniques (Ritchie, 1995). By analysing charcoal fragments and reconstructing fire history, valuable insight into the dynamics of fire history and human interaction with the environment can be gained (Clark, 1982; Scott *et al.*, 2000). It has therefore become important to understand the processes of charcoal formation, both physical and chemical, and biological properties, as

they determine the degree of charcoal preservation for environmental interpretations (Scott and Damblon, 2010). The use of charcoal in describing and understanding past environments was limited until the 1970s, however developments in the methods have resulted in an increase in the use of this proxy (Carcaillet, 2007).

Charcoal is formed as a result of the combustion of vegetation and has a high carbon content of 60-90% (Scott, 2010). In Quaternary studies, there has been some debate as to the transportation mechanisms of micro- and macro-charcoal fragments: microscopic charcoal fragments can be waterborne or wind-blown, and macroscopic charcoal fragments can be transported via water or erosional processes (Scott *et al.*, 2000). Scott (2002) states that the most suitable sites for charcoal analysis are those where transportation of charcoal fragments are not through fluvial processes. Transportation and reworking of allochthonous charcoal fragments in the sediment samples may prove to be problematic in analyses, as such particles may not necessarily be of the same age as the atmospheric charcoal component in the sample. The assumption can therefore be made that atmospheric micro-fragments of charcoal from burning of surrounding vegetation can provide accurate results of the charcoal ratios of a site (Scott, 2002). The charcoal fragments possess a number of characteristics: they are able to preserve the anatomy of the plant (allowing for taxonomic identification); are fairly inert; and can be well-preserved in the fossil record (Scott, 2010).

Natural fires are largely controlled by climatic conditions, and although it results in vegetation disturbance, can also increase productivity, vegetation diversity and nutrient cycling (Daniau *et al.*, 2010). Vegetation can therefore track climate change directly (lightning ignition, fuel moisture and prevalence of fire weather) and indirectly (changes in vegetation and productivity) (Daniau *et al.*, 2010). In summer rainfall regions, biomass becomes dry and more ignitable during dry winter periods (Scott, 2002). Although interpretation should be done with caution, charcoal records may therefore provide us with an indication of when drier conditions were prevalent, and fire frequency more regular (Scott, 2002). However, lightning is characteristic of subtropical conditions, where it can be associated with rainy conditions. It is therefore important to use a multi-proxy analysis when attempting to reconstruct palaeo-environmental conditions, as the use of pollen data in conjunction with charcoal records will assist in establishing a relationship between

vegetation, natural burning, climate change and anthropogenic impacts (Ritchie, 1995; Scott *et al.*, 2000; Whitlock and Larsen, 2001; Scott, 2002)

Some difficulties are experienced in the analytical methods and the interpretation of charcoal data, as outlined by Ritchie (1995). Issues regarding poor chronology in many sediment types hinder the investigation of the history of local fires, once again emphasising the importance of appropriate sites and sediment type. Charcoal taphonomy raises questions regarding the identification of airborne and water-borne sources, particularly in lacustrine deposits (Ritchie, 1995). A further limitation of reconstructing an accurate fire-history is the use of sediment samples at a lower resolution. As the occurrence of natural fires does not occur frequently, the fire history obtained from the sediment samples will only be as accurate as the sediment samples are able to provide (Clark, 1982). To obtain a more detailed fire history, the sediment core would have to be analysed at a very high resolution.

Scott (2002) provides a summary of fire fluctuations in South Africa during the Holocene, although it is clear that correlations in fire history between distant sites are not necessarily expected. Differences in charcoal patterns at various sites indicate that fire events are merely an indication of local fires which occurred in close proximity to the site (Scott, 2002). An interesting relationship can be seen in records from Lake Eteza and Port Durnford, two coastal swamp sites in KwaZulu-Natal. The records contain zones where charcoal concentrations and *Podocarpus* pollen concentrations are simultaneously high (Scott, 2002). Although the reasons for this are unclear and requires further analysis, a possible explanation could be the availability of large amounts of grass fuel (Scott, 2002). At Wonderkrater spring, an increase in fire frequency can be observed at a time which coincides with the arrival of Iron Age culture in the region, and the charcoal peaks can be attributed to local burning. When examined in conjunction with pollen data from the site, it can be inferred that the charcoal is as a result of burning where *Zea* cultivation took place, as *Zea* pollen (which must have been produced locally) was not (as Scott (2002) argues), a result of long-distance dispersal. However, at Lake Funduzi in Limpopo Province, charcoal concentrations during the period of Iron Age people are very low (Scott, 2002). This may be an indication that people did not initiate fires in the area. Pollen records show that there may have been impacts from human activities and changes in hydrology, however this does not coincide with charcoal peaks and may be an indication that human presence followed at a later stage. An

increase in charcoal concentrations with the arrival of the Iron Age people would be expected, although the charcoal records do not indicate similar situations (Scott, 2002). The importance of using palaeo-environmental information and archaeological evidence in conjunction with charcoal data is therefore essential. The use of charcoal analysis does have potential for estimating fire frequency, although there are constraints within the technique and potentially a need for more sophisticated charcoal analysis techniques (Scott, 2002).

4.4 RADIOCARBON ANALYSIS

Radiocarbon dating, developed in the 1940s by Libby has been described by Fredrick Johnson as the equivalent of an 'atomic bomb' being dropped on archaeology, and can be considered a watershed event in palaeo-research (Taylor, 2000). The use of radiocarbon dating has provided researchers with a technique with which to construct chronological phases of archaeological data (Taylor, 2000), thereby offering a mode of sound investigation.

There are various dating techniques which may be applied to the last ten million years, which are based on the decay of radioactive isotopes (Saarnisto, 1988). Provided that materials remain in a closed system, isotopes ratios can be seen as functions of time and original isotope composition as the rate of processes are known, and are not affected by environmental changes. There are however circumstances where these conditions are not met and the use of unstable isotopes are problematic. A variety of radiometric methods have been developed including uranium series, radiocarbon and potassium-argon (Saarnisto, 1988), however Accelerated Mass Spectrometry (AMS) Radiocarbon dating is commonly used as it can be used for dating organic materials up to an age limit of approximately 75,000 years. These include wood, charcoal, peat, lake sediment, and bones and teeth (Saarnisto, 1988; Williams *et al.*, 1998).

During their lifecycle, all living organism produce the radioactive Carbon-14 isotope (^{14}C /radiocarbon) while decay of the isotope occurs at an equal rate, resulting in a dynamic equilibrium. Once the organism dies the production of radiocarbon ceases, however the decay continues to occur at a half-life ($T_{1/2}$) of 5568 ± 30 years (Williams *et al.*, 1998). This rate of decay (Figure 4.1) is known as Libby's conventional figure, and may be used as a basis for all dates unless otherwise stated (Saarnisto, 1988; Williams *et al.*, 1998). Samples

dated may produce some statistical error, however calibration of dates and calculations of standard deviation is attainable. Statistical standard deviation for dates during the Holocene are often approximately 100 years (Saarnisto, 1988), and are ideal for studies related to this time period.

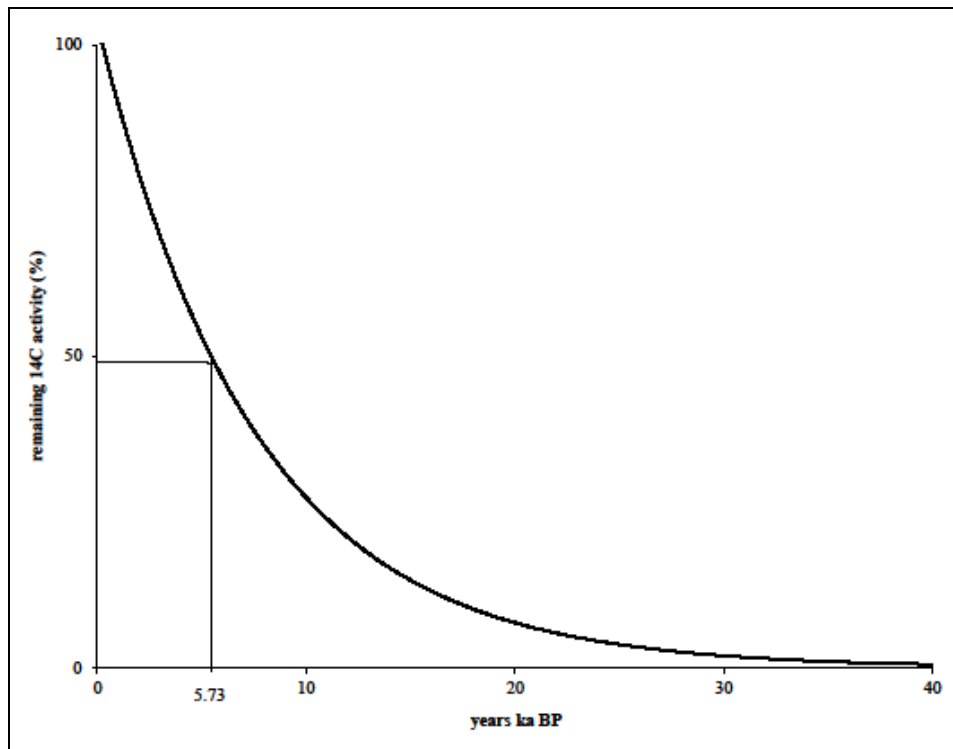


Figure 4.1 Radiocarbon decay curve (adapted from Walker, 2005)

A limitation, or possible error, which may occur during the use of radiocarbon dating is contamination of the sample, either by older or younger sediments (Saarnisto, 1988; Anderson *et al.*, 2007). This can however be limited by ensuring that the source of contamination is limited, and that field and laboratory procedures are carried out cautiously.

Obtaining a reliable chronology for a sediment core, allows for an age-depth model to be produced, described by Blaauw (2010: 1) as “the backbone of most palaeo-environmental studies”. These models are built on the assumption of how sediment has accumulated between samples of known calibrated age (Blaauw, 2010). Calibration of radiocarbon dates have allowed for more accurate results to be achieved, due to natural fluxes in ¹⁴C on a historical timescale (Saarnisto, 1988), and the importance of using calibrated ages cannot be

overstated (Blaauw, 2010). Calibration curves are available for the southern Hemisphere for the last 11,000 cal yr BP (McCormack *et al.*, 2004), and it was previously recommended by Pilcher (1991) that older dates remain uncalibrated.

4.5 TROELS-SMITH SEDIMENT CHARACTERISATION

Ideally, any system used for stratigraphic sediment description should not assume that the investigator has a strong background in the science, but rather facilitate the description of depositional environments (Kershaw, 1997). Troels-Smith (1955) possesses such characteristics, creating a widely-used tool for stratigraphic description (Williams *et al.*, 1998). The Troels-Smith (1955) methods allows for three major sediment properties to be incorporated into the description of the sediments. This method was modified by Kershaw (1997). The physical properties (darkness, stratification, elasticity, dryness, colour, structure and sharpness of boundaries) and humicity (degree of decomposition of organic material) are measured on a scale of 0 – 4. Components of the sediment (e.g. mosses, herbs and detritus) are noted, where the combined value of the components must not exceed 4. However, a slight change (of less than 5%) in the content of each component may be recorded as a plus or minus sign (Troels-Smith, 1955; Kershaw, 1997). Sediment properties and components are represented by symbols, which may be depicted more densely or overlapped with other symbols to represent the quantity of each component (Kershaw, 1997). The Troels-Smith (1955) system for classification of sediment is used to provide a diagrammatical description of the sediment stratigraphy. The system allows for the column to be plotted alongside pollen or other palaeo-ecological diagrams, which enables a number of core and sediment descriptions to be made concurrently (Kershaw, 1997).

4.6 GEOCHEMICAL ANALYSIS

The recent changes in atmospheric CO₂ and other greenhouse gases are likely to affect plant–atmospheric interactions, therefore information on how plants respond to their environment would enable researchers to examine the progression of environmental and climatological fluctuations (Gebrekirstos *et al.*, 2009). The natural abundance of stable isotopes is often used as an indicator of these ecosystem processes (Wang *et al.*, 2010), as environmental factors such as temperature, evaporation and moisture influence carbon isotope concentrations (Scott and Vogel, 2000). Soil organic matter has become a universal

terrestrial material used to provide insight to past environments, and carbon and nitrogen stable isotopic analyses ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) has become a common proxy for achieving these objectives (Terwilliger *et al.*, 2008).

Plants that utilize the C_3 and C_4 photosynthetic pathways fractionate atmospheric carbon differently during the production of carbohydrates, which results in distinguishing carbon isotope composition of the plant tissue (Johnson *et al.*, 1997). The photosynthetic pathways of Crassulacean Acid Metabolism (CAM) plants use a combination of the C_3 and C_4 photosynthetic pathways and have a carbon isotope composition between those of C_3 and C_4 plants (Johnson *et al.*, 1997). Analysis of $\delta^{13}\text{C}$ values have become a means of reconstructing C_3/C_4 compositions of vegetation, and their associated environmental conditions, as plants are a primary source of soil organic matter (Terwilliger *et al.*, 2008). On average, $\delta^{13}\text{C}$ values of C_3 plants are 15‰ lower than those of C_4 plants (Terwilliger *et al.*, 2008), and the distribution of C_3 and C_4 vegetation is controlled by temperature during the growing season (Vogel, 1978). C_3 vegetation consists primarily of woody vegetation such as trees and some shrubs, and grasses which experience cold growing seasons such as temperate or shaded forest areas (Johnson *et al.*, 1997; Smith *et al.*, 2002). C_4 vegetation consists predominantly of grasses and cereal crops which are adapted to growing during warm seasons, and shrubs which are adapted to growing during growth seasons with high temperatures and radiation, as experienced in the subtropical, savannah and arid regions of Africa (Johnson *et al.*, 1997; Smith *et al.*, 2002). In southern Africa, C_3 plants prefer growing conditions within a winter rainfall area and cool high altitude summer rainfall regions, whereas C_4 plants prefer warm summer rainfall regions (Smith *et al.*, 2002). CAM plants are able to conserve metabolic activity during periods of drought, allowing them to survive in arid conditions (Luo and Sternberg, 1991). Generally, C_4 grasses are found in warmer environments, whereas C_3 grasses are found in cooler environments (Cabido *et al.*, 1997), however at high altitude areas, both C_3 and C_4 grasses may occur and consideration needs to be given to C_3 and C_4 sedges occurring in wetland environments.

Nitrogen isotopes can be used in conjunction with carbon isotopes to provide information on palaeo-environments, however they have been less commonly used due to analytical difficulties. Analysis of nitrogen isotopes leads to greater difficulty in unambiguously

interpreting $^{15}\text{N}/^{14}\text{N}$ data, as there are more complexities involved in nitrogen inputs and fractionations within the environment (Leng *et al.*, 2006). Globally, plant $\delta^{15}\text{N}$ values normally range from -5 to $+8\text{‰}$, and soil $\delta^{15}\text{N}$ from 0 to $+8\text{‰}$. Values at a particular location can be partly determined by climate. Surface- and ground-water in areas not affected by pollution may contribute dissolved inorganic nitrogen and dissolved organic nitrogen with $\delta^{15}\text{N}$ between 0 to $+10\text{‰}$. Major sources of polluting nitrogen, such as fertilizers and human and animal waste, can increase values to as high as $+8$ to $+18\text{‰}$ (Leng *et al.*, 2006).

4.7 CONCLUSION

This chapter provides an evaluation of the theory and techniques of the various proxies (*viz.* pollen analysis; charcoal analysis; radiocarbon analysis; stratigraphic description and geochemical analysis) applied in this research. All proxies are discussed in terms of their general application, and limitations and theoretical background provided where necessary. Once all theoretical aspects of the research methods were considered, specific methods were chosen for the study based on their merit and appropriate application. The specific procedures and methods used for each proxy are discussed in Chapter Five, alongside the method used for collection of vegetation and pollen reference material, and for mapping and surveying vegetation communities at the research site, Dartmoor Vlei.

CHAPTER FIVE

METHODS

5.1 FIELD TECHNIQUES

5.1.1 Vegetation and pollen reference material

Flowering plants were identified and collected throughout the wetland and surrounding slopes to develop the existing pollen reference collection. All specimens which were not identified in the field were collected, pressed and identified in the herbarium or through the use of keys. Flower heads were collected in small, sealed plastic bags and silicon crystals were added to dry out the sample before processing.

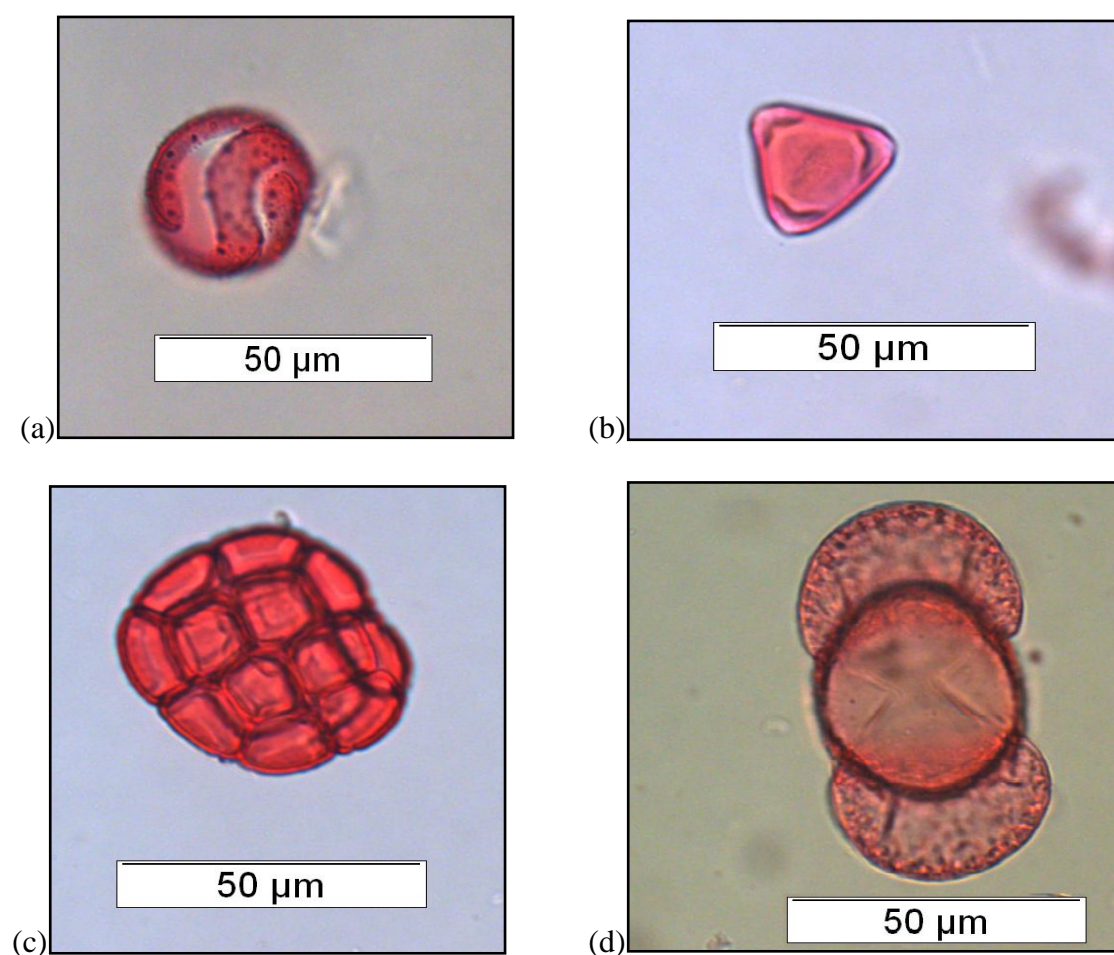


Plate 5.1 Examples of modern pollen reference slides: (a) *Eriocaulon dregei* (b) *Protea simplex* (c) *Acacia mearnsii* (d) *Podocarpus sp.*

Pollen was extracted from the sediment sample using the preparation procedure for reference material as revised from Hill (1992) and Baxter (1996) (Appendix A), and sample slides were mounted using glycerine jelly.

The pollen reference slides (Plate 5.1) were used to create a series of digital microphotographs which were used as additional reference material in the identification of fossil pollen extracted from the core.

5.1.2 Vegetation survey

A vegetation survey was conducted at Dartmoor Vlei between February 2010 and March 2010 within the wetland and on the slopes immediately surrounding the wetland (Figure 5.1). The Braun-Blanquet (1932) scale was used to quantify the percentage cover of each species identified in a 1 x 1 m quadrat (Table 5.1), and the total percentage vegetation cover of each quadrat was recorded.

Table 5.1 Conversion of Braun-Blanquet scale to % cover of individual species.

Braun-Blanquet Scale	Range of Cover (%)
5	76 – 100
4	51 – 75
3	26 – 50
2	6 – 25
1	1 – 5

Leucosidia sericea, the only large trees/shrubs at the site, was restricted to a single location. Where *L. seicea* dominated the quadrat, the canopy cover and height of each individual plant was recorded, and the number of stems from each individual plant with a diameter greater than 20 cm. A total of 58 quadrats were analysed.

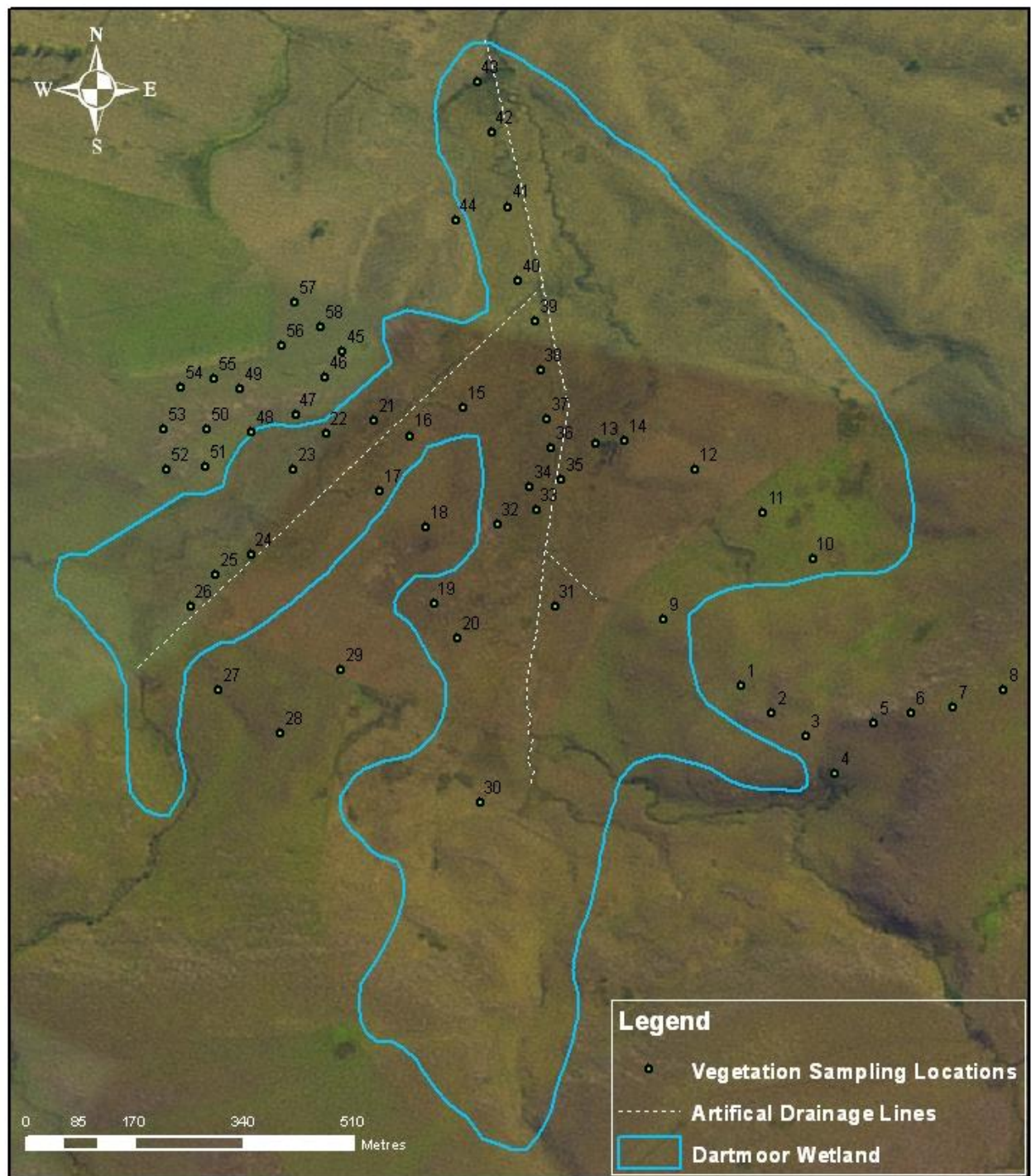


Figure 5.1 Location of Braun-Blanquet vegetation sampling quadrats in Dartmoor Vlei and immediate surroundings

5.1.3 Core extraction

The location for the extraction of a sediment core was chosen based on the depth established through the use of fibreglass rods inserted into the wetland sediment, and through reference

to sediment depths recorded by Edwards (2009). Two locations were identified at the deepest points of the wetland, DA1 (350 cm) and DA2 (240 cm), and cores were extracted using a Russian peat corer. The continuous sediment cores were extracted (Plate 5.2) with minimal disturbance to prevent contamination, and Troels-Smith (1955) stratigraphic description as adapted by Kershaw (1997) (Appendix B) was conducted in the field. On completion of the Troels-Smith analysis (Appendix C), the sediment cores were wrapped in aluminium foil and plastic, labelled, and transported to the laboratory and stored in a refrigerator until further analysis.



Plate 5.2 Extraction of a sediment core at Dartmoor Vlei using a Russian peat corer

5.2 LABORATORY TECHNIQUES

DA2 was chosen for detailed palaeo-ecological analyses based on the proportion of organic content of the sediment core. For the purpose of the pollen, charcoal and geochemical analyses the core was analysed to a depth of 196 cm due to very low organic content and lack

of fossil pollen in the residual saprolite layer at the base of the core. Although a stratigraphic description of the core was conducted in the field, it was repeated in the laboratory (Appendix C) using the Troels-Smith (1955) classification system.

5.2.1 Subsampling

The core was subsampled (Appendix D) at a fixed resolution of 2 cm, with the upper-most sample being at 10 cm. This was due to waterlogging and unconsolidated sediment at the top of the core. The core was subsampled to a depth of 196 cm as sediment beyond this depth comprised of predominantly residual saprolite and containing negligible organic components. Approximately 1 cm³ of sediment was extracted for each sample (Birks and Gordon, 1985). For the purpose of pollen analyses, samples were taken to a depth of 144 cm as initial pilot investigation indicated very low levels of pollen preservation in the lower samples. A schematic summary of analyses carried out on core DA2 is provided (Figure 5.3).

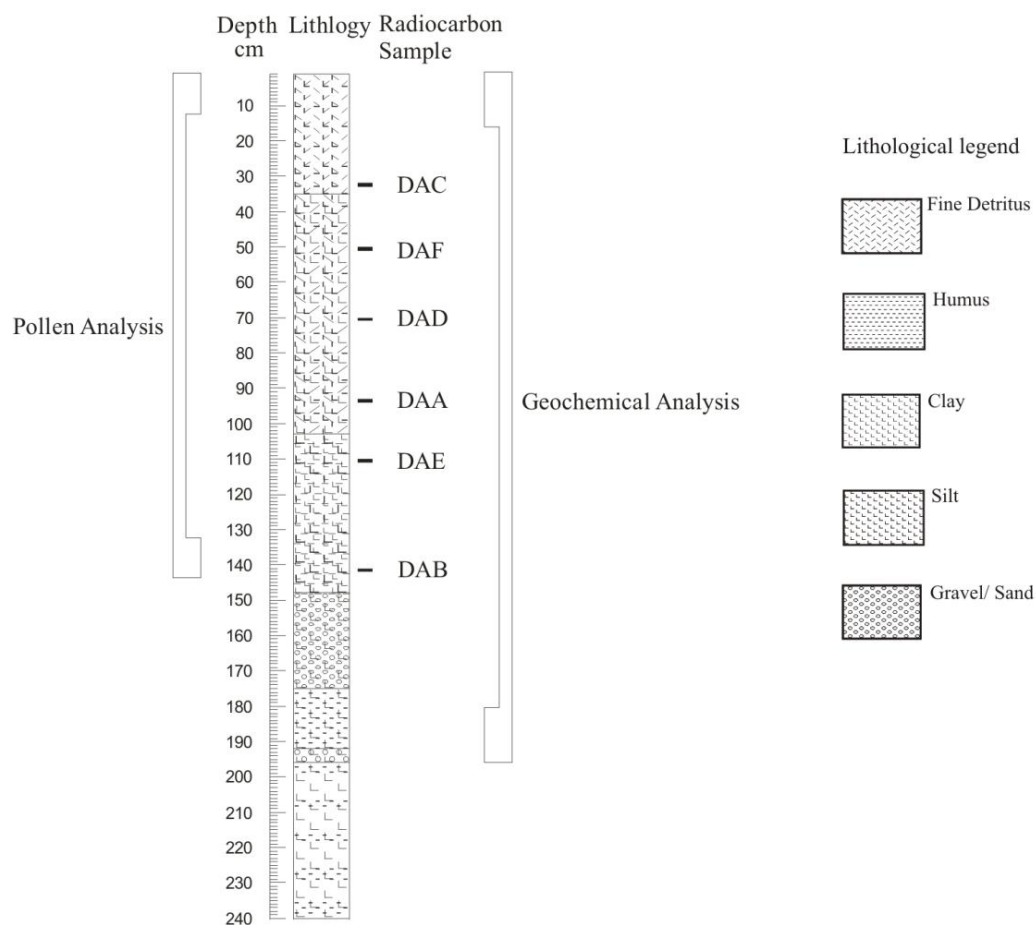


Figure 5.3 Summary of analyses carried out on core DA2

5.2.2 Chronology

5.2.2.1 Radiocarbon Dating

Accelerated Mass Spectrometry (AMS) radiocarbon dating was conducted at the University of Waikato (New Zealand), and Beta Analytic (Florida). Six samples were selected based on predetermined justification (Table 5.2). Samples were dried overnight and rootlets removed to ensure a dry-weight of at least 2 grams, to ensure adequate carbon content for AMS dating.

Table 5.2 Radiocarbon dates

Sample	Lab Codes	Depth (cm)	Justification
DAA	Wk-27732	93	Samples selected based on changes in the lithology of the core
DAB	Wk-27733	141	
DAC	Beta-286997	32	Samples selected based on changed observed in the geochemical results of the core
DAD	Beta-286998	70	
DAE	Beta-286999	110	
DAF	Beta-289909	51	Sample selected based on a gap in the existing age model

Radiocarbon ages were calibrated and an age model developed using CLAM (Classical Age Modelling) and R software, in conjunction with the southern Hemisphere calibration curve (SHCal04) as for ages younger than 11,000 ^{14}C yr BP (Blaauw, 2010). The calibration curve for the southern Hemisphere does not extend beyond 11,000 yr BP and therefore calibration of dates beyond this age was achieved using the international calibration curve (IntCal09) and corrected with a factor of 56 ± 24 years for the southern Hemisphere (McCormac *et al*, 2004; Blaauw, *per. comm.*, 2012).

5.2.2.2 Time stratigraphic marker horizons

Human impacts have had a profound impact on vegetation communities, even from a historical perspective. It is therefore not only important to consider such impacts when interpreting pollen diagrams (Faegri and Iverson, 1989), but to use historical documentation

relating to human presence and occurrence of certain pollen taxa as stratigraphic markers. *Pinus* and *Zea mays* are two exotic taxa which can be used as stratigraphic markers. Although no exact dates exist for the first *Z. mays* crop production in the Karkloof, KwaZulu-Natal became inhabited by the Iron Age people approximately 2000 - 1500 years ago, and indication of the presence of these people in the Midlands region has been found in archaeological evidence (Mazel, 1989). *Z. mays* is also present in the Lake Sibaya record at this time (Stager *et al.*, 2013). The clearance of natural vegetation for cultivation of exotic plantations began in the Karkloof in 1876 with the establishment of Black Wattle (Sherry, 1968). *Pinus* was first introduced into South Africa as early as the late 1600s by colonial settlers and to the coastal region of KwaZulu-Natal from about 1928 (Neumann *et al.*, 2010). The establishment of *Pinus* plantations in the Karkloof possibly only took place in the 1950s and 1960s (McCann, 2012, *pers. com.*). Although these figures do not provide precise dates, they can be used to establish a minimum age constraint for the introduction of each of these taxa in the region.

5.2.3 Stable Light Isotope Analysis

Carbon and nitrogen isotope analysis was carried out at the Department of Archaeology, University of Cape Town. Eighty-nine samples (taken at a resolution of 2 cm) were used to determine %N, $\delta^{15}\text{N}$, %C, $\delta^{13}\text{C}$, and the C:N ratio of each sample.

Samples were weighed into tin cups to an accuracy of 1 microgram on a Sartorius micro balance. The cups were then squashed to enclose the sample. The samples were combusted in a Flash EA 1112 series elemental analyzer (Thermo Finnigan, Milan, Italy). The gases were passed to a Delta Plus XP IRMS (isotope ratio mass spectrometer) (Thermo Electron, Bremen, Germany), via a Conflo III gas control unit (Thermo Finnigan, Bremen, Germany) (Newton, *pers. comm.*, 2012).

5.2.4 Gravitational separation technique

The gravitational separation (swirling) technique (Wheeler, 2007; Hunt and Rushworth, 2005) was used for the separation of fossil pollen and charcoal fragments from the 68 subsamples extracted from the core. Based on the principle of gravitational separation,

pollen and charcoal fragments remain in suspension in a swirling dish and can therefore be poured off, while heavier objects remain at the bottom of the solution (Appendix E). The solution containing fossil pollen was mounted onto semi-permanent microscope slides using an Aquamount solution (Aquatex, refractive index 1.4), and refrigerated until analysis.

5.2.5 Pollen Counts

Pollen counts were conducted along fixed transects on the slides, and all pollen grains within the field of view (at 40X magnification) were counted and identified using a Leica DM750 microscope. Where pollen grains were not easily identified, images were taken and the location of the grain was recorded to identify at a later stage. All grains were counted, with the exception of those which were damaged beyond recognition, folded, or corroded. Where pollen clusters (2 or more grains) of the same palynomorph occurred, these were recorded as a single occurrence to avoid an over-representation of the vegetation type (Faegri and Iversen, 1989). A number of reference material sets (including those made from samples collected from Dartmoor Vlei) were used to identify pollen grains and spores. Reference material data sets include those housed at the Geography Department (UKZN), and the African Pollen Database.

To obtain a representative sample of the parent vegetation, a minimum of 500 pollen grains were counted for each sample. The number of transects that required counting varied between samples due to level of pollen preservation and concentration of the sample on the slide. For each sample, complete transects were counted even once the minimum of 500 pollen grains was achieved.

5.2.6 Pollen diagrams

Pollen, charcoal and geochemical data were plotted using Psimpoll Version 4.263 (Bennett, 2005). Pollen and charcoal diagrams were plotted for 144 cm of the core, and geochemical data for 190 cm of the core. Pollen diagrams were plotted for Regional and Local Pollen sums, and for a comparison of grassland and indigenous forest taxa. Pollen which most likely originated from immediate surrounds of the wetland was classed as local pollen, whereas pollen from the surrounding region was classed as regional pollen. Rare taxa (<0.1% of the Regional pollen sum), were excluded from the pollen diagrams. Zonation of

pollen data was achieved through the use of the CONISS function in Psimpoll, and based on the sum of the regional pollen count. Diagrams were amended and merged using CorelDRAW X3.

CHAPTER SIX

RESULTS

6.1 VEGETATION DESCRIPTION

Vegetation surrounding Dartmoor Vlei depicted various zones where changes in vegetation composition occurred. A schematic drawing was done and a map created (Figure 5.1) of where vegetation was sampled using the Braun-Blanquet classification system. The area within the perimeter of the wetland, and the north-west and south-east facing slopes were sampled. Results for individual quadrats (1 – 58) are provided (Appendix I). A list of species found at Dartmoor Vlei and their average relative abundance (Braun-Blanquet) is provided (Table 6.1), indicating that Cyperaceae and Poaceae are the most dominant.

Table 6.1 Relative abundance of species recorded at Dartmoor Vlei

Species	Relative abundance	Species	Relative abundance
Cyperaceae spp.	1.690	<i>Panicum sp.</i>	0.052
<i>Eragrostis curvula</i>	0.603	<i>Protea simplex</i>	0.052
<i>Themeda triandra</i>	0.603	<i>Pteridium aquilinum</i>	0.052
Poaceae spp.	0.569	<i>Watsonia densiflora</i>	0.052
<i>Tristachya leucothrix</i>	0.379	<i>Xyris capensis</i>	0.052
<i>Eragrostis capensis</i>	0.362	<i>Agapanthus sp.</i>	0.034
<i>Aristida sp.</i>	0.345	<i>Asteraceae sp.</i>	0.034
<i>Helichrysum spp.</i>	0.328	<i>Brunsvigia grandiflora</i>	0.034
<i>Calopsis paniculata</i>	0.310	<i>Cyanotis speciosa</i>	0.034
<i>Pychnostachys reticulata</i>	0.293	<i>Helichrysum adenocarpum</i>	0.034
<i>Acalypha sp.</i>	0.276	<i>Rhus bicolor</i>	0.034
<i>Eriocema distinctum</i>	0.276	<i>Rusus auneifolius</i>	0.034
<i>Eriocaulon dregei</i>	0.224	<i>Sateria sp.</i>	0.034
<i>Senecio isatidioides</i>	0.224	<i>Sebaea natalensis</i>	0.034
<i>Trachypogon spicatus</i>	0.207	<i>Agrimonia procera</i>	0.017
<i>Geranium schlechteri</i>	0.190	<i>Aristea woodii</i>	0.017
<i>Juncus lamatophyllus</i>	0.190	<i>Aristida congesta</i>	0.017
<i>Mentha aquatic</i>	0.190	<i>Berkheya achinacea</i>	0.017
<i>Carex cognate</i>	0.172	<i>Bherkeya rhapontica</i>	0.017
<i>Eriosema sp.</i>	0.172	<i>Commelia Africana</i>	0.017
<i>Rubus auneifolius</i>	0.155	<i>Crussula natalensis</i>	0.017
<i>Scenecio sp.</i>	0.155	<i>Erica woodii</i>	0.017

Species	Relative abundance	Species	Relative abundance
<i>Stiburus allopecuroides</i>	0.155	<i>Eragrostis sp.</i>	0.017
<i>Aristida junciformis</i>	0.138	<i>Geranium cafferum</i>	0.017
<i>Heteropogon contortus</i>	0.138	<i>Habenaria dives</i>	0.017
<i>Lobelia flaccida</i>	0.138	<i>Harpocloa flax</i>	0.017
<i>Typha capensis</i>	0.138	<i>Helichrysum spiralepis</i>	0.017
<i>Diclis reptans</i>	0.121	<i>Helishrysum spiralepis</i>	0.017
<i>Eragrostis sp.</i>	0.121	<i>Heteropogon sp.</i>	0.017
<i>Tephrosia sp.</i>	0.121	<i>Hypoxis filiformus</i>	0.017
<i>Geranium sp.</i>	0.103	<i>Hypoxis parvula</i>	0.017
<i>Lotonis sp.</i>	0.103	<i>Kniphofia laxiflora</i>	0.017
<i>Monocymbium cerasiiforme</i>	0.103	<i>Monopsis decepiens</i>	0.017
<i>Sutera floribunda</i>	0.103	<i>Polygala hottentota</i>	0.017
<i>Eucomis sp.</i>	0.086	<i>Rubus ludwigii</i>	0.017
<i>Persicaria serrulata</i>	0.086	<i>Rubus proteus</i>	0.017
<i>Schoenoplectus corymbosus</i>	0.086	<i>Sabeae natalensis</i>	0.017
<i>Eragrostis racemosa</i>	0.069	<i>Schistostephium crataegifolium</i>	0.017
<i>Helichrysum aureonitens</i>	0.069	<i>Senecio oxyriifolius</i>	0.017
<i>Hypochaeris radicata</i>	0.069	<i>Silene burchellii</i>	0.017
<i>Rhus discolor</i>	0.069	<i>Sporobolus sp.</i>	0.017
<i>Alectra sessiliflora</i>	0.052	<i>Stachys natalensis</i>	0.017
<i>Dinekia capensis</i>	0.052	<i>Vernonia hirsute</i>	0.017
<i>Macowania corymbosa</i>	0.052	<i>Vernonia thodey</i>	0.017
Moss (<i>Lycopodium</i> type)	0.052	<i>Zornia linearis</i>	0.017
<i>Oxalis obliquifolia</i>	0.052		

6.2 TROELS-SMITH STRATIGRAPHIC DESCRIPTION

The sediment core (Plate 6.1) was divided into stratigraphic units according to Troels-Smith stratigraphic description (Appendix D), with stratigraphic unit boundaries at the following depths: 19 cm; 35 cm; 103 cm; 148 cm; 165 cm; 175 cm; 192 cm; 196 cm and 240 cm (Figure 6.1). The core consisted of a very dark brown fibrous top layer (0-35 cm) containing *Detritus granosus*, *Substantia humosa*, *Argilla steatodes* and *Argilla granosa*, progressing gradually to lighter brown and olive brown sediment containing less *Detritus granosus* to 148 cm. The base of the core consisted of a turquoise-coloured residual saprolite containing *Argilla steatodes* and *Argilla granosa*, with layers of *Grana minora* and *Grana majora* at 148-175 cm and 192-196 cm. The surface layers of the core consisted of mostly organic material, progressing to more clay and silt towards the base of the core.

6.3 RADIOCARBON ANALYSIS

Although the length of the core was 240 cm, the bottom most subsample for radiocarbon dating was taken at 141 cm and indicated an age of 10,379 \pm 45 yr BP (Table 6.2). No age reversals were evident in the age model, indicating that no disturbance or reworking of sediment occurred at Dartmoor Vlei to this depth (Figure 6.2).

Table 6.2 Radiocarbon results for Dartmoor Vlei, indicating calibrated and uncalibrated ages.

Sample	Lab Codes	Depth (cm)	^{14}C yr BP	Cal yr BP Range
DAC	Beta-286997	32	940 \pm 40	670 - 774 (92.8%)
DAF	Beta-289909	51	2770 \pm 40	2750 - 2886 (92.4%)
DAD	Beta-286998	70	6090 \pm 40	6671 - 6892 (95%)
DAA	Wk-27732	93	8074 \pm 40	8718 - 9021 (94.8%)
DAE	Beta-286999	110	8870 \pm 50	9548 - 9834 (87.7%)
DAB	Wk-27733	141	10,379 \pm 45	11,983 – 12,239 (65.9%)

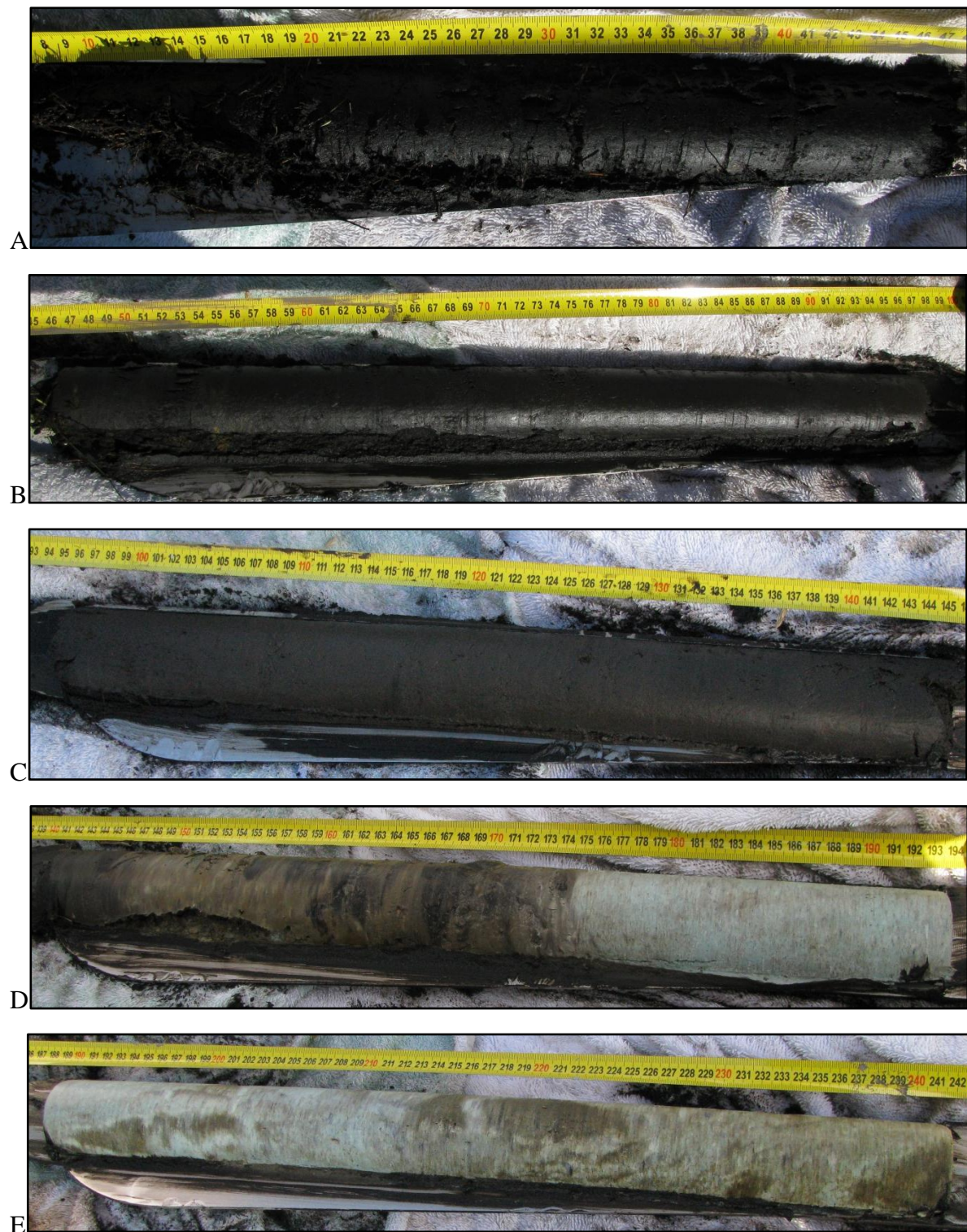


Plate 6.1 Sediment core DA2 extracted from Dartmoor Vlei. Core depths depicted:
A. 0 – 48 cm; B. 48 – 96 cm; C. 96 – 144 cm; D. 144 – 192 cm; E. 192 – 240 cm.

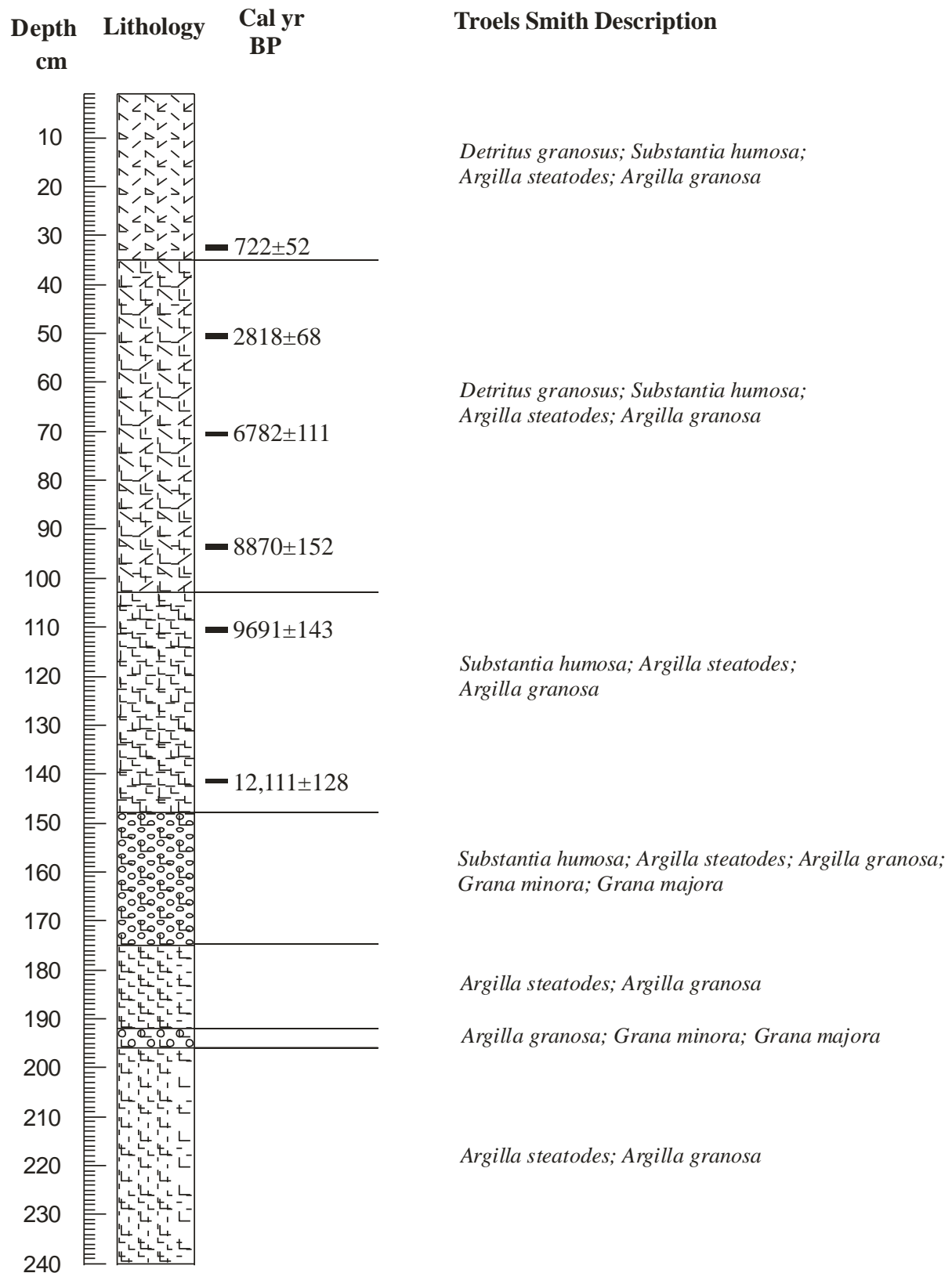


Figure 6.1 Troels-Smith stratigraphic description of core DA2, indicating cal yr BP

6.3.1 Age model

A summary of all calibrated ages (Table 6.2) and calibrations for individual ages were created (Appendix F, Appendix G). Further age-models were created using various interpolation styles (Appendix H), but based on parsimony, the linear interpolated calibration curve is used to depict the age-depth model for Dartmoor Vlei.

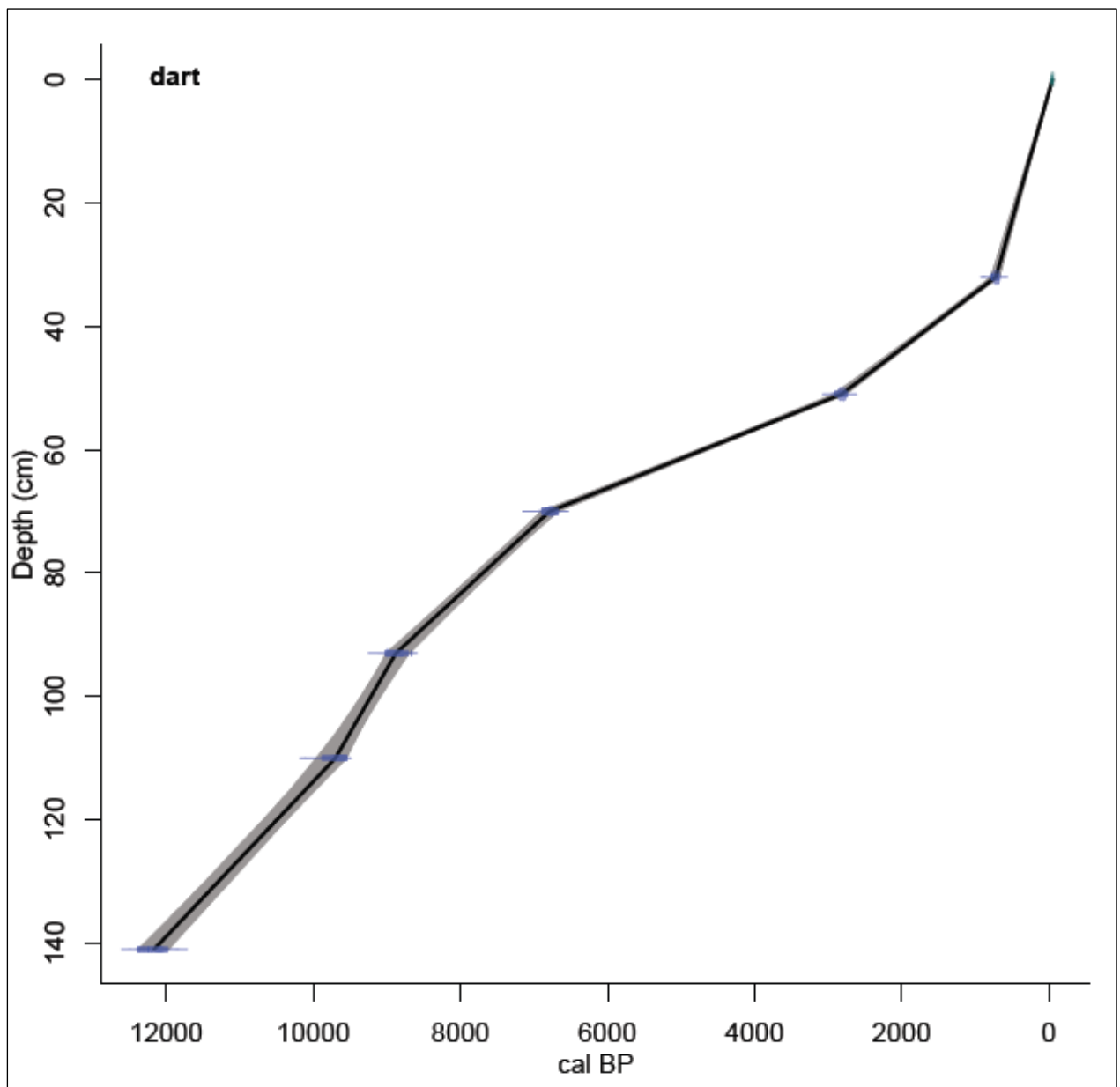


Figure 6.2 Calibrated linear interpolation age-depth model for Dartmoor Vlei

6.3.2 Sedimentation rates

Sedimentation rates at Dartmoor Vlei between the present and 722 ± 52 cal yr BP are highest at 0.044 cm/yr. Sedimentation rates decrease thereafter to an average of 0.009 cm/yr, 0.005 cm/yr and 0.012 cm/yr for the age ranges 722 ± 52 to 2818 ± 68 , 2818 ± 68 to 6782 ± 111 and 6782 ± 111 to 8870 ± 152 cal yr BP, respectively. Between 8870 ± 152 to 9691 ± 143 cal yr BP the sedimentation rates increase to an average of 0.021 cm/yr, followed by a decrease in the average rate to 0.013 cm/yr for the period 9691 ± 143 to $12,111 \pm 128$ cal yr BP (Table 6.3).

Table 6.3 Average sediment accumulation rates for Dartmoor Vlei

Depth Range (cm)	Age range (cal yr BP)	Average accumulation rate (cm/yr)
0 - 32	present - 722 ± 52	0.044
32 - 51	722 ± 52 - 2818 ± 68	0.009
51 - 70	2818 ± 68 - 6782 ± 111	0.005
70 - 93	6782 ± 111 - 8870 ± 152	0.012
93 - 110	8870 ± 152 - 9691 ± 143	0.021
110 - 141	9691 ± 143 - $12,111 \pm 128$	0.013

6.4 ZONATION OF CORE MATERIAL

Five zones were derived from the Constrained Incremental Sum of Squares (CONISS) function (Figure 6.3) in Psimpoll to assist in the description and interpretation of pollen, charcoal and geochemical data. Zones are divided where minor stratigraphic intervals occur, and for the purpose of this research, the CONISS zonations are based on regional pollen data. Zonations D4 to D1 are based on the regional pollen sum, but as Zone D0 (144-190 cm) lacks corresponding pollen data it therefore comprises of a separate zone for the geochemical data alone. Zone D3 accounts for a large portion of the record (*ca.* 6864 cal yr), but due to minimal changes occurring over this time-period, the zone was not further subdivided.

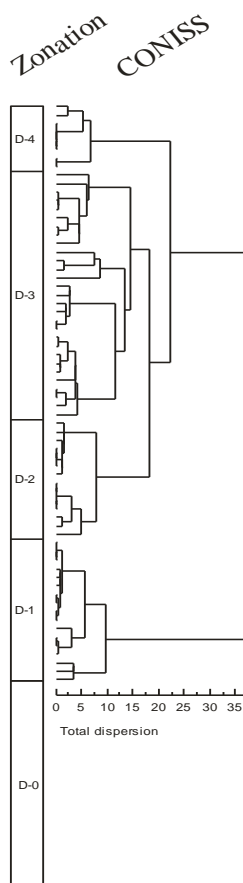


Figure 6.3 Zonation derived from CONISS, based on the regional pollen sum

6.5 GEOCHEMICAL ANALYSIS

The results for geochemical analyses (Appendix J) are shown in Figure 6.4, and a depiction of the relationship between $\delta^{13}\text{C}$ and C:N results (Figure 6.5) are provided.

Zone D0: 190-144 cm; undetermined - *ca.* 12,100 cal yr BP

The Total Organic Carbon (TOC) and Total Nitrogen (TN) contents of Zone D0 are very low, although slight increases are observed towards the top of the zone. The $\delta^{13}\text{C}$ values are relatively constant throughout the zone at approximately -20 to -22 ‰. The $\delta^{15}\text{N}$ values increases to a peak of 6.06‰ at 174 cm (>12,167 cal yr BP), thereafter decreasing to the base of the zone. The C:N ratio fluctuates throughout the zone with minimum values of approximately 6 at 154, 170 and 174 cm (>12,167 cal yr BP). Zone D0 indicates C_3 vegetation and a mix of terrestrial and aquatic plants during this time period.

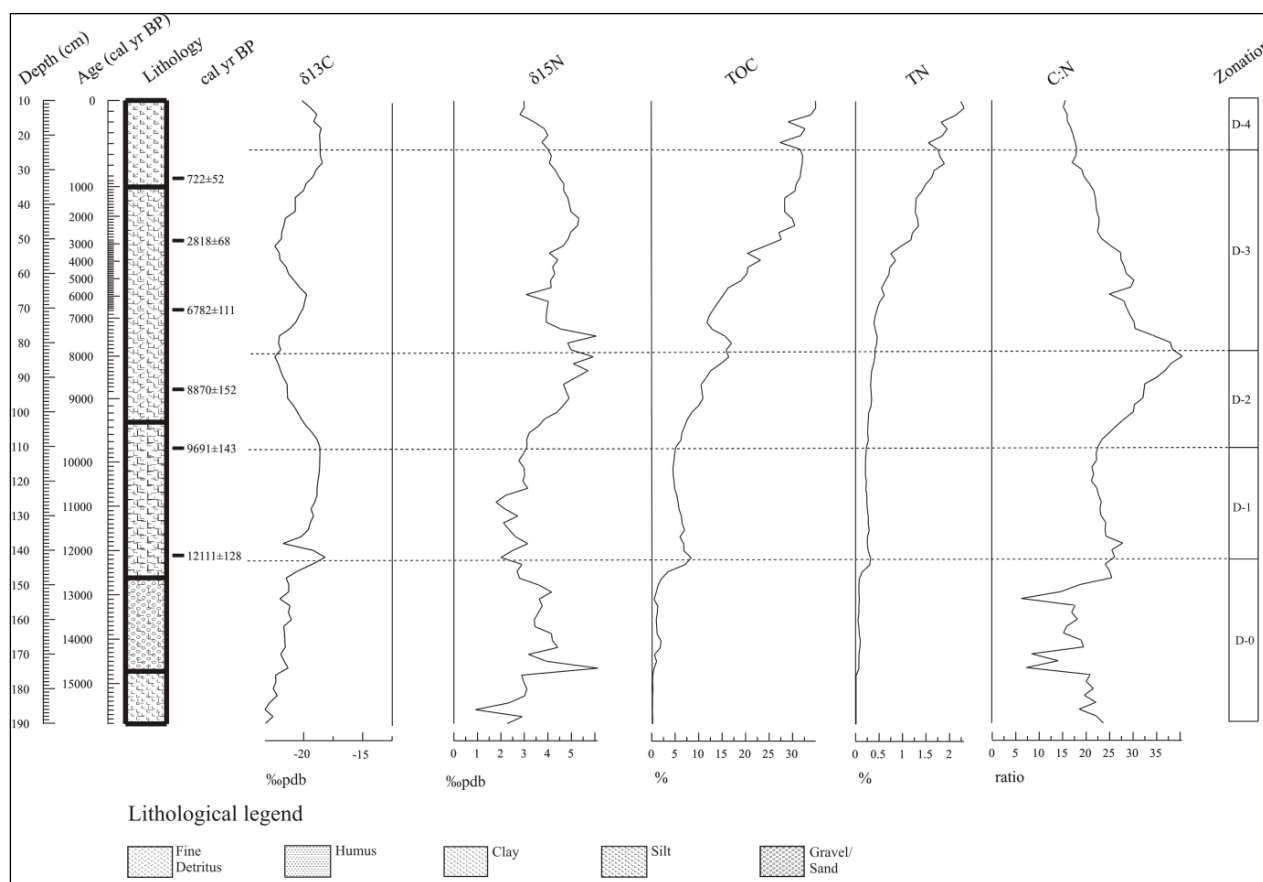


Figure 6.4 Geochemical analysis

Zone D1: 144-110 cm; *ca.* 12,100 - 9690 cal yr BP

The Total Organic Carbon and Total Nitrogen content increases slightly in Zone D1, although both values are still low at TOC of *ca.* 5-6% and TN of *ca.* 0.2-0.3%. The $\delta^{13}\text{C}$ values at the top of the zone at *ca.* -18‰, however changes are observed at the base of the zone where values fluctuate from -18 to -21 at 12,200 cal yr BP and 11,900 cal yr BP respectively. The $\delta^{15}\text{N}$ values fluctuate between 2 and 3‰ throughout the zone, and the C:N ratio remains constant at *ca.* 23.3. In this zone, there is a higher proportion of C_4 and terrestrial vegetation.

Zone D2: 110 - 83 cm; 9690 - 7970 cal yr BP

In Zone D2, the Total Nitrogen values remain unchanged from Zone D1, however Total Organic Carbon increases from *ca.* 5% at the base of the zone to *ca.* 16.5% at the top of the zone. The C:N ratio also increases from *ca.* 22.5 to *ca.* 40.5 from the base of the zone to the

top of the zone respectively. $\delta^{15}\text{N}$ values increase in Zone D2, while $\delta^{13}\text{C}$ values show a constant decrease. A mixture of C_3 and C_4 terrestrial vegetation occurs during this time period.

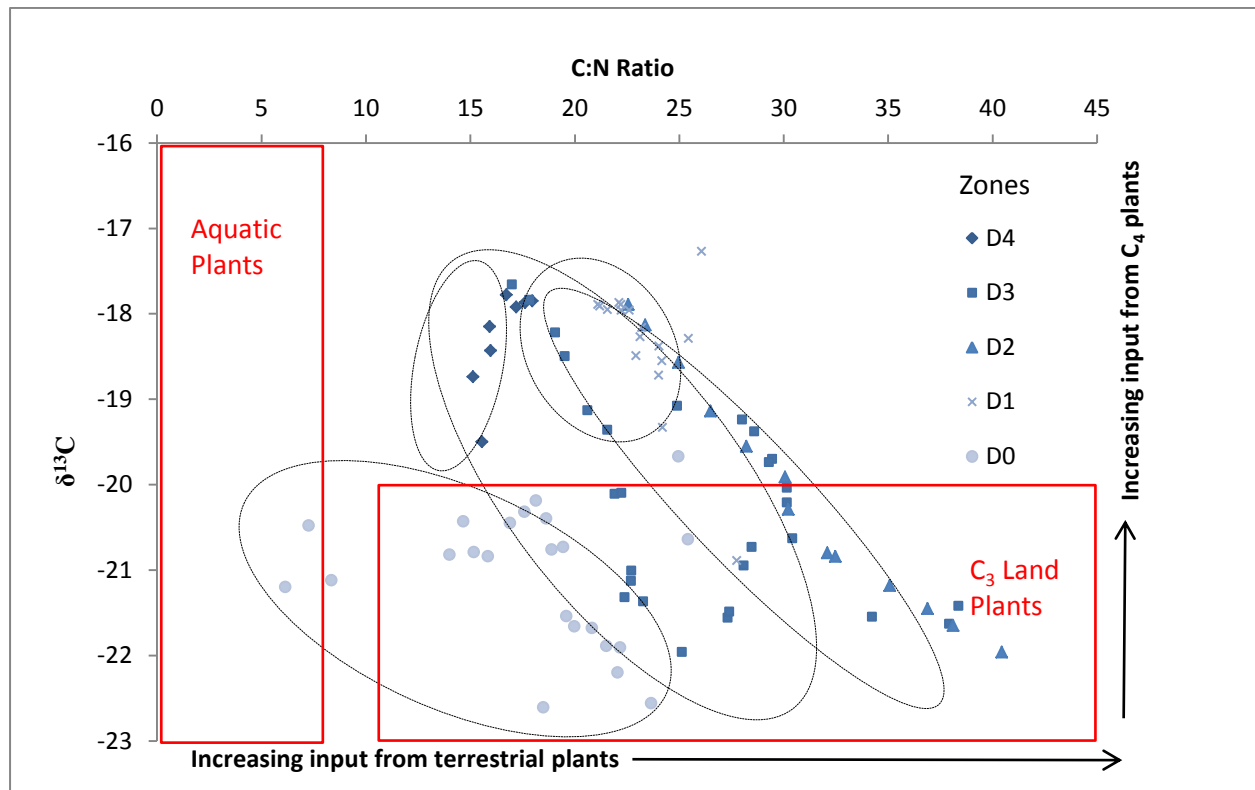


Figure 6.5 $\delta^{13}\text{C}$ versus C:N relationship

Zone D3: 83 - 25 cm; 7970 - 550 cal yr BP

In Zone D3, the Total Nitrogen content begins to increase steadily from *ca.* 0.4% at the base of the zone to *ca.* 1.9% at the top of the zone. The Total Organic Carbon decreases briefly at the base of the zone, but then begins to increase once again. $\delta^{13}\text{C}$ values generally increase in Zone D3, however there is a decrease in the values between 6000 and 3000 cal yr BP. $\delta^{15}\text{N}$ values fluctuate from the base of the zone to *ca.* 44 cm, and then decreases steadily. The C:N decreases in Zone D3, except for a brief period between 6000 and 6400 cal yr BP, during which it increases. As in Zone D2, A mixture of C_3 and C_4 terrestrial vegetation occurs during this time period.

Zone D4: 25 - 0 cm; 550 - present cal yr BP

In Zone D4, both $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values decrease at the top of the zone. Total Nitrogen and Total Organic Carbon both increase overall, reaching the highest content at the top of the core, while the C:N ratio decreases negligibly, and Zone D4 indicates a dominance of C_4 vegetation.

6.6 POLLEN ANALYSIS

Pollen taxa were grouped according to four primary parameters: local, regional, arboreal and non-arboreal. Neophytes, aquatic taxa, *Pseudoschizae* and undetermined taxa were differentiated, and forest and grassland taxa divided. A total of 49 pollen taxa were identified (Table 6.4, Appendix K), and plotted using selected classifications (Table 6.5). CONISS was applied to the regional pollen diagram to create four zones which were used in the description and interpretation of pollen data (Figure 6.3).

The following pollen diagrams were plotted against the age-profile of the core, and the depth of the core:

- i) Regional (Figure 6.6 and Appendix L)
- ii) Total (Appendix L)
- iii) Afromontane Forest and Grassland (Figure 6.7 and Appendix L)

In addition, local pollen taxa were plotted against the age and depth profiles (Appendix L) for reference purposes.

Table 6.4 Classification of taxa according to regional, local, arboreal and non-arboreal groupings (*indicates taxa with total counts of <1%)

Regional Taxa		
AMARANTHACEAE		non-arboreal
ASTERACEAE	<i>Artemisia</i>	non-arboreal
ASTERACEAE	<i>Stoebe</i> *	non-arboreal
ASTERACEAE	undiff.	non-arboreal
ASTERACEAE	<i>Vernonia</i> *	non-arboreal
BORAGINACEAE	<i>Heliotropium</i> *	non-arboreal
COMMELINACEAE	*	non-arboreal
DIPSACACEAE	<i>Scabiosa</i>	non-arboreal
ERICACEAE		non-arboreal
EUPHORBIACEAE	<i>Euphorbia</i>	non-arboreal
EUPHORBIACEAE	undiff.	non-arboreal
FABACEAE		non-arboreal
GERANIACEAE	*	non-arboreal
HYPERICACEAE	<i>Hypericum</i> *	non-arboreal
IRIDACEAE	undiff.	non-arboreal
LAMIACEAE	undiff.	non-arboreal
LAMIACEAE	<i>Leonotis</i> *	non-arboreal
OXALIDACEAE	<i>Oxalis</i> *	non-arboreal
THYMELIACEAE		non-arboreal
ACANTHACEAE		arboreal
ANACARDIACEAE		arboreal
APIACEAE	*	arboreal
AQUIFOLIACEAE	<i>Ilex mitis</i> *	arboreal
ARALIACEAE		arboreal
BORAGINACEAE	<i>Cordia</i>	arboreal
BRASSICACEAE		arboreal
CELASTRACEAE	*	arboreal
CELTIDACEAE	<i>Celtis</i>	arboreal
CORNACEAE	<i>Cornus</i> *	arboreal
EBENACEAE	<i>Diospyros</i> *	arboreal
EBENACEAE	<i>Euclea</i>	arboreal
EBENACEAE	undiff.*	arboreal
MYRICACEAE	<i>Myrica</i> *	arboreal
MYRTACEAE		arboreal
OLEACEAE		arboreal
PODOCARPACEAE	<i>Podocarpus</i>	arboreal
POLYGALACEAE	<i>Polygala</i> *	arboreal
PROTEACEAE		arboreal
ROSACEAE	<i>Cliffortia</i>	arboreal
ROSACEAE	<i>Leucosidea</i>	arboreal
ROSACEAE	undiff.*	arboreal

Local Taxa	
CYPERACEAE undiff.	non-arboreal
ERIOCAULACEAE <i>Eriocaulon</i>	non-arboreal
HALORAGACEAE	non-arboreal
LILIACEAE	non-arboreal
POACEAE	non-arboreal
MONOLETE spore	
TRILETE spore	
TRILETE <i>Mohria</i> spore	

Neophytes

POACEAE <i>Zea mays</i>	non-arboreal
MIMOSOIDEAE Type II	arboreal
PINACEAE <i>Pinus</i>	arboreal

Non-pollen Palynomorphs

<i>Pseudoschizea</i>
Undetermined
Non-pollen palynomorphs

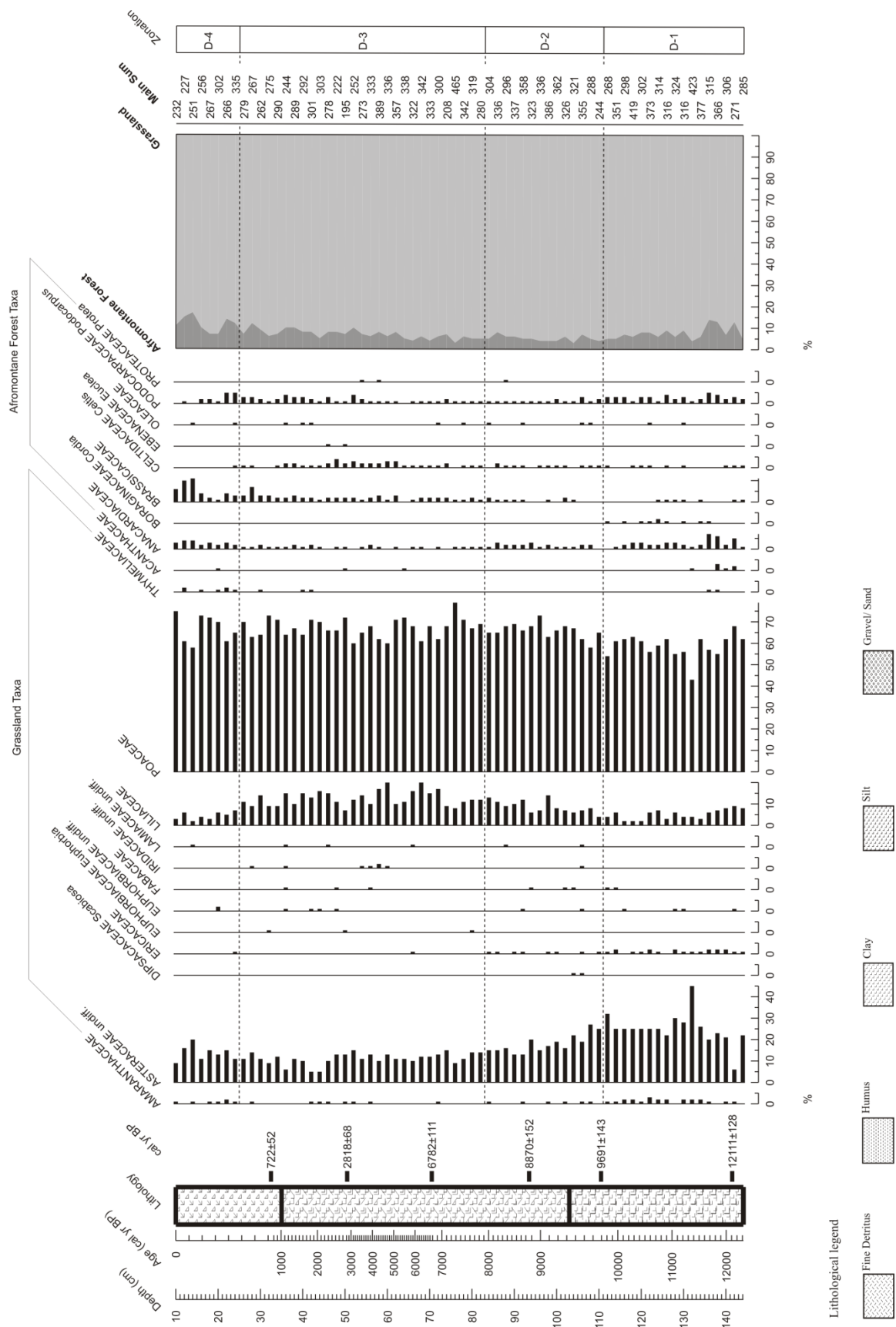


Figure 6.7 Grassland and Indigenous forest taxa plotted against depth and time

Zone D1: 144-110 cm; ca.12,100 - 9690 cal yr BP

Regional taxa dominating this zone are Asteraceae, Ericaceae, Anacardiaceae and *Podocarpus*. Asteraceae declines at 12,100 cal yr BP, however the majority of the zone indicates high frequencies of this taxon. Ericaceae is found in highest concentration in this zone, and frequency of Anacardiaceae increases later in the zone. *Podocarpus* does not show drastic change in this zone, although concentrations are relatively high. Brassicaceae and *Celtis* concentrations show a marked decline, whereas *Cordia* indicates a positive increase. Liliaceae concentrations are slightly lower at the early parts of the zone, but increase towards the later in the zone. There are no systematic changes in the concentration of Poaceae, however Cyperaceae frequencies decrease briefly at ca. 12,000 cal yr BP and ca. 10,300 cal yr BP. Generally, Afromontane forest/arboreal taxa increase in this zone, and regional pollen signals are high.

Zone D2: 110 - 83 cm; 9690 - 7970 cal yr BP

Asteraceae, Ericaceae, Anacardiaceae and *Podocarpus* dominate this zone in terms of regional taxa, although there is also a marked increase in the frequency of Brassicaceae towards the early part of the zone. Asteraceae decreases marginally, whilst Anacardiaceae and *Celtis* increase towards the early part of the zone. There are no systematic changes in the frequency of *Podocarpus* and Ericaceae. There is a brief increase in *Protea* between ca. 8900 and ca. 8500 cal yr BP, and Liliaceae frequency begins to increase towards the early part of the zone. Poaceae and Cyperaceae frequencies are mirrored in this zone, with Poaceae increasing in the mid-zone and decreasing towards the early and late stages of the zone. Overall, Afromontane forest/ arboreal pollen signals decrease marginally in this zone, with local pollen signals strengthening towards the early stages of the zone.

Zone D3: 83 - 25 cm; 7970 - 550 cal yr BP

Zone D3 represents a significant portion of the record of Dartmoor Vlei. Dominant regional taxa in this zone are Asteraceae, Anacardiaceae, Brassicaceae, *Celtis* and *Podocarpus*. Overall, Asteraceae frequencies are lower in this zone. There is a brief decrease between ca. 2260 and ca. 1160 cal yr BP, and a slight increase towards the younger part of the zone. There are no significant changes in Anacardiaceae frequencies, although a relative increase in frequencies can be noted at ca. 1930 and ca. 720 cal yr BP. Brassicaceae and *Podocarpus*

show a generally increasing trend in the frequencies from the base of the zone towards the younger region of the zone, whereas *Celtis* increases significantly in the mid-range of this zone. *Protea* frequencies also increase between *ca.* 7500 and *ca.* 3650 cal yr BP, however decrease again towards the younger region of the zone. *Zea mays* occurs for the first time in the records between *ca.* 1600 and *ca.* 650 cal yr BP, however it is the only exotic taxon recorded in this zone. Locally, Liliaceae frequencies increase. There are no significant changes in Poaceae and Cyperaceae frequencies; however a relative increase in Poaceae frequency at *ca.* 5100 cal yr BP indicates a corresponding decrease in Cyperaceae. Similarly, an increase in Cyperaceae at *ca.* 2700 cal yr BP is mirrored by a decrease in Poaceae frequencies. There are no notable changes in the proportion of regional and local pollen taxa, however the local signal is stronger in this zone than the previous zones. Forest and grassland taxa, however, indicates that there is a slight increase in the number of Afromontane forest taxa in this zone, increasing marginally from the base of the zone towards the top.

Zone D4: 25 - 0 cm; 550 - present cal yr BP

Zone D4 indicates a decrease in *Ericaceae*, *Celtis* and *Protea*, which were more frequent in Zone D3. Brassicaceae and Anacardiaceae frequencies are high in this zone, and Thymeliaceae frequencies increase from previous zones. *Leucocidea sericea* is present for the first time in the record. *Zea mays* is once again found at the base of the zone at *ca.* 530 cal yr BP only, and Mimosoideae Type II occurs singly at *ca.* 240 cal yr BP. *Podocarpus* frequencies decrease notably in zone D4, whilst *Pinus* is present for the first time in the record, and increase significantly from *ca.* 450 cal yr BP towards the top of the zone. Regional pollen taxa increase marginally from the previous zone. Asteraceae frequencies are high, although Liliaceae decreases towards the top of the zone. Poaceae and Cyperaceae frequencies do not differ significantly from the top of the previous zone, however the proportion of Afromontane forest taxa increases slightly.

6.7 CHARCOAL ANALYSIS

Charcoal counts (Bhugeloo, 2011) were divided into four size-classes, being: <25 µm; 25 - 75 µm; 75 - 150 µm and >150 µm. Once raw charcoal counts (Appendix M) were obtained (Bhugeloo, 2011), charcoal diagrams were plotted using Psimpoll 4.25. For ease of

comparison, charcoal zonation was based on the zonation obtained by applying the CONISS function to the regional pollen counts, allowing for four similar zones to be created. For the purpose of interpretation, charcoal diagrams were plotted as frequencies and fragment (Appendix N) counts against the age-profile of the core, and frequencies (Appendix N) and fragment counts (Figure 6.8) against the depth of the core.

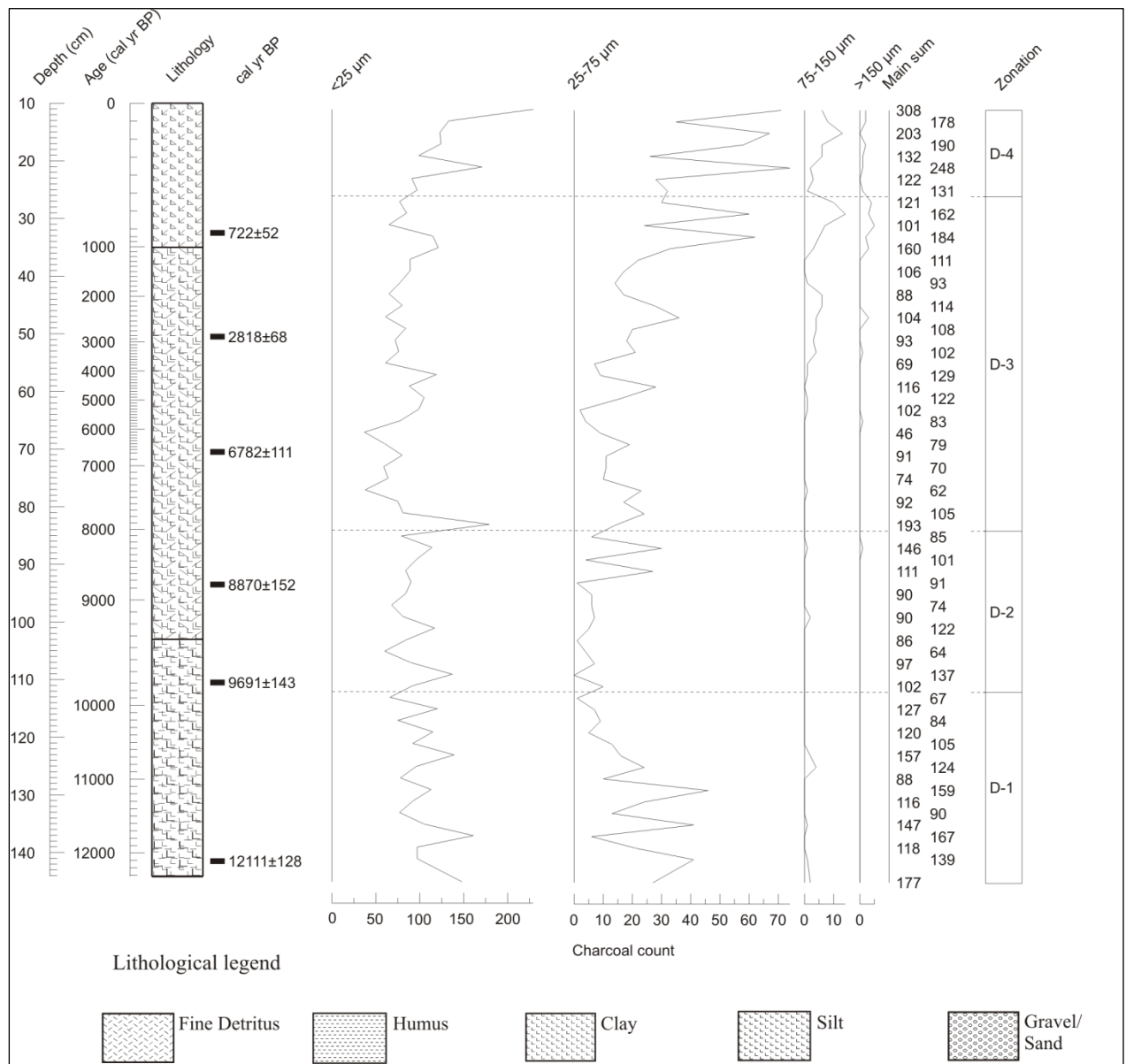


Figure 6.8 Charcoal diagram for Dartmoor Vlei

Zone D1: 144-110 cm; *ca.* 12,100 - 9690 cal yr BP

Charcoal fragments in Zone D1 are predominantly in the <25 µm size class. The highest charcoal counts (161 fragments) in this zone are at *ca.* 11,800 cal yr BP for the <25 µm size class, whilst the lowest count in this size class is at *ca.* 9850 cal yr BP (66 fragments). Charcoal fragments in the 25-75 µm size class peaks at *ca.* 11,100 cal yr BP (41 fragments), *ca.* 11,600 cal yr BP (41 fragments) and *ca.* 12,000 cal yr BP (46 fragments). Although there are no charcoal fragments in the >150 µm size class, fragments in the 75-150 µm size class peaks at *ca.* 10,800 cal yr BP (four fragments).

Zone D2: 110 - 83 cm; 9690 - 7970 cal yr BP

Charcoal fragments in the <25 µm size class do not differ significantly in numbers from those of zone D1, and are still the dominant size class in this zone. There is a lower count in the 26-75 µm size class at the base of the zone; however it increases towards the top of the zone, peaking at *ca.* 8600 cal yr BP and *ca.* 8250 cal yr BP with 30 and 27 fragments respectively. Charcoal counts for the 75-150 µm and >150 µm size classes remain negligible.

Zone D3: 83 - 25 cm; 7970 - 550 cal yr BP

Fragments in the <25 µm size class remain relatively consistent yet again, however there is a relative increase in the number of fragments in the 26-75 µm size class, notably at 720 cal yr BP and 630 cal yr BP. There is also a distinct increase in the counts of the 75-150 µm and >150 µm size classes at the same period, which indicated very few fragments at the base of the zone. The lowest total count for the core is observed at *ca.* 6000 cal yr BP, where the total count is at 46 fragments.

Zone D4: 25 - 0 cm; 550 - present cal yr BP

In Zone D4, charcoal counts at the top of the zone (modern dates) are at its highest (total count 308 fragments). There is a marked increase in charcoal fragments in the >25 µm and 75-150 µm size classes from the base of the zone to the top of the zone. Charcoal counts in the 26-75 µm size class are higher than those of previous zones, peaking at 74 fragments. Although fragments in the >150 µm size class are lower than those at the top of the previous zone, they are present in low numbers.

CHAPTER SEVEN

INTERPRETATION

7.1 INTRODUCTION

This chapter provides an interpretation of the palaeo-environmental conditions experienced at Dartmoor Vlei, Mt. Gilboa. The discussion is based on the four zones determined from the regional pollen records, and will be described and discussed based on ecological information composed for each pollen taxa (Appendix O). The interpretation will incorporate previous palaeo-environmental research conducted in the eastern region of South Africa (Chapter 2) and primary similarities and differences in trends are discussed. The dynamics of the grassland/forest relationship will be examined and interpreted based on the results of the various proxies used in this research.

7.2 PALAEO-ENVIRONMENTAL CHANGES AT DARTMOOR VLEI

7.2.1 Zone D1: 144-110 cm; *ca.* 12,100 - 9690 cal yr BP, Early Holocene

Zone D1 denotes an environment at Dartmoor Vlei which is evidently different from the rest of the record, and from the present day environment. Asteraceae, Ericaceae and Boraginaceae frequencies are high, decreasing towards the top of the core, whereas Brassicaceae frequencies increase significantly. Ericaceae, found in cool montane and subalpine grassland and alpine heath, is found in highest concentration at 12,000 - 10,000 cal yr BP, and frequency of Anacardiaceae at approximately the same period is an indication of montane and subalpine grassland. Both Ericaceae and Anacardiaceae (predominately *Rhus*) are present in the contemporary vegetation communities at Dartmoor Vlei (*pers. obs.*), and in comparing Zone D1 frequencies to that of Zone D4, it is evident that Ericaceae and Anacardiaceae must have occurred abundantly at Dartmoor Vlei between *ca.* 12,100 – 9700 cal yr BP, possibly indicating heath dominated vegetation.

At Wonderkrater, warmer conditions are experienced at *ca.* 15,500 cal yr BP (13,000 ¹⁴C yr BP), becoming slightly cooler at *ca.* 14,900 cal yr BP (12,700 ¹⁴C yr BP; Scott *et al.*, 2003), although cool moist conditions are indicated at Mfabeni at the same period (Finch and Hill, 2008). Asteraceae briefly declines at Dartmoor Vlei at 12,100 cal yr BP, however the

majority of the zone indicates high frequencies of this taxon, signalling the presence of a grassland vegetation. This is in agreement with Scott (1982b; 1987 and 1990), who suggests the early Holocene was characterised by warmer, dry conditions.

Podocarpus, an arboreal taxon, remains consistently high in this zone, although concentrations are relatively high. *Podocarpus* are found in montane and subalpine forests, favouring moist conditions. Brassicaceae and *Celtis* concentrations show a marked decline at this time, both occur in alpine forests and are associated with cool, moist conditions. There is an increase in *Cordia*, *Podocarpus*, *Celtis*, Brassicaceae and Fabaceae pollen at ca. 12,200 cal yr BP, in agreement with records by Grundling *et al.* (1998) who indicate an increase in hydromorphous forests at Mfabeni at ca. 13,300 cal yr BP (11,570 ¹⁴C yr BP).

There is a single, brief spike in arboreal pollen at Dartmoor Vlei at ca. 11,500 cal yr BP, which coincides with evidence from Mfabeni, however consideration needs to be given to the geographic variability between coastal and inland sites. Generally, the record at Dartmoor Vlei indicates high concentrations of arboreal taxa between ca. 12,300 cal yr BP and 8870 cal yr BP, except for a brief but marked decrease at ca. 12,200 cal yr BP. Rietvlei indicates low arboreal pollen concentrations between 11,490 and 7730 cal yr BP (Scott and Vogel, 1983), which is not in agreement with results from Dartmoor Vlei. At Lake Eteza (coastal site) where arboreal pollen frequencies decrease at ca. 10,500 cal yr BP (Neumann *et al.*, 2010), which may be due to a decrease in forest area.

Liliaceae concentrations are lower at the early parts of the zone, but increase towards the later stages. Although this taxon does not produce large quantities of pollen and are insect pollinated, the concentrations of Liliaceae pollen are high throughout the record. This may be due to Liliaceae species being locally over-represented. There are no systematic changes in the concentration of Poaceae, however Cyperaceae frequencies decrease briefly at ca. 10,300 and ca. 12,000 cal yr BP, indicating slightly drier local conditions. Charcoal fragments increase at this time, suggesting fire frequencies and intensity were greater. A relative increase in $\delta^{15}\text{N}$ indicates a shift from wetter to drier conditions locally (Terwilliger *et al.*, 2008; Leng *et al.*, 2006). Afromontane forest/arboreal taxa increase in this zone, and regional pollen signals are high. Although Scott *et al.* (2005) suggest considerable variation

in climatic conditions in South Africa between *ca.* 13,600 and 6000 cal yr BP (11,850 and 5400 ^{14}C yr BP), local conditions at Dartmoor Vlei do not indicate systematic changes between wet and dry periods in this zone, but rather a cool, locally dry environment. This is supported by geochemical results, which do not indicate significant shifts between wetter and drier conditions or from C_3 to C_4 vegetation locally (Terwilliger *et al.*, 2008).

7.2.2 Zone D2: 110 - 83 cm; 9690 - 7970 cal yr BP, Mid-Holocene

There is a slight decrease in Ericaceae frequencies in this zone, which can be attributed to warmer conditions, however the frequency of Ericaceae is still high. Although Asteraceae frequencies do not increase significantly, this taxon is abundant in the record at *ca.* 9500 cal yr BP, a similar result indicated by Scott and Vogel (1978) at Wonderkrater. Scott *et al.* (1995) suggest a period of noticeable warming at Winterberg and Wonderkrater (Scott, 1982c) at *ca.* 10,000 cal yr BP. Anacardiaceae frequencies are very low at *ca.* 9600 cal yr BP, increasing significantly to *ca.* 8000 cal yr BP, an indication that montane and subalpine grasslands are increasing at this time. This is corroborated by Cyperaceae frequencies which begin to decline at the same time, although beginning to increase again at *ca.* 8300 cal yr BP. There is a brief increase in *Protea* between 8500 and 8900 cal yr BP, an indication of montane and sub-alpine grassland and montane forests in the region of Dartmoor Vlei, supported by a general increase in Poaceae at approximately the same time. Similar increases in Poaceae are recorded at Wonderkrater for the same period. $\delta^{13}\text{C}$ values indicate a local shift towards more C_3 and C_4 dominated vegetation in Zone D2, whilst $\delta^{15}\text{N}$ values and C:N ratios indicate a shift towards locally wetter conditions (Terwilliger *et al.*, 2008).

Podocarpus frequencies do not show marked changes, except for a brief decrease at 9600 and 9400 cal yr BP. *Celtis* and Brassicaceae frequencies begin to increase in Zone D2. *Celtis* may be associated with high rainfall regions (Scott, 1982a) and Brassicaceae is commonly found on damp grassy scree slopes of the alpine belt (Court-Picon *et al.*, 2005), however both species are adapted to dry conditions (Scott, 1982a; Court-Picon *et al.*, 2005). Generally, Afromontane forest/ arboreal pollen signals decrease marginally between 9600 and 7900 cal yr BP, with local pollen signals strengthening towards the early stages of the zone. This may be in accordance with record from Tswaing by Partridge *et al.* (1993), and from Winterberg

by Meadows and Meadows (1988) who indicate dry, moderately warm conditions at *ca.* 8800 cal yr BP (8000 yr BP), followed by wetter conditions at *ca.* 7700 cal yr BP (7000 ¹⁴C yr BP).

7.2.3 Zone D3: 83 - 25 cm; 7970 - 550 cal yr BP, Late Holocene

Significant environmental change has occurred at Dartmoor Vlei since the mid-Holocene. *Protea* frequencies increase between *ca.* 7500 and *ca.* 3650 cal yr BP, possibly due to the generally wetter conditions experienced during the Holocene Altithermal, between *ca.* 8800 and 4400 cal yr BP (8000 and 4000 ¹⁴C yr BP). Locally, a shift towards moister conditions is evident from the geochemical data, indicating very wet conditions (Terwilliger *et al.*, 2008) at *ca.* 8000 cal yr BP. There is a marked decrease in charcoal counts during this period, indicating a decrease in fire frequency and intensity. Again, this may be attributed to the wetter conditions experienced during the time of the Holocene Altithermal.

At Lake Eteza, Neumann *et al.* (2010) indicate an increase in Poaceae frequencies between *ca.* 8000 and 7000 cal yr BP, followed by a decrease at *ca.* 6800 cal yr BP. Although Dartmoor Vlei does not indicate a marked increase in Poaceae frequencies for this time period, Poaceae frequencies are high. A similar decrease in Poaceae frequencies is recorded at Dartmoor Vlei between *ca.* 7200 and 6600 cal yr BP. Mfabeni records indicate local drying at about 6800 cal yr BP (6000 ¹⁴C yr BP; Finch and Hill, 2008), although there is no real indication of similar dry conditions in the pollen record at Dartmoor Vlei, or in the records from Cathedral Peak (Lodder, 2010) and Wonderkrater (Scott, 1982c) where moister conditions are recorded at 6200 cal yr BP and *ca.* 6800 cal yr BP (6000 ¹⁴C yr BP) respectively. However, the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ results indicate a brief, short period of local drying (Terwilliger *et al.*, 2008) at *ca.* 6000 cal yr BP, and a slight shift towards C₃ and C₄ vegetation.

Asteraceae frequencies decrease marginally between 4000 and 1000 cal yr BP, reaching its lowest number between *ca.* 2200 and 1100 cal yr BP, however increases again slightly after 1000 cal yr BP. Although Asteraceae is an indicator of grassland conditions, there are no other clear indications of shifts to grassland conditions.

There are no significant changes in Anacardiaceae frequencies, although a relative increase in frequencies can be noted at *ca.* 1900 and *ca.* 700 cal yr BP, indicating possible shift towards montane and subalpine grassland conditions. Brassicaceae show a generally increasing trend in frequency between 8700 and 600 cal yr BP, which may be an indication of moist conditions in the alpine belt. There are no systematic changes in Poaceae and Cyperaceae frequencies; however a relative increase in Poaceae frequency at *ca.* 5100 cal yr BP and a corresponding decrease in Cyperaceae, may be indicative of drier grassland conditions. An increase in Cyperaceae at *ca.* 2700 cal yr BP is mirrored by a decrease in Poaceae frequencies, indicating locally wetter conditions, although geochemical data indicates a general trend towards drier conditions through the record towards the present, and charcoal fragments begin to increase during this period, indicating an increase in fire frequency and intensity.

Although concentrations are high throughout the record, *Podocarpus* reaches a maximum between 2500 and 400 cal yr BP. At 5800 cal yr BP, *Podocarpus* frequencies are very low. Other arboreal taxa such as Brassicaceae, Anacardiaceae and *Celtis*, which were relatively abundant after 8000 cal yr BP, show a similar decline at this time, possibly due to a decrease in forest cover. This may be due to environmental conditions becoming drier, as Ericaceae frequencies, favouring drier conditions, momentarily increase at this time. At Mfabeni, Finch and Hill (2008) record a sharp decrease in arboreal pollen after *ca.* 6800 cal yr BP (6000 ¹⁴C yr BP), although the record from Dartmoor Vlei does not coincide with this. The record does not indicate a lesser extent of forest abundance, which appears to be relatively stable throughout. *Celtis*, favouring high rainfall regions (Scott, 1982a), is significantly higher between 5200 and 2600 cal yr BP, and *Euclea* is found in montane and subalpine grasslands (Killick, 1963) occurring at higher frequencies during the same period for the first time in the record. This may be associated with the increase in *Podocarpus* concentrations at Cathedral Peak at 3960 cal yr BP, indicating moist conditions (Lodder, 2010). However, records from Mfabeni (Finch and Hill, 2008), Nhlangu (Mazus, 1996) and Lake Eteza (Scott and Steenkamp, 1996) indicate forest retreat in approximately the same period. Again, this may be associated with the location of these sites and the influence of coastal conditions, as moist cool conditions prevail after *ca.* 1900 cal yr BP (2000 ¹⁴C yr BP) at Mfabeni.

Zea mays is present for the first time in the record between *ca.* 1600 and *ca.* 650 cal yr BP, and as a cultivated exotic species it is a strong indicator of anthropogenic impacts in the region. The frequency of pollen from this taxon is low, and due to the distance at which *Z. mays* is dispersed, it could be an indication of human activity within a greater KwaZulu-Natal Midlands region (rather than locally), as Iron age settlers are first recorded in the Karkloof region at *ca.* 1300 cal yr BP (Mazel, 1989). The increase in *Z. mays* prior to this date may be attributed to Iron Age farming activities in the eastern parts of South Africa which began at *ca.* 1600 BP (Neumann *et al.*, 2010).

The existence of *Z. mays* at *ca.* 1600 cal yr BP is a major finding in the pollen record at Dartmoor Vlei, and may warrant a further division of zones at this point due to the significance of this taxon and association with human activities in the region. The occurrence of *Z. mays* coincides with a decline in some arboreal pollen taxa such as *Podocarpus*, *Celtis* and *Olea*, and an increase in fire frequency and intensity, which could be as a result of anthropogenic impacts.

7.2.4 Zone D4: 25 - 0 cm; 550 cal yr BP - present

A decrease in *Ericaceae* suggests that conditions become marginally wetter from *ca.* 1600 cal yr BP to the present. A decrease in *Celtis* and *Protea*, is observed from *ca.* 600 cal yr BP to the present, however overall, there is no systematic decrease in forest abundance in the region, as Brassicaceae and Anacardiaceae frequencies remain high. Although previously present in the record, Thymeliaceae frequencies increases notably from *ca.* 550 cal yr BP, indicating a shift towards grassland conditions, and *Leucocidea sericea*, occurring in montane and sub-alpine grasslands (Killick 1963), is present for the first time in the record at *ca.* 400 cal yr BP. As a pioneer species, *L. sericea* may become invasive where overgrazing occurs or erosion is taking place (Pooley, 2005), and possibly appears at this time due to farming activities in the region.

Z. mays is evident at 530 cal yr BP, and is attributed to human activity within the region. Cereal-type Poaceae is first recorded at Cathedral Peak at *ca.* 890 cal yr BP, and it is therefore likely that *Z. mays* in the pollen record from Dartmoor Vlei is an indication of human presence in the region, along with other indications of anthropogenic impacts such as

the occurrence of *Pinus* and increase in *L. sericea*. *Z. mays* is not observed in the record beyond 530 cal yr BP, which may be attributed to poor pollen preservation, or simply discontinued cultivation of *Z. mays* in the region. Charcoal fragments increase significantly at the same time, an indication of more frequent and intense fire regimes, again attributed to human activity. This may be an indication that farming activities shifted from crop cultivation (*Z. mays* in particular) towards livestock which required more intensive veld management and therefore an increase in burning. The record does not contain any further cereal-type Poaceae from 530 cal yr BP to the present, and may be attributed to change in land-use in the area, or mis-identification of other cereal-type Poaceae.

Mimosoideae Type II occurs singly at *ca.* 240 cal yr BP. A possible parent taxon is *Acacia mearnsii*, introduced into South Africa approximately 150 years ago, therefore it could be argued that the single pollen grain was incorrectly identified or originated from another *Acacia* species, or due to the error margin in radiocarbon dating, as the pollen record and historical data are inconsistent. *Podocarpus* frequencies decrease notably from 400 cal yr BP, whilst *Pinus* increases systematically from *ca.* 450 cal yr BP towards the top of the zone. This may be attributed to the error margin of the radiocarbon dating of the record, as *Pinus* did not occur in the region at this time, and these discrepancies preclude the usefulness of this taxon as a time stratigraphic marker horizon. Although vigilance was taken to ensure the correct identification of *Podocarpus* and *Pinus*, it is plausible that pollen grains were incorrectly identified, however it is most possibly due to the error margin in the dating of the core, particularly at the top of the core.

Asteraceae frequencies are still high between *ca.* 550 cal yr BP and the present, indicating grassland conditions, and Liliaceae decreases at this time, indicating slightly drier conditions locally. This is in agreement with records from Cathedral Peak. Poaceae and Cyperaceae frequencies do not differ significantly from *ca.* 550 cal yr BP to the present, although there is a slight increase in the proportion of Afromontane Forest taxa. $\delta^{13}\text{C}$ records indicate a slight shift towards C_4 dominated vegetation locally in the last 750 years.

CHAPTER EIGHT

CONCLUSION

8.1 INTRODUCTION

The aim of this research was to investigate Holocene palaeo-environmental change in the Midlands Mistbelt grasslands and forests of the KwaZulu-Natal Midlands through the application of a multi-proxy approach (*viz.* fossil pollen, charcoal, carbon and nitrogen isotope analyses). As a conclusion, this chapter will review the objectives originally set out at the outset of the research.

8.2 REVIEW OF AIM AND OBJECTIVES

To survey, map and develop an inventory of the modern vegetation of the wetland and immediate surrounds

A vegetation survey was conducted at Dartmoor Vlei where 58 1 x 1m quadrats were sampled using the Braun-Blanquet classification system, and an excess of 140 species were recorded and identified where possible. Plots were within the perimeter of the wetland, and on the north-west and south-east facing slopes adjacent to the wetland. An inventory of the vegetation at Dartmoor Vlei was created, and substantiated by the SANBI species list for the quarter degrees adjacent to the study site.

To develop a local modern pollen reference collection, as an aid to fossil pollen identification

A series of digital microphotographs were taken from approximately 60 pollen reference slides created from known vegetation samples collected at Dartmoor Vlei. Reference material was verified and supported by existing reference material from the Geography Department (UKZN), and the African Pollen Database.

To identify suitable coring locations and extract a series of minimally disturbed sediment cores from the wetland

Two locations were identified for core extraction at Dartmoor Vlei based on sediment depth established through the use of rods inserted into the wetland sediment, and through reference to sediment depths as recorded by Edwards (2009). Two cores, DA1 (350 cm) and DA2 (240 cm), were extracted using a Russian peat corer, and on completion of Troel-Smith stratigraphic analysis of both cores, core DA2 was chosen for further analysis.

To select samples from basal and intermediate sections of a selected core for AMS radiocarbon analysis to establish chronological control for the core; and create an age-depth model

Six samples were chosen for AMS radiocarbon analysis to establish chronological control for the sediment core. Two initial samples were chosen based on changes in the lithology of the core, a further three based on changes observed in the geochemical results of the core and a final sample was chosen to fill a gap in the chronology of the core. A linear age-depth model was created for the 12,000 year old record, and no age reversals were observed.

To identify and quantify fossil pollen along the length of the core to detect local and regional vegetation changes

Sediment core DA2 was subsampled at 2 cm intervals and pollen extracted through the use of a gravitational separation technique. A minimum of 500 pollen grains were counted for each subsample (total of 68 subsamples), identified through the use of antecedent reference material. Local and regional taxa were differentiated, and grassland and forest taxa identified to distinguish between these biomes.

To conduct geochemical (C and N isotope) analyses along the length of the core to detect changes in the relative proportion of C₃ and C₄, and aquatic and land plants inhabiting the wetland site.

Geochemical analysis was carried out on eighty-nine samples from the top 190 cm of core DA2, at a resolution of 2 cm, which indicated shifts from aquatic, to C₃ and C₄ land plants.

To reconstruct past Holocene environmental history of the KwaZulu-Natal Midlands

An understanding of palaeo-environmental changes which occurred at Dartmoor Vlei during the Holocene was derived through the use of various proxies (*viz.* fossil pollen, charcoal, carbon and nitrogen isotope analyses). The Dartmoor Vlei record indicates an apparently different environment during the early Holocene, where heath vegetation dominated the landscape, and arboreal pollen concentrations were high. Conditions become moister at between *ca.* 5200 and 2600 cal yr BP, as arboreal taxa frequencies increase. Anthropogenic influence was detected through the presence of *Zea mays* for the first time in the record at 1600 cal yr BP., and the impact of humans as a result of burning practices was observed through the charcoal record. Between 1600 cal yr BP and the present, the impact of human activities are evident from an increase in fire frequency and intensity, introduction of the exotic pollen taxon *Pinus*, and a possible escalation in grazing pressure indicated by an increase in *Leucosidea sericea* frequencies. Throughout the record, there is a constant reminder of the patch mosaic relationship between grassland and indigenous forests at Mt Gilboa. The results from Dartmoor Vlei were compared to other research from the summer rainfall region of South Africa, presenting similarities and differences in findings from various sites in the country.

8.3 SYNTHESIS

Environmental conditions at Dartmoor Vlei from *ca.* 12,000 to 9700 cal yr BP are distinctly unique from the rest of the core. The regional pollen signal indicates the presence of grassland and heath vegetation, in agreement other cores from the early Holocene characterised by drier conditions. High concentrations of Ericaceae and Anacardiaceae between *ca.* 12,000 and at 10,000 cal yr BP, and high Poaceae and low Cyperaceae concentrations support the deduction that the environment at Dartmoor Vlei was drier locally. Arboreal pollen taxa associated with montane and subalpine forests, are found in high concentrations between *ca.* 12,300 and 9000 cal yr BP, however a brief, marked decrease is recorded at 12,200 cal yr BP. Geochemical data between *ca.* 10,300 and 12,000 cal yr BP indicate drier conditions locally. High concentrations of Poaceae and a brief increase in *Protea* between 8900 and 8500 cal yr BP, suggest that conditions supporting montane and sub-alpine grassland and montane forests remain in the region of Dartmoor Vlei. Locally, conditions become moister after *ca.* 8300 cal yr BP.

Table 8.1 Summary of key environmental changes which occurred at Dartmoor Vlei

Time period	Inferred environmental change
<i>ca.</i> 12,000 to 9700 cal yr BP	Inferred vegetation is distinct from the remainder of the core, regional pollen signal indicates the presence of grassland and heath, possibly representing drier conditions (supported locally by geochemical data).
8900 to 8500 cal yr BP	Increase in taxa associated with montane and sub-alpine grassland and montane forests
<i>ca.</i> 8000 cal yr BP	Transition towards locally wetter conditions, coincident with the Holocene Altithermal
<i>ca.</i> 6000 to 5100 cal yr BP	Vegetation characterised by locally drier grassland with a decrease in arboreal taxa recorded. Supported by geochemical data indicating a brief period of local drying.
<i>ca.</i> 5200 to 2600 cal yr BP	Locally wetter conditions
<i>ca.</i> 2000 to 1500 cal yr BP	The neophyte <i>Zea mays</i> is present for the first time in the record, evidence of human presence in the region. There is also a decrease in arboreal taxa, possibly attributed to human presence.
<i>ca.</i> 1600 cal yr BP	Local conditions at Dartmoor Vlei become marginally wetter.
After <i>ca.</i> 550 cal yr BP	<i>Leucocidea sericea</i> is present for the first time in the record, which may be associated with farming activities in the region.
After 400 cal yr BP	<i>Podocarpus</i> frequencies notably decrease, whilst exotic <i>Pinus</i> increases significantly from <i>ca.</i> 450 cal yr BP to the present.

The mid-Holocene marks a period where significant changes begin to occur. Locally wetter conditions are evident from geochemical data at *ca.* 8000 cal yr BP, associated with the Holocene Altithermal (Chase and Meadows, 2007), and a marked decrease in charcoal counts indicate a decrease in fire frequencies and intensity. A decrease in Poaceae frequencies is recorded between *ca.* 7200 and 6600 cal yr BP, and geochemical data indicates a brief period of drying at *ca.* 6000 cal yr BP. An increase in Poaceae frequency at *ca.* 5100 cal yr BP and a corresponding decrease in Cyperaceae, may be indicative of locally drier grassland conditions, followed by an increase in Cyperaceae at *ca.* 2700 cal yr BP and a decrease in Poaceae frequencies, a possible indication of locally wetter conditions. A short period of drier conditions is experienced at *ca.* 5800 cal yr BP, as Ericaceae frequencies briefly increase and arboreal taxa such as *Podocarpus*, Brassicaceae, Anacardiaceae and *Celtis* decrease. Between *ca.* 5200 and 2600 cal yr BP, *Celtis* and *Euclea* frequencies increase, an indication of conditions becoming moister.

Archaeological evidence suggests that Iron Age settlers first inhabited KwaZulu-Natal approximately 2000 – 1500 years ago (Mazel, 1989), and the palaeo-data derived from Dartmoor Vlei strongly agrees with such findings. After 1600 cal yr BP *Zea mays* is present for the first time in the record, and is a major occurrence in the pollen record at Dartmoor Vlei. *Z. mays* is the first cultivated exotic taxon which appears in the record, a clear indication of farming activity in the region (Scott and Nyakale, 2002). The decline of arboreal pollen taxa such as *Podocarpus*, *Celtis* and *Olea* during the same period, and a marked increase in fire frequency and intensity may be attributed to anthropogenic impacts such as forest clearance for fuel and a source of building material, and burning of vegetation to encourage green growth (Moll, 1976).

From *ca.* 1600 cal yr BP to the present, local conditions at Dartmoor Vlei become marginally wetter. A shift towards grassland conditions from *ca.* 550 cal yr BP is indicated by an increase in Thymeliaceae (Scott, 1982a) and *Leucocidea sericea* is present for the first time in the record, which may be associated with farming activities in the region (Pooley, 2005). *Z. mays* is recorded at 530 cal yr BP attributed to human presence in the region (Scott and Nyakale, 2002). Other indicators of anthropogenic impacts such as the occurrence of *Pinus* (an exotic taxon used in timber plantations) and increase in *L. sericea* (a possible indicator of grazing pressure) are recorded. The increase in charcoal fragments at the same time indicates more frequent and intense fire regimes, attributed to possible early veld management (Clark, 1982; Scott *et al.*, 2000). From 400 cal yr BP *Podocarpus* frequencies notably decrease, whilst exotic *Pinus* increases significantly from *ca.* 450 cal yr BP to the present.

The patch-mosaic relationship of montane and sub-alpine grassland and montane forests in the region of Dartmoor Vlei provides evidence of the mosaic pattern which exists in both the present and the historical landscape. The pollen record indicates slight shifts towards periods of forest expansion and retreat; however there is evidence of the dynamic relationship between forest and grasslands throughout the Holocene. Although anthropogenic influences such as veld management through burning practices and crop cultivation impacted on this relationship in the recent past, the relationship between forest and grasslands at Mt Gilboa remains evident.

The palaeo-environmental changes which have occurred in the KwaZulu-Natal Midlands region specifically are relatively unknown. Dartmoor Vlei provided a suitable site for such research to be conducted. There are many pressures on biodiversity in the Midlands Mistbelt Grasslands and the Karkloof forest, and the impact of land transformation calls for urgent attention to be given to conservation efforts, especially as more of South Africa's landscapes become threatened. Ecosystems are being exposed to change on an extraordinary scale, and caution needs to be taken before irreversible degradation and extinctions occur (Armstrong *et al.*, 1998). Relative to their size, the forest and grassland biomes are home to the largest proportions of threatened plants, and compared to all other grassland types, the Mistbelt grassland contains the largest proportion of threatened plants (Scott-Shaw, 1999). The need for understanding environmental change in a region such as Mt Gilboa where a patch-mosaic of grasslands and indigenous forests exist, is therefore warranted and justified. This research has contributed to the literature and knowledge of Holocene environmental changes in KwaZulu-Natal by providing historical insight into past environmental conditions and human activity in the KwaZulu-Natal Midlands. Continued research will further enhance the current understanding of environmental changes in the area, clarify the historical patch-mosaic relationship between grasslands and forests, and so assist in conservation efforts of these biomes in need of preservation.

REFERENCES

- Abell, P.I. and Plug, I. (2000). The Pleistocene/Holocene transition in South Africa: evidence from the Younger Dryas event. *Global and Planetary Change* 26: 173-179
- Anderson, N.J., Bugmann, H., Dearing, J.A. and Gaillard, M. (2006). Linking palaeoenvironmental data and models to understand the past and to predict the future. *Trends in Ecology and Evolution* 21(12): 696-703
- Anderson, D.E., Goudie, A.S. and Parker, A.G., (2007). *Global environments through the Quaternary: Exploring environmental change*. Oxford University Press, Oxford
- Armstrong, A.J., Benn, G., Bowland, A.E., Goodman, P.S., Johnson, D.N., Maddock, A.H. and Scott-Shaw, C.R. (1998). Plantation forestry in South Africa and its Impact on Biodiversity. *Southern African Forestry Journal* 182: 59-65
- Avery, D.M. (1993). Last interglacial and Holocene altithermal environments in South Africa and Namibia: micromammalian evidence. *Palaeogeography, Palaeoclimatology, Palaeoecology* 101: 221-228
- Ballard, C. and Lenta, G. (1985). The complex nature of agriculture in colonial Natal: 1860-1909. In: Guest, B. and Sellers (eds). *Enterprise and Exploitation in a Victorian Colony: aspects of the economic and social history of Colonial Natal*. University of Natal Press, Pietermaritzburg
- Bamford, M.K. and Grab, S.W. (2005). Highlights of Quaternary research in Southern Africa, and proceeding forwards. *Quaternary International* 129: 1-3
- Batten, D.J. (1999). Small palynomorphs. In: Jones, T.P. and Rowe, N.P. *Fossil plants and spores: Modern Techniques*. The Geological Society, London
- Baxter, A.J. (1996). *Late quaternary palaeoenvironments of the Sandveld, Western Cape Province, South Africa*. Unpublished Ph.D. Thesis. University of Cape Town, Cape Town

Begg, G.W. (1989). *The Wetlands of Natal (Part 3): The location, status and function of the priority wetlands of Natal*. Natal Town and Regional Planning Commission, Pietermaritzburg. Report 73.

Behre, K.E. (1988). The role of man in European vegetation history. In: Huntley B, Webb T III (eds) *Vegetation history*. Kluwer, Dordrecht, 633–672

Bennett, K.D. (2005). *Psimpoll*. Uppsala Universitet, Villavgen

Bhugeloo, A. (2011). *A fire history reconstruction of the Karkloof forests in the KwaZulu-Natal Midlands, South Africa over the Holocene period*. Unpublished B.Sc. Honours Thesis, University of KwaZulu-Natal, Durban

Birks, H.J.B. (1995). *Quantitative paleoenvironmental reconstructions*. In Maddy, D. and Brew, J.S. (eds.), *Statistical modelling of Quaternary science data*. Quaternary Research Association, Cambridge: 161-254

Birks, H.J.B. and Gordon, A.D. (1985). *Numerical methods in Quaternary pollen analysis*. Academic Press, London

Birks, H.H. and Birks, H.J.B. (2005). *Chapter 23: Reconstructing Holocene climates from pollen and plant macrofossils*. In Mackay, A., Battarbee, R., Birks, J. and Oldfield, F. (eds). *Global change in the Holocene*. Hodder Arnold, London.

Birks, H.J.B. and Birks, H.H. (1980). *Quaternary palaeoecology*. Edward Arnold, London

Blaauw, M. (2010). Methods and code for ‘classical’ age-modelling of radiocarbon sequences. *Quaternary Geochronology* 5: 512-518

Bradshaw, R.H.W. (2008). Detecting human impact in the pollen record using data-model comparison. *Vegetation History and Archaeobotany* 17:597–603.

Braun-Blanquet, J. (1932). *Plant sociology* (Transl. G. D. Fuller and H. S. Conrad). McGraw-Hill, New York.

Bredenkamp, G.J., Spada, F. and Kazmierczak, E. (2002). On the origin of northern and southern hemisphere grasslands. *Plant Ecology* 163: 209–229

Breman, E., Gillson, L. and Willis, K. (2011). How fire and climate shaped grass-dominated vegetation and forest mosaics in northern South Africa during past millennia. *The Holocene*: 1-13

Bunting, M.J. (2008). Pollen in wetlands: using simulations of pollen dispersal and deposition to better interpret the pollen signal. *Biodiversity Conservation* 17: 2079-2096

Burroughs, W.J. (2005). *Climate change in prehistory: The end of the reign of chaos*. Cambridge University Press, Cambridge

Cabido, M., Ateca, N., Astegiano, M.E. and Anton, A.M. (1997). Distribution of C₃ and C₄ grasses along an altitudinal gradient in Central Argentina. *Journal of Biogeography* 24: 197-204

Carcaillet, C., Bouvier, M., Fréchette, B., Larouche, A.C., and Richard, P.J.H. (2001). Comparison of pollen-slide and sieving methods in lacustrine charcoal analyses for local and regional fire history. *The Holocene* 11: 467-476

Carcaillet, C. (2007). Charred particle analyses. In: Elias, S.A. (Ed.), *Encyclopedia of Quaternary Science*. Elsevier, Amsterdam: 1582–1593.

Castañeda, I.S., Werne, J.P., Johnson, T.C. and Filley, T.R. (2009). Late Quaternary vegetation history of southeast Africa: The molecular isotopic record from Lake Malawi. *Palaeogeography* 2009

Chapman, J.D. and White, F. (1970). *The evergreen forests of Malawi*. Commonwealth Forestry Institute, Oxford

Chase, B.M. and Meadows, M.E. (2007). Late Quaternary dynamics of southern Africa's winter rainfall zone. *Earth-Science Reviews* 84: 103–138

Clark, R.L. (1982). Point count estimation of charcoal in pollen preparations and thin sections of sediments. *Pollen et Spores* 24: 523-535

Coetzee, J.A. (1955). The morphology of *Acacia* pollen. *South African Journal of Science*.

Coetzee, J.A. and van Zinderen Bakker, E.M. (1970). Palaeoecological problems of the quaternary of Africa. *South African Journal of Science* 66: 78-84

Connor, S.E., Thomas, I., Kvavadze, E.V., Arabuli, G.J., Avakov, G.S. and Sagona, A. (2004). A survey of modern pollen and vegetation along an altitudinal transect in southern Georgia, Caucasus region. *Review of Palaeobotany and Palynology* 129: 229-250

Court-Picon, M., Buttler, A. and De Beaulieu, J.L. (2005). Modern pollen-vegetation relationships in the Champsaur valley (French Alps) and their potential in the interpretation of fossil pollen records of past cultural landscapes. *Review of Palaeobotany and Palynology* 135: 13-39

Daniau, A.L., Harrison, S.P., and Bartlein, P.J. (2010). Fire regimes during the Last Glacial. *Quaternary Science Reviews* 29: 2918-2930

Darbyshire, I., Lamb, H. and Umer, M. (2003). Forest clearance and regrowth in northern Ethiopia during the last 3000 years. *The Holocene* 13: 537-546

Duffin, K.I. (2008). The representation of rainfall and fire intensity in fossil pollen and charcoal records from a South African savanna. *Review of Palaeobotany and Palynology* 151: 59–71

Dupont, L.M., Behling, H. and Kim, J.H. (2008). Thirty thousand years of vegetation development and climate change in Angola (Ocean Drilling Program Site 1078). *Climate of the Past* 4: 107-124

Edwards, R. (2009). *The origin and evolution of Dartmoor Vlei in the KwaZulu-Natal Midlands, South Africa*. Unpublished MSc Thesis, University of KwaZulu-Natal, Durban

Eeley, H.A.C., Lawes, M.J. and Piper, S.E. (1999). The influence of climate change on the distribution of indigenous forest in KwaZulu Natal, South Africa. *Journal of Biogeography* 26: 595-617

Ellis, B. (1998). *The impact of white settlers on the natural environment of Natal, 1845-1870*. M.A. Thesis, Department of Historical Studies, University of Natal, Pietermaritzburg

Everard, D.A. (1985). The effect of fire on the *Podocarpus latifolius* forests of the Royal Natal National Park, Natal Drakensberg. *South African Journal of Botany* 52: 60-66

Faegri, K. (1966). Some problems of representativity in pollen in analysis. *Palaeobotanist* 15: 135-140

Faegri, K. and Iverson, J. (1989). *Textbook of pollen analysis*. John Wiley and Sons, Chichester

Fairbanks, D.H.K. and Benn, G.A. (2000). Identifying regional landscapes for conservation planning: a case study from KwaZulu-Natal, South Africa. *Landscape and Urban Planning* 50: 237-257

Ferguson, M.A. and Huisamen, J. (undated). *Indigenous timbers of the Southern Cape: Their management, supply, characteristics and use*. Directorate Indigenous Forest Management, Department of Water Affairs, Knysna

Finch, A.A., Shaw, P.A., Holmgren, K. and Lee-Thorp, J. (2003). Corroborated rainfall records from aragonitic stalagmites. *Earth and Planetary Science Letters* 215: 265-273

Finch, J.M. (2005). *Late Quaternary palaeoenvironments of the Mfabeni Peatland, Northern KwaZulu-Natal*. MSc Thesis, University of KwaZulu Natal, Pietermaritzburg

Finch, J.M. and Hill, T.R. (2008). A late Quaternary pollen sequence from Mfabeni Peatland, South Africa: Reconstructing forest history in Maputaland. *Quaternary Research* 70: 442-450

Finch J.M., Leng, M.J. and Marchant, R. (2009). Late Quaternary vegetation dynamics in a biodiversity hotspot, the Uluguru Mountains of Tanzania. *Quaternary Research* 72: 111-122

Funkhouser, J.W. and Evitt, W.R. (1959). Preparation techniques for acid-soluble microfossils. *Micropaleontology* 5: 369-375

Gastaldo, R.A. (1999). Collection and analysis techniques for palaeoecological studies in coastal-deltaic settings. In: Jones, T.P. and Rowe, N.P. *Fossil plants and spores: Modern Techniques*. The Geological Society, London

Gebrekirostos, A., Worbes, M., Teketay, D., Fetene, M. and Mitlöhner, R. (2009). Stable carbon isotope ratios in tree rings of co-occurring species from semi-arid tropics in Africa: Patterns and climatic signals. *Global and Planetary Change* 66: 253–260

Gillson, L. and Ekblom, A. (2009). Resilience and Thresholds in Savannas: Nitrogen and Fire as Drivers and Responders of Vegetation Transition. *Ecosystems* 12: 1189–1203

Gil-Romera, G., Scott, L., Marais, E. and Brook, G.A. (2007). Late Holocene environmental change in the northwestern Namib Desert margin: New fossil pollen evidence from hyrax middens. *Palaeogeography, Palaeoclimatology, Palaeoecology* 249: 1-17

Goudie, A. (1992). *Environmental Change: Contemporary problems in Geography. Third Edition*. Clarendon Press, Oxford

Grimm, E.C. (1992). *Tilia*. Springfield, Illinois, USA: Illinois State Museum.

Grundling, P., Mazus, H. and Baartman, L. (1998). *Peat resources in Northern KwaZulu-Natal wetlands: Maputaland*, Department of Environmental Affairs and Tourism, Pretoria.

Hamilton, A.C. (1981). The Quaternary history of African forests: its prevalence to conservation. *African Journal of Ecology* 19: 1-6

Hamilton, A.C. (1972). The interpretation of pollen diagrams from Highland Uganda. *Palaeoecology of Africa* 7: 45-149

Heusser, C.J. (1971). *Spores of Chile: Modern types of the Pteridophyta, Gymnospermae, and Angiospermae*. University of Arizona Press, Tucson

Hill, T.R. (1992). *Contemporary pollen spectra from the Natal Drakesberg and their relation to associated vegetation communities*. PhD Thesis, Departments of Botany and Geography, Rhodes University

Hill, T.R. (1996). Statistical determination of sample size and contemporary pollen counts, Natal Drakensberg, South Africa. *Grana* 35: 119-124

Holmgren, K., Lee-Thorp, J.A., Cooper, G.R.J., Lundblad, K., Partridge, T.C., Scott, L., Sithaldeen, R., Talma, A.S., Tyson, P.D. (2003). Persistent millennial-scale climate variation over the past 25,000 years in Southern Africa. *Quaternary Science Reviews* 22: 2311-2326

Hunt, C.O. (1985). Recent advances in pollen extraction techniques: a brief overview. In *Palaeobiological Investigations*, eds. N. R. J. Fieller, D. D. Gilbertson and N. G. A. Ralph, 181 – 187. Oxford: British Archaeological Reports, International Series

Hunt, C.O. and Rushworth, G. (2005). Cultivation and human impact at 6000 cal yr BP in tropical lowland forest at Niah, Sarawak, Malaysian Borneo. *Quaternary Research* 64: 460-468

Hurwitz, N. (1957). *Agriculture in Natal 1869-1950*. National Regional Survey Vol. 12. University of Natal, South Africa

Intergovernmental Panel on Climate Change (2007). Summary for policymakers. In: *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth

Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and Miller, H.L. (eds.)]. Cambridge University Press, Cambridge

Jacobson, G.L. and Bradshaw, R.H.W. (1981). The selection of sites for palaeovegetational studies. *Quaternary Research* 16: 80-96

Johnson, B.J., Miller, G.H., Fogel, M.L. and Beaumont, P.B. (1997). The determination of late Quaternary paleoenvironments at Equus Cave, South Africa, using stable isotopes and amino acid racemization in ostrich eggshell. *Palaeogeography, Palaeoclimatology, Palaeoecology* 136 (1997) 121 – 137

Kershaw, A.P. (1997). A modification of the Troels-Smith system of sediment description and portrayal. *Quaternary Australasia* 15: 63-69

Killick, D.J.B. (1963). *An account of the Plant Ecology of the Cathedral Peak Area of the Drakensberg*. Department of Agricultural Technical Services: Pretoria

Kotze, D.C., Ellery, W.N., Patrick, B. and Bambus, O. (2009). *An assessment of the effect of rehabilitation interventions on the health of Dartmoor Vlei, KwaZulu-Natal Midlands*. In: *WETOutcome Evaluate: An evaluation of the rehabilitation outcomes at six wetland sites in South Africa*. Water Research Commission, Pretoria. WRC Report No. TT 343/09

KwaZulu-Natal Province Provincial Gazette (30 August 2012). Volume 6, Number 799, Pietermaritzburg.

Lawes, M.J., MacFarlane, D.M. and Eeley, H.A.C. (2004). Forest landscape pattern in the KwaZulu-Natal midlands, South Africa: 50 years of change or statis? *Austral Ecology* 29: 613-623

Lawes, M.J., Griffiths, M.E. and Boudreau, S. (2007). Colonial logging and recent subsistence harvesting affect the composition and physiognomy of a podocarp dominated Afrotropical forest. *Forest Ecology and Management* 247: 48-60

Leng, M.J., Lamb, A.L., Heaton, T.H.E., Marshall, J.D., Wolfe, B.B., Jones, M.D., Holmes, J.A. and Arrowsmith, C. (2006). Chapter 4. Isotopes in lake sediments: 147-184. In: *Isotopes in Palaeoenvironmental Research*. Springer, Dordrecht, The Netherlands.

Linder, H.P. (2003). The radiation of the Cape flora, southern Africa. *Biological Reviews of the Cambridge Philosophical Society* 78: 597-638.

Lodder, J. (2010). *The late Quaternary palaeoenvironments of a subalpine wetland in Cathedral Peak, KwaZulu-Natal Drakensberg*. Unpublished MSc Thesis, University of KwaZulu-Natal, Pietermaritzburg.

Lu, S-S. and Samways, M.J. (2002). Conservation management recommendations for the Karkloof blue butterfly, *Orachrysops ariadne* (Lepidoptera : Lycaenidae). *African Entomology* 10: 149 - 159

Luo, Y. and Sternberg, L. (1991). Deuterium heterogeneity in starch and cellulose nitrate of CAM and C₃ plants. *Phytochemistry* 30: 1095-1098

Low, A.B. and Rebelo, A.G. (1996). *Vegetation of South Africa, Lesotho and Swaziland*. Department of Environmental Affairs and Tourism, Pretoria

Macfarlane, D.M. (2000). *Historical change in the landscape pattern of indigenous forest in the Karkloof/Balgowan region in the midlands of KwaZulu-Natal*. MSc Thesis, University of Natal, Pietermaritzburg

Mazel, A. (1989). *Stone Age people of Natal*. In: Duminy, A. and Guest, B. (eds). *Natal and Zululand from earliest times to 1910: A new history* (1-27). University of Natal Press, Pietermaritzburg.

Mazus, H. (1996). *Pollen records from Nhlangu Peatland on the Zululand coastal plain*, Council for Geoscience Internal Report no. 1996-0234, Pretoria.

Marchant, R. (2010). Understanding complexity in savannas: climate, biodiversity and people. *Current Opinion in Environmental Sustainability* 2: 101-108

McCormack, F.G., Hogg, A.G., Blackwell, P.G., Buck, C.E., Higham, T.F.G. and Reimer, J.P. (2004). SHCCal04 Southern Hemisphere Calibration 0 – 1000 cal BP. *Radiocarbon* 46:1087-1092

Meadows, M.E., Meadows, K.F. and Sugden, J.M. (1987). The development of vegetation on the Winterberg Escarpment. *The Naturalist* 31: 26-32

Meadows, M.E. and Meadows, K.F. (1988). Late Quaternary vegetation history of the Winterberg Mountains, Eastern Cape, South Africa. *South African Journal of Science* 84: 253-259

Meadows, M.E. and Linder, H.P. (1993). A palaeoecological perspective on the origin of Afromontane grasslands. *Journal of Biogeography* 20:345-355

Meadows, M. (2001). The role of Quaternary environmental change in the evolution of landscapes: case studies from southern Africa. *Catena* 42: 39-57

Moll, E.J. (1976). *The vegetation of the Three Rivers region, Natal*. Natal Town and Regional Planning Report, Volume 33. Natal Town and Regional Planning Commission, Pietermaritzburg.

Moll, E.J. (1978). A quantitative floristic comparison of four Natal forests. *South African Forestry Journal* 104: 25-34

Moore, P.D. and Webb, J.A. (1978). *An illustrated guide to pollen analysis*. Hodder and Stoughton, London

Mucina, L. and Rutherford, M.C. (2006). *The Vegetation of South Africa, Lesotho and Swaziland*. South African National Biodiversity Institute, Pretoria.

Mumbi, C.T., Marchant, R., Hooghiemstra, H. and Wooller, M.J. (2008). Late Quaternary vegetation reconstruction from the Eastern Arc Mountains, Tanzania. *Quaternary Research* 69: 326-341

Nash, D. J. and Meadows, M. E. (2012). Chapter 4: Africa. In: Metcalfe, S.E. and Nash, D.J. (eds). *Quaternary Environmental Change in the Tropics*. John Wiley & Sons, Chichester

Neke, K.S. and Du Plessis, M.A. (2004). Land transformation threat and conservation planning. *Conservation Biology* 18: 466-477

Neumann, F.H., Stager, J.C., Scott, L., Venter, H.J.T. and Weyhenmeyer, C. (2008). Holocene vegetation and climate records from Lake Sibaya, KwaZulu-Natal (South Africa). *Review of Palaeobotany and Palynology* 152: 113-128

Neumann, F.H., Scott, L., Bousman, L. and van As, L. (2010). A Holocene sequence of vegetation change at Lake Eteza, coastal KwaZulu-Natal, South Africa. *Review of Palaeobotany and Palynology* 162: 39-53

Nyakale, M. and Scott, L. (2002). Interpretation of Late Holocene pollen in channel fills in the eastern Free State, South Africa, in terms of local conditions and sediment reworking. *South African Journal of Botany* 68: 1-5

Ortu, E., Brewer, S., and Peyron, O. (2006). Pollen-inferred palaeoclimate reconstructions in mountain areas: problems and perspectives. *Journal of Quaternary Science* 21(6): 615-627

Owen, D.L. and van der Zel, D.W. (2000). *Trees, forests and plantations on southern Africa*. Southern African Institute of Forestry: Forestry Handbook Vol. 1: 3-7

Palgrave, K.C. (2002). *Trees of Southern Africa*. Struik Publishers, Cape Town

Partridge, T.C., Kerr, S.J., Metcalfe, S.E., Scott, L., Talms, A.S. and Vogel, J.C. (1993). The Pretoria Saltpan: a 200 000 year southern African lacustrine sequence. *Palaeogeography, Palaeoclimatology, Palaeoecology* 101: 317-337

Partridge, T.C., Avery, D.M., Botha, G.A., Brink, J.S., Deacon, J., Herbst, R.S., Maud, R.R., Scholtz, A., Scott, L., Talma, A.S. and Vogel, J.C. (1990). Late Pleistocene and Holocene climatic change in southern Africa. *South African Journal of Science* 86: 302-305

Partridge, T.C., Scott, L. and Schneider, R.R. (2004). Between Agulhas ad Benguela: responses of Southern African climates if the late Pleistocene to current fluxes, orbital precession and the extent of the circum-antarctic vortex. In: Battarbee, R.W., Gasse, F. and Stickley, C. (eds). *Past climate variables through Europe and Africa*. Springer, Dordrecht, The Netherlands

Pearsall, D.M. (1989). *Paleoethnobotany: A Handbook of Procedures. Second Edition*. Academic Press, California.

Pilcher, J.R. (1991). *Radiocarbon dating*. In: Smart, P.L. and Frances, P.D. (eds). *Quaternary dating methods: A user's guide*. Quaternary Research Association, Cambridge

Pooley, E. (2005). A field guide to wild flowers: KwaZulu-Natal and the Eastern region 2nd Edition. The Flora Publication Trust, Durban

Prentice, I.C. (1988). Records of vegetation in time and space: the principles of pollen analysis. In: Huntley, B. and Webb, T. (eds), *Vegetation History*. Kluwer Academic Publishers, Dordrecht

Repinski, P., Holmgren, K., Lauritzen, S.E. and Lee-Thorpe, J.A. (1999). A late Holocene climate record from a stalagmite, Cold Air Cave, Northern Province, South Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* 150: 269-277

Ritchie, J.C. (1995). Tansley review No. 83. Current trends in studies of long-term plant community dynamics. *New Phytologist* 130: 469-494

Roberts, N. (1998). *The Holocene: An Environmental History. 2nd Edition*. Blackwell Publishing, Oxford

Ruddiman, W.F., (2003). Orbital insolation, ice volume, and greenhouse gases. *Quaternary Science Reviews* 22: 1597–1629

Rycroft, H.B. (1942). *The plant ecology of the Karkloof Forest, Natal*. MSc Thesis, University of Natal, Pietermaritzburg

Rycroft, H.B. (1944). The Karkloof forest Natal. *Journal of the South African Forestry Association* 11: 14-25

Saarnisto, M. (1988). Time-scales and dating. In: Huntley, B. and Webb, T. (eds). *Vegetation History*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Samways, M.J. (2007). Implementing ecological networks for conserving insect and other biodiversity. In: Stewart, A., Lewis, O., New, T.R., (eds). *Insect Conservation Biology*, CABI, Wallingford, Oxon, UK.

Sangu, G., and Bracebridge, C. (2005). Results of Flora. In *Uluguru Component Biodiversity Survey 2005 (Volume II): Uluguru South Forest Reserve.*, eds. Bracebridge, C., Fanning, E., Howell, K.M., Rubio, P. and St. John, F.A.V. 25-35. Dar es Salaam: Society for Environmental Exploration and the University of Dar es Salaam: CARE-Tanzania, Conservation and Management of the Eastern Arc Mountain Forests (CMEAMF): Uluguru Component, Forestry and Beekeeping Division of the Ministry of Natural Resources and Tourism.

Scott, A.C. (2010). Charcoal recognition, taphonomy and uses in palaeoenvironmental analysis. *Palaeogeography, Palaeoclimatology, Palaeoecology* 291: 11-39

Scott, A.C., and Damblon, F. (2010). Charcoal: Taphonomy and significance in geology, botany and archaeology. *Palaeogeography, Palaeoclimatology, Palaeoecology* 291: 1-10

Scott, A.C., Moore, J. and Brayshay, B. (2000). Introduction to fire and the palaeoenvironment. *Palaeogeography, Palaeoclimatology, Palaeoecology* 164: 7-11

Scott, L. (2002). Microscopic charcoal in sediments: Quaternary fire history of the grassland and savannah regions of South Africa. *Journal of Quaternary Science* 17: 77-86

Scott, L. (1999). Vegetation history and climate in the savannah biome South Africa since 190,000ka: a comparison of pollen data from the Tswaing Crater (the Pretoria Saltpan) and Wonderkrater. *Quaternary International* 57/58: 215-23

Scott, L. (1993). Palynological evidence for late Quaternary warming episodes in Southern Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* 101: 229-235

Scott, L. (1990). Environmental change reflected by pollen in some Holocene sediments from Transvaal, South Africa and Marion Island, southern Ocean. *South African Journal of Science* 86: 464-466

Scott, L. (1987). Late Quaternary forest history in Venda, southern Africa. *Review of Palaeobotany and Palynology* 53: 1-10

Scott, L. (1984). Palynological evidence for Quaternary palaeoenvironments in southern Africa. In: Klein, R.G. (ed) *Southern Africa prehistory and palaeoenvironments*, Balkema, Rotterdam: 65-80

Scott, L. (1983). Palynological evidence for vegetation patterns in the Transvaal (South Africa) during the late Pleistocene and Holocene. *Bothalia* 14: 445-449

Scott, L. (1982a). Late Quaternary fossil pollen grains from the Transvaal, South Africa. *Review of Palaeobotany and Palynology* 36: 241-278

Scott, L. (1982b). Pollen analysis of Cainozoic deposits in the Transvaal, South Africa, and their bearing on palaeoclimates. *Palaeoecology of Africa* 15: 101-107

Scott, L. (1982c). A late Quaternary pollen record for the Transvaal Bushveld, South Africa. *Quaternary Research* 17: 339-370

Scott, L. (1982d). A 5000-year old pollen sequence from spring deposits in the bushveld at the north of Soutpansberg, South Africa. *Palaeoecology of Africa* 14: 45-55

Scott, L., Bousman, C.B. and Nyakale, M. (2005). Holocene pollen from swamp, cave and hyrax dung deposits at Blydefontein (Kikvorsberge), Karoo, South Africa. *Quaternary International* 129: 49-59.

Scott, L., Cadman, A. and McMillan, I. (2006). Early history of Cainozoic Asteraceae along the Southern African west coast. *Review of Palaeobotany and Palynology* 142: 47-52

Scott, L., Holmgren, K., Talma, A.S., Woodbourne, S. and Vogel, J.C. (2003). Age interpretation of the Wonderkrater spring sediment and vegetation change in the Savanna Biome, Limpopo Province, South Africa. *South African Journal of Science* 99: 484-488

Scott, L. and Nyakale, M. (2002). Pollen indications of Holocene environments at Florisbad spring in the central Free State, South Africa. *The Holocene* 12: 535-541

Scott, L. and Vogel, J.C. (2000). Evidence of environmental conditions during the last 20 000 years on Southern Africa from ^{13}C in fossil hyrax dung. *Global and Planetary Change* 26: 207-215

Scott, L. and Steenkamp, M. (1996). Environmental History and recent human influence at Lake Teza, KwaZulu-Natal. *South African Journal of Science* 92: 348-350

Scott, L., Steenkamp, M. and Beaumont, P.B. (1995). Palaeoenvironmental conditions in South Africa at the Pleistocene-holocene transition. *Quaternary Science Reviews* 14: 937-947

Scott, L. and Vogel, J.C. (1983). Late Quaternary pollen profile from the Transvaal Highveld, South Africa. *South African Journal of Science* 79: 266-272

Scott, L. and Vogel, J.C. (1978). Pollen analysis of the thermal spring deposit at Wonderkrater (Transvaal, South Africa). *Palaeoecology of Africa* 10: 155-162

Scott-Shaw, C. (1971). *Stories from the Karkloof Hills*. Shuter and Shooter (Pty) Ltd, Pietermaritzburg.

Scott-Shaw, R., (1999). *Rare and threatened plants of KwaZulu-Natal and neighbouring regions: A plant red data book*. KwaZulu-Natal Nature Conservation Service, Biodiversity Division, Scientific Services Directorate, Pietermaritzburg

Sjöppa, H. and Bennett, K.D. (2003). Quaternary pollen analysis: recent progress in palaeoecology and palaeoclimatology. *Progress in Physical Geography* 27: 548-579

Sherry, S.P. (1968). The black wattle (*Acacia mearnsii* de Wild). University of Natal Press. Pietermaritzburg

Smith, J.M., Lee-Thorp, J.A. and Sealy, J.C. (2002). Stable carbon and oxygen isotope evidence for late Pleistocene to middle Holocene climatic fluctuations in the interior of southern Africa. *Journal of Quaternary Science* 17: 683-695

Stager, J.C., Ryves, D.B., King, C., Madson, J., Hazzard, M., Neumann, F.H. and Maud, R. (2013). Late Holocene precipitation variability in the summer rainfall region of South Africa. *Quaternary Science Reviews* 67: 105-120

Stockmarr, J. (1971). Tablets with spores used in absolute pollen analysis. *Pollen et Spores* 8: 615-621

Taylor, R.E. (2000). The contribution of radiocarbon dating to the new world archaeology. *Radiocarbon* 42: 1-21

Taylor, H.C. (1961). The Karkloof forest: A plea for its protection. *Forestry in South Africa* 1: 123-134

Terwilliger, V.J., Eshetu, Z., Colman, A., Bekele, T., Gezahgne, A., Fogel, M.L. (2008). Reconstructing palaeoenvironment from $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of soil organic matter: A calibration from arid and wetter elevation transects in Ethiopia. *Geoderma* 147: 197–210

Traverse, A. (1999). Palynology/ecology interface. In: Jones, T.P. and Rowe, N.P. *Fossil plants and spores: Modern Techniques*. The Geological Society, London

Troels-Smith, J. (1955). Characterisation of unconsolidated sediments. *Danmarks Geologiske Undersøgelse* 3: 1-73

Van de Mortel, J.E. and Aarts, M.G.M. (2006). Comparative transcriptomics - model species lead the way. *New Phytologist* 170: 199-201

Van Oudtshoorn, F. (1999). *Guide to grasses of Southern Africa*. Briza Publications, Pretoria.

Van Zinderen Bakker, E.M. (1953). *South African pollen grains and spores. Part I*. Amsterdam: 148 A.A. Balkema.

Van Zinderen Bakker, E.M. (1956). *South African pollen grains and spores. Part II*. Amsterdam: A.A. Balkema.

Van Zinderen Bakker, E.M. and Coetzee, J.A. (1959). *South African pollen grain and spores. Part III*. Amsterdam: A.A. Balkema.

Vavrus, S., Ruddiman, W.F. and Kutzbach, J.E. (2008). Climate model tests of the anthropogenic influence on greenhouse-induced climate change: the role of early human agriculture, industrialization, and vegetation feedbacks. *Quaternary Science Reviews* 27: 1410– 1425

Vogel, J.C. (1978). Isotopic assessment of dietary habits of ungulates. *South African Journal of Science* 74: 298-301

Von Maltitz, G., Mucina, L., Geldenhuys, C.J., Lawes, M., Eeley, H., Adie, H., Vink, D., Fleming, G. and Bailey, C. (2003). Classification system for South African indigenous forests: An objective classification for the Department of Water Affairs and Forestry. *Environmentek Report ENV-P-C 2003-017*, CSIR. Pretoria

Wakelin, J. and Hill, T. (2007). The impact of land transformation on breeding blue swallows *Hirundo atrocaerulea* undevall, in Kwazulu-Natal, South Africa. *Journal for Nature Conservation* 15: 245-255

Walker, M.J.C. (2005). *Quaternary dating methods*. John Wiley and Sons, Ltd, England.

Wang, L., D'Odorico, P., Ries, L. and Macko, S.A. (2010), Patterns and implications of plant-soil $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values in African savanna ecosystems. *Quaternary Research* 73: 77-83

Watrin, J., Lézine, A., Gajewski, K. and Vincens, A. (2007). Pollen-plant-climate relationships in sub-Saharan Africa. *Journal of Biogeography* 34: 489-499

Weyer, V.D. (2000). *Land transformation in the Karkloof cathment between 1944 and 1999: towards a database for future planning*. Unpublished MSc Thesis, University of Natal, Pietermaritzburg

Wheeler, J. (2007). *The implications of iron-working on the woodlands of Rievaulx and Bilsdale, North Yorkshire, United Kingdom: historical, palaeoecological and palaeoenvironmental perspectives*. Circa 1068-2000, University of Bradford.

Whitlock, C. and Larsen, C. (2001). Charcoal as a fire proxy. In: Smol, J.P., Birks, H.J.B. and Last, W.M. (2001). *Tracking environmental change using lake sediments. Volume 3: Terrestrial, algal and siliceous indicators*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Willarda, D.A., Weimera, L.M., and Riegel, W.L. (2001). Pollen assemblages as paleoenvironmental proxies in the Florida Everglades. *Review of Palaeobotany and Palynology* 113: 213–235

Williams, M.A.J., Dunkerley, D.L., De Dekker, P., Kershaw, A.P. and Stokes, T. (1993). *Quaternary Environments*. Edward Arnold, London

Williams, M.A.J., Dunkerley, D.L., De Dekker, P., Kershaw, A.P. and Chappell, J. (1998). *Quaternary Environments. Second Edition.* Edward Arnold, London

Willis, K.J. and Birks, H.J.B. (2006). What is natural? The need for long-term perspective in biodiversity conservation. *Science* 314: 1261-1265

Zubakov, V.A. and Borzenkova, I.I. (1990). *Global palaeoclimate of the late Cenozoic: developments in palaeontology and stratigraphy 12.* Elsevier, Amsterdam

PERSONAL COMMUNICATION

Blaauw, M. (2012). Personal Communication. School of Geography, Archaeology and Palaeoecology, Queen's University Belfast, United Kingdom

McCann, K. (2012). Personal Communication. The Wildlands Conservation Trust, Pietermaritzburg

Newton, I. (2012). Personal Communication. Stable Light Isotope Laboratory, Archaeology Department, University of Cape Town

APPENDIX A

Preparation Procedure for Reference Material

Source: Finch (2005) revised from Hill (1992) and Baxter (1996)

Note: Centrifuge at 4000 rpm for 3 minutes, unless otherwise specified.

Use 100ml sealable, polypropylene tubes in a swing-out centrifuge.

A. Chemical Pre-processing

1. Place specimen in a 100 ml polypropylene tube
2. Add 20 ml 10% NaOH to the tube and stir
3. Heat in a water bath (50-60°C) for 5 minutes, stirring often
4. Strain and wash through a clean 200 µm mesh sieve. Lightly crush the material on the screen and wash through with distilled water
5. Centrifuge and decant
6. Transfer content to a 10 ml centrifuge tube using glacial acetic acid
7. Stir, centrifuge and decant
8. Add 20 ml acetolysis mixture (comprising 9 parts acetic anhydride: 1 part sulphuric acid). Place in a heated water bath (50-60°C) for 5 minutes, stirring occasionally
9. Remove from water bath and place within cold water for a few seconds (this stops the reaction)
10. Stir, centrifuge and decant
11. Wash 3-5 times with distilled water, adding 1-3 drops of aqueous safranin stain into the final wash
12. Wash in a mild solution of phenol to prevent bacteriological and fungal spoilage
13. Invert the tubes onto blotting paper and allow them to drain

B. Mounting Slides

1. Clean and label the microscope slides (3 replicates for each specimen)
2. Cut tiny blocks of glycerine jelly (preferentially a brand which is phenol impregnated) and using a dissecting needle, pick up pollen grains/spores from the blotting paper. Wipe the glycerine around the inside of the centrifuge tube to pick up the pollen residue
3. Place glycerine jelly on the centre of the slide and pass over a heating plate to melt the jelly. Caution: do not allow the jelly to boil as the texture of the jelly and the structure of the pollen will be damaged (heating plate must be approx. 40-45°C)
4. Carefully lower a coverslip over the jelly using a dissecting needle. While allowing the jelly to cool and set, invert the slide so that the pollen grains, suspended in the glycerine jelly, settle on the inside of the cover slip. This ensures that all the grains are in the same focal plane and makes for easier microscopy
5. Once the jelly has set, scrape off any excess that may have extruded from the coverslip
6. Paint a few coats of clear nail varnish around the edge of the coverslip to act as a sealant

APPENDIX B

Characteristics of the modified Troels-Smith system of sediment description with original terms in bracets (Kershaw, 1997: 65).

Physical Features	
Degree of darkness	Varies from 0 in the lightest occurring shades (eg. clear (Nigror) quartz sand and lake marl), through 1 (eg. calcareous clay), 2 (eg. fresh swamp peat), 3 (eg. partly humified peat) to 4 in the darkest sediments (eg. completely disintegrated peat).
Degree of stratification	Visual or structural horizontal banding or layering. Varies (Stratification) from 0 where the deposit is completely homogeneous or breaks in all directions, to 4 which consists of clear thin layers or bands.
Degree of elasticity	The sediment's ability to regain its shape after being (Elasticitas) squeezed or bent. Varies from 0 in plastic clay, sand, disintegrated peat etc. to 4 in fresh peat.
Degree of dryness	Deposits fall between 0 (clear water) and 4 (air dry material). (Siccitas) 1 indicates very wet runny sediment such as surface lake muds, 2 represents saturated sediments, the normal condition below the water table, while sicc. 3 indicates moist, unsaturated sediments.
Colour	Best determined by reference to Munsell soil colour charts. Changes in colour with exposure to air should be noted.
Structure	The dominant structural feature (eg. fibrous, homogeneous)
Sharpness of boundary	The boundary can be diffuse (> 1cm: lim. 0), very gradual (Limes superior) (<1cm to > 2mm: lim. 1), gradual (< 2mm to >1mm: lim. 2), sharp (<1mm to > 0.5mm) or very sharp (< 0.5mm).
Humicity The degree of humification or disintegration of organic (Humicitas) substances. It is measured by determination of the nature and amount of material passing through the fingers on squeezing; 0 (fresh peat yielding clear water), 1 (slightly decomposed peat yielding dark coloured, turbid water), 2 (decomposed peat yielding half its mass), 3 (very decomposed peat yielding three-quarters of its mass) and 4 (totally decomposed peat yielding almost all its mass).	
Components	
Mosses (<i>Turfa bryophytica</i>)	<i>Sphagnum</i> is the most common peat-former.
Woody plants (<i>Turfa lignosa</i>)	Roots of trees and shrubs together with attached stumps and branches, frequently in growth position.
Herbs (<i>Turfa herbacea</i>)	Roots of herbaceous plants together with attached stems and leaves, frequently in growth position.
Woody detritus (<i>Detritus lignosus</i>)	Fragments of woody plants >2mm.
Herb detritus (<i>Detritus herbosus</i>)	Fragments of herbaceous plants >2mm.
Fine detritus (<i>Detritus granosus</i>)	Fragments of woody or herbaceous plants <2mm.
Charcoal	Carbonised fragments of predominantly woody plants.
Organic lake mud	Homogeneous organic lake sediment composed of remains (<i>Limus detrituosus</i>) of microplankton and humified remains of macrophytes.
Humus (<i>Substantia humosa</i>)	Completely disintegrated organic substances and precipitated humic acids.
Organosilicates (<i>Limus siliceous</i>)	Siliceous skeletons or skeleton fragments of diatoms, sponges etc.
Carbonates (<i>Limus calcareus</i>)	Calcium carbonate or marl. Similar in colour and texture to <i>L. siliceous</i> but soluble in hydrochloric acid.
Iron oxides (<i>Limus ferrugineus</i>)	Iron oxides of various types and colours.
Clay (<i>Argilla steatodes</i>)	Mineral particles <0.002mm
Silt (<i>Argilla granosa</i>)	Mineral particles 0.002-0.06mm
Sand (<i>Grana minora</i>)	Mineral particles 0.06 - 2mm.
Gravel (<i>Grana majora</i>)	Mineral particles >2mm.

APPENDIX C

Procedure for Subsampling

Adapted from Finch (2005), revised from Faegri and Iverson (1989)

1. Use a clean, sharp scalpel to clean the entire surface of the core. Cut away superficial material using cleaning movements, which are parallel to the strata so as not to contaminate between strata.
2. Determine sampling intervals by examining the stratigraphy, and considering the estimated depth of the core in relation to its length. For example, it is important to sample on either side of distinct chronological/stratigraphic boundaries. A sampling interval of 2 cm was used.
3. Samples should consist of approximately 2 cm³ of sediment situated at a depth of 1 cm beneath the wall of the core. Samples can be cut out using a scalpel or spatula where there is no need to determine exact volumes. Subsampling sufficient material for pollen analysis and isotope analysis is recommended.
4. Store each sample within an airtight plastic storage bags.
5. Samples for C¹⁴ dating need to represent the shortest possible period, i.e. should consist of a short slice across the whole core. These samples should consist of approximately 50 g of peat and should be stored in airtight plastic storage bags and refrigerated.

Troels-Smith Data Sheets for Sediment Core DA2

Elevation - 1563 m a.s.l.

Site: Dartmoor Transect number: _____ Core name: DA 2 Dist. from site edge: _____ Date: 6 March 2010

[illegible]

Site: Dartmoor Transect number: _____ Core name: DA 2 Dist. from site edge: _____ Date: 6 March 2010

[illegible]

APPENDIX E

Swirling Technique for Pollen and Charcoal Extraction

Procedure:

Laboratory preparation of sub-samples from sediment and/or peat extracted from pollen cores for pollen analysis using the gravitational separation ‘swirling’ technique:

(a) Sub-sampling of pollen cores to extract peat and/or alluvial sediment

1. The pollen cores are taken from the cold room and placed on the bench top. The pollen cores have been stored wrapped in ‘Clingfilm’ and aluminium foil are unwrapped to expose the peat and/or sediment surface. A scalpel is used to cut 1cm^3 sub-samples along the length of the core (the standard sub-sampling strategy is to extract sub-samples at 8cm points to maximum depth). The 1cm^3 sub-samples are placed in labelled storage tubes/phials prior to processing. If the sub-samples cannot be processed following extraction from the core/s, they will be refrigerated until preparation can be undertaken.

(b) Pollen extraction using KOH and $\text{Na}_4\text{O}_7\text{P}_2$, followed by ‘swirling’ – gravitational separation

1. The wet or moist sub-sample – 1cm^3 – is placed in a 50ml glass beaker. 40ml of 10% KOH is added, along with 5mg of $\text{Na}_4\text{O}_7\text{P}_2$ powder.
2. Place the labelled beakers in a heating block that is situated in a fume cupboard, and heat for 10 minutes. The solution will bubble gently.
3. Regulate the bubbling of the liquid by placing the beakers in a heating block. Monitor process to ensure that the beakers do not boil dry or reduce below the 20ml mark. If they should, top up the beakers with distilled H_2O .

4. Record the colour of the liquid.
5. After 10 minutes remove the beakers from the heat tray. Pour the contents of each beaker through a 140 μ sieve onto a Perspex 'swirling' dish and swirl very gently. Mains supply H₂O is used to swill the sieve onto the swirling dish. The macro remains are examined and recorded. A water filter is used on the laboratory mains H₂O supply, attached to the tap with rubber tubing, to reduce contamination by modern pollen and to provide H₂O supply. A ring of sediment will form around the outer edge of the liquid contained within the 'swirling' dish and is indicative of gravitational separation. At this point, the 'swirling' dish is tipped gently allowing the liquid containing the sub-fossil pollen to be tipped onto a 6 μ sieve, and the draining liquid can be poured directly down the sink drain – run to waste. The 6 μ sieve is topped up with filters main H₂O and rinsed, with the waste liquid running down the sink drain. The 'swirling' dish is rinsed and put to one side.
6. The solution contained within the 6 μ sieve is aggregated to break the surface tension, being tapped repeatedly to encourage the solution to pass through the sieve. The silts and clays pass through the sieve but particulates, including sub-fossil pollen remain. Add H₂O to the 6 μ sieve to float the particulates and pour onto the 'swirling dish'. Repeat this process a minimum of 3 times (peat may required a minimum of 4 washes).
7. On the final wash, when the liquid is in the 6 μ sieve, using a disposable plastic pipette, flush the remaining solution through the sieve using the jettison effect of the pipette, but allow enough solution to remain in the base of the sieve to dilute 2 drops of Safranin O solution 1%. If the sub-sample should run dry, a small amount of H₂O can be added from the filtered mains supply.
8. Decant the stained sub-sample into a labelled phial using the same disposable pipette. Secure phial to make sure that so solution will not leak. Dispose of pipette.

9. A preliminary test to ascertain if the extraction process has been successful can be made at this point, prior to the disposal of the pipette, by dropping 1 x droplet of the processed liquid onto a microscope slide. The solution can then be checked under a microscope to reveal sub-fossil pollen and associated particulates.

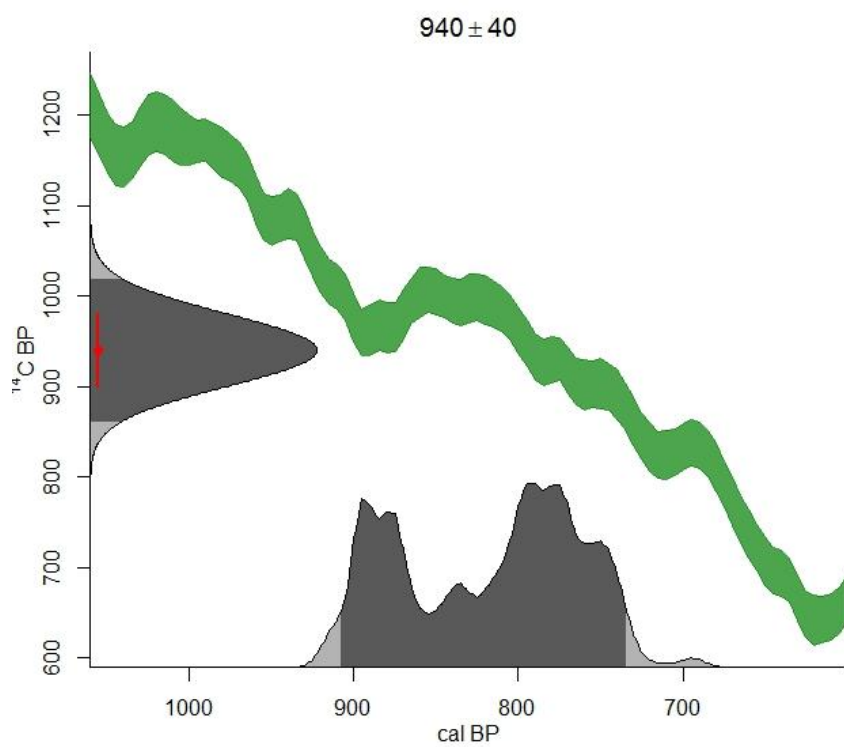
(c) Mounting process

1. Allow phials containing the processed solution to stand in a refrigerator for twelve hours. Remove sub-samples from refrigerator and using a pipette remove the clear solution above the sediment. Add 2 – 4 droplets of Aquamount to the sediment and shake well. Leave the Aquamount solution for a further twelve hours in the refrigerator. Remove Aquamount solution from refrigerator and using a pipette drop 1 – 2 droplets of solution onto a microscope slide that has been previously labelled with the sub-sample details. If necessary spread the solution thinly across the microscope slide using a wooden cocktail stick. Place a microscope cover slip over the solution onto the slide and place in a refrigerator for twelve hours to settle and set.

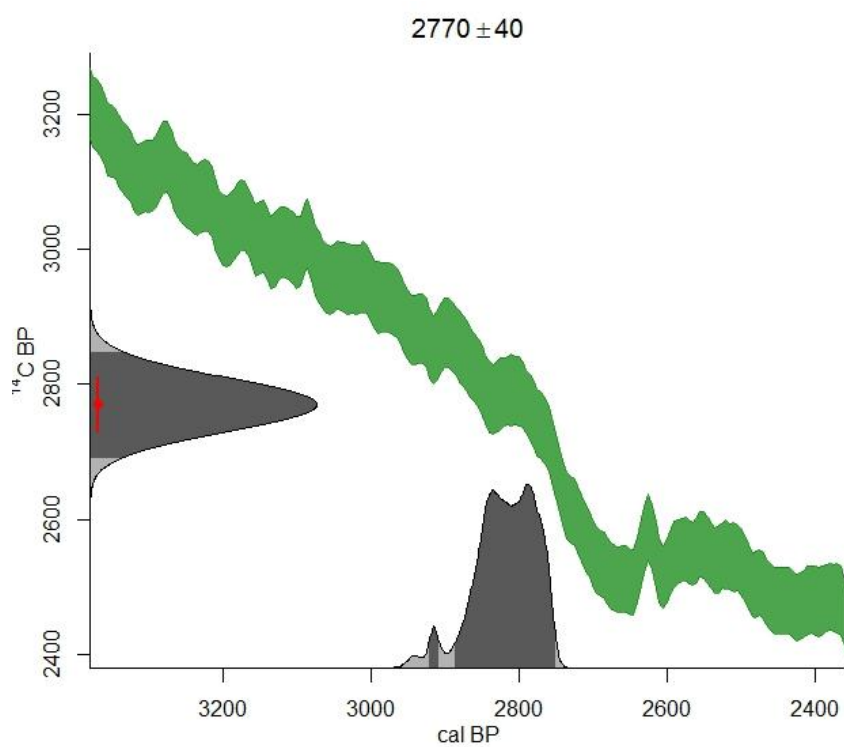
APPENDIX F

Calibrated ages of individual samples

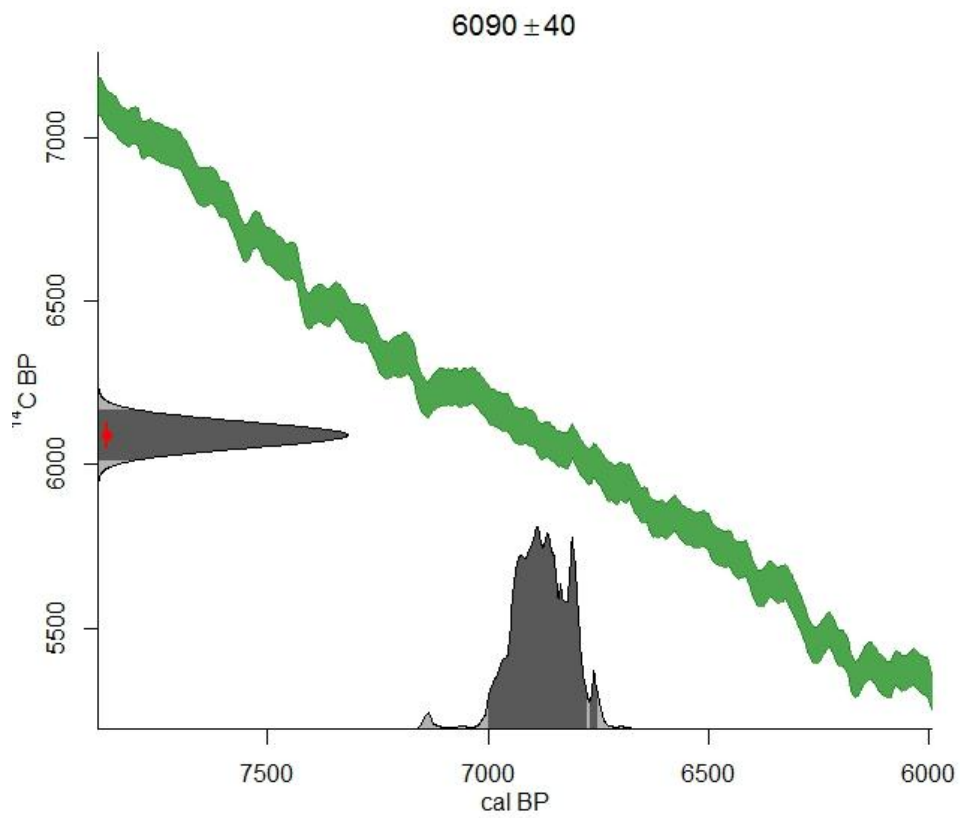
Depth range: 32 cm



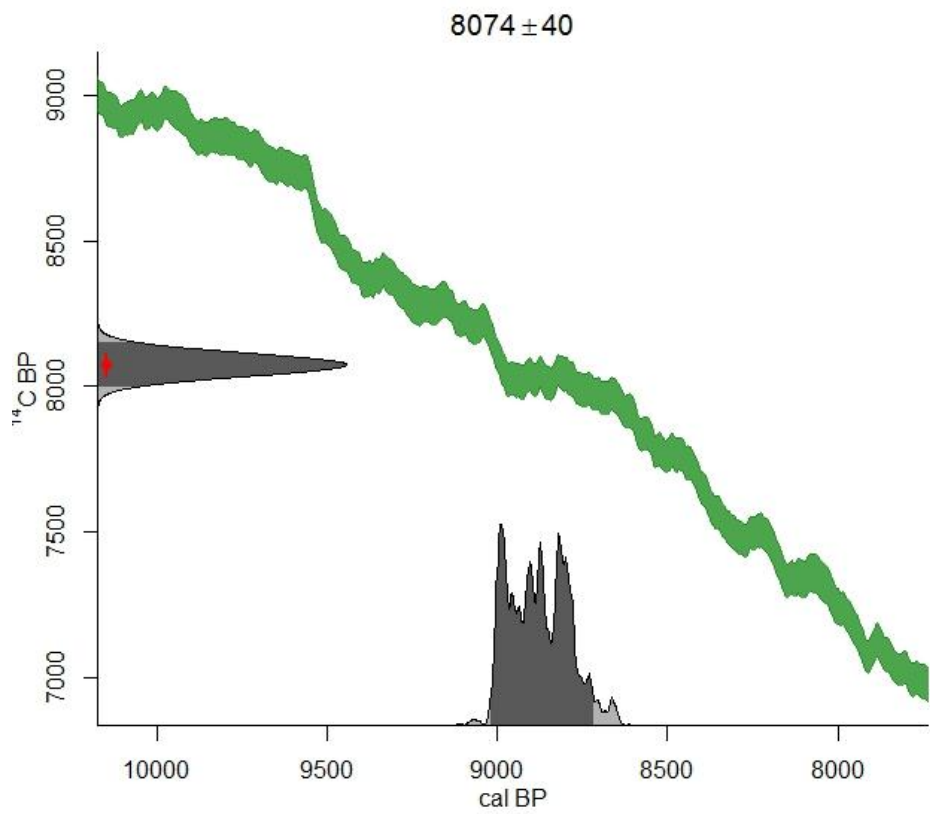
Depth range: 51 cm



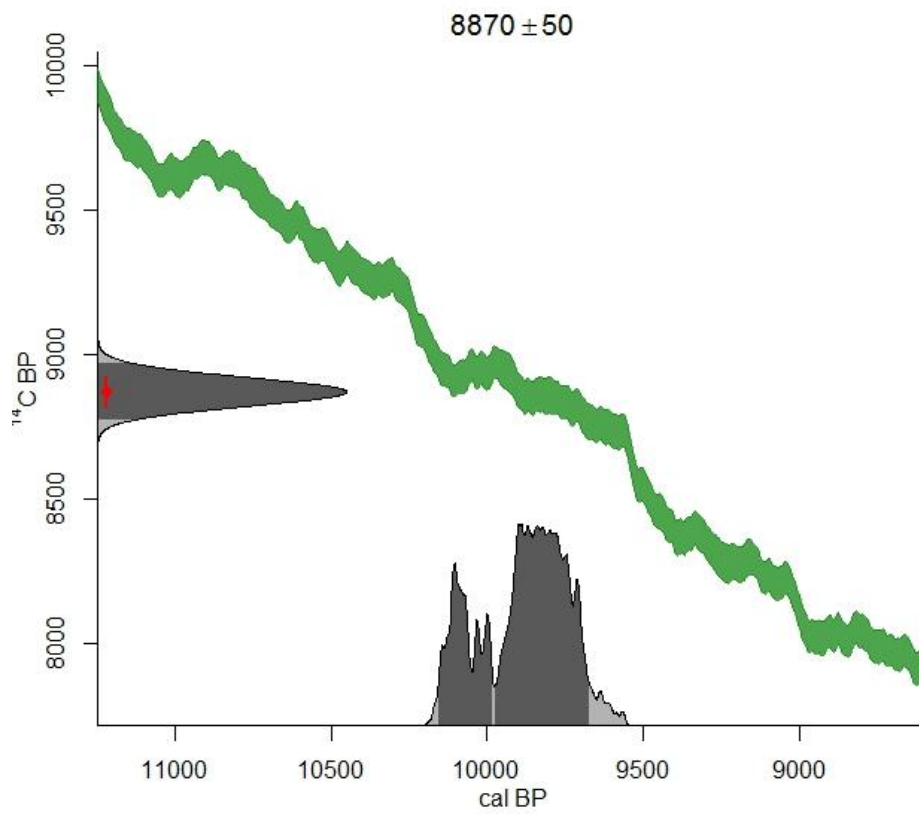
Depth range: 70 cm



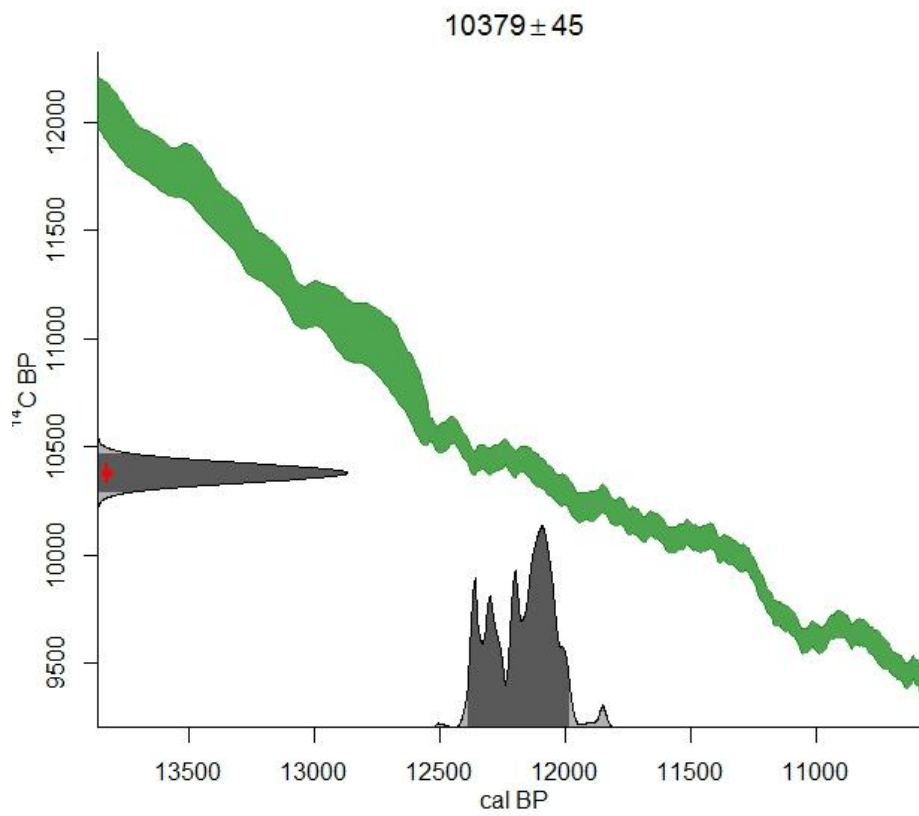
Depth range: 93 cm



Depth range: 110 cm



Depth range: 141 cm



APPENDIX G

Interpolated Calibrated Ages

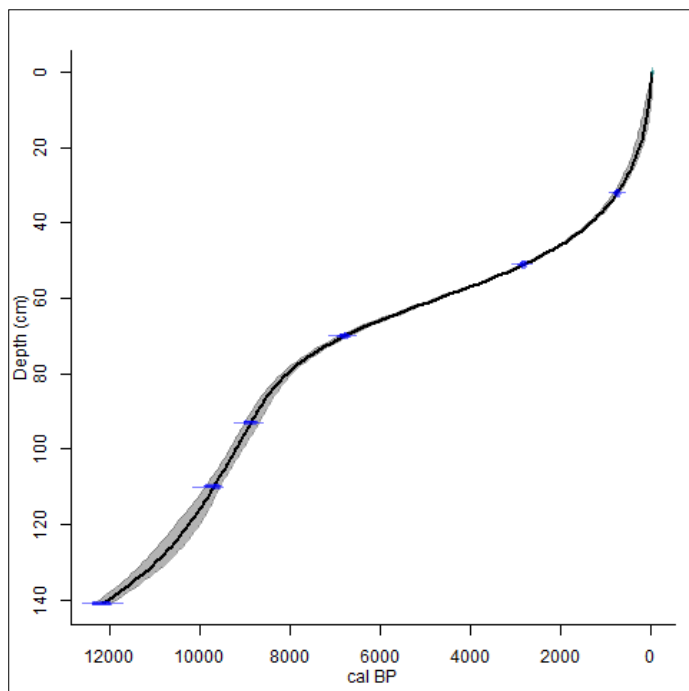
Depth (cm)	Cal. Min. date	Cal. Max. date	Best Date	Depth (cm)	Cal. Min. date	Cal. Max. date	Best Date
0	-59	-41	-50	40	1561	1664	1606
1	-35	-16	-26	41	1671	1776	1716
2	-11	9	-2	42	1781	1889	1826
3	13	34	22	43	1890	2000	1937
4	36	60	46	44	1999	2115	2047
5	59	85	71	45	2108	2229	2158
6	82	111	95	46	2217	2345	2268
7	106	136	119	47	2325	2460	2378
8	129	162	143	48	2433	2575	2489
9	151	188	167	49	2541	2690	2599
10	174	214	191	50	2648	2807	2709
11	197	241	216	51	2755	2922	2820
12	220	267	240	52	2968	3128	3029
13	243	292	264	53	3178	3332	3238
14	266	318	288	54	3387	3536	3447
15	289	344	312	55	3595	3742	3656
16	312	370	336	56	3804	3949	3865
17	334	397	361	57	4011	4156	4074
18	357	424	385	58	4218	4363	4283
19	379	450	409	59	4425	4571	4492
20	402	476	433	60	4631	4779	4701
21	425	502	457	61	4837	4991	4910
22	447	528	481	62	5043	5201	5119
23	470	554	505	63	5249	5413	5328
24	493	580	530	64	5454	5626	5538
25	515	606	554	65	5658	5840	5747
26	538	633	578	66	5863	6054	5956
27	560	659	602	67	6068	6270	6165
28	583	685	626	68	6271	6486	6374
29	606	712	650	69	6475	6701	6583
30	629	738	675	70	6678	6914	6792
31	651	764	699	71	6773	7001	6883
32	674	790	723	72	6867	7086	6974
33	786	899	833	73	6962	7170	7064
34	899	1005	944	74	7056	7257	7155
35	1010	1113	1054	75	7148	7342	7246
36	1120	1222	1164	76	7241	7432	7337
37	1231	1331	1275	77	7331	7523	7427
38	1341	1442	1385	78	7421	7614	7518
39	1452	1553	1495	79	7509	7705	7609

Depth (cm)	Cal. Min. date	Cal. Max. date	Best Date	Depth (cm)	Cal. Min. date	Cal. Max. date	Best Date
80	7600	7797	7700	111	9640	9964	9773
81	7688	7892	7791	112	9723	10039	9853
82	7772	7983	7881	113	9805	10113	9933
83	7859	8076	7972	114	9886	10191	10012
84	7945	8168	8063	115	9967	10270	10092
85	8028	8259	8154	116	10049	10345	10172
86	8109	8351	8245	117	10129	10423	10252
87	8192	8445	8335	118	10210	10500	10332
88	8274	8541	8426	119	10290	10580	10411
89	8354	8634	8517	120	10367	10659	10491
90	8436	8728	8608	121	10447	10737	10571
91	8521	8821	8699	122	10526	10818	10651
92	8600	8918	8789	123	10607	10897	10731
93	8682	9014	8880	124	10685	10976	10810
94	8744	9055	8928	125	10765	11054	10890
95	8804	9100	8976	126	10840	11134	10970
96	8867	9148	9024	127	10917	11213	11050
97	8924	9194	9071	128	10996	11293	11130
98	8981	9244	9119	129	11070	11373	11209
99	9037	9293	9167	130	11144	11452	11289
100	9090	9344	9215	131	11220	11535	11369
101	9144	9399	9263	132	11292	11616	11449
102	9197	9449	9311	133	11365	11700	11529
103	9249	9502	9358	134	11442	11783	11608
104	9297	9554	9406	135	11518	11869	11688
105	9344	9608	9454	136	11595	11955	11768
106	9389	9661	9502	137	11673	12041	11848
107	9432	9715	9550	138	11750	12125	11927
108	9476	9773	9598	139	11825	12210	12007
109	9516	9831	9645	140	11900	12297	12087
110	9556	9891	9693	141	11970	12384	12167

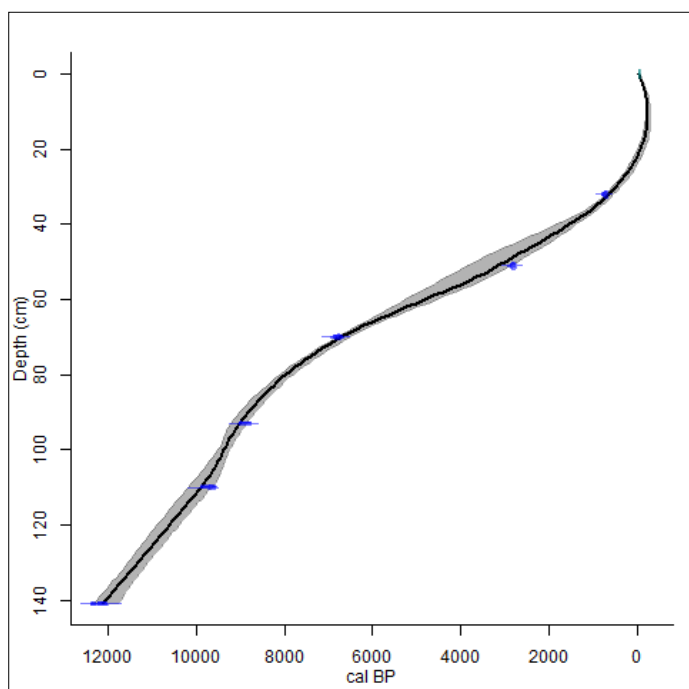
APPENDIX H

Age-depth models

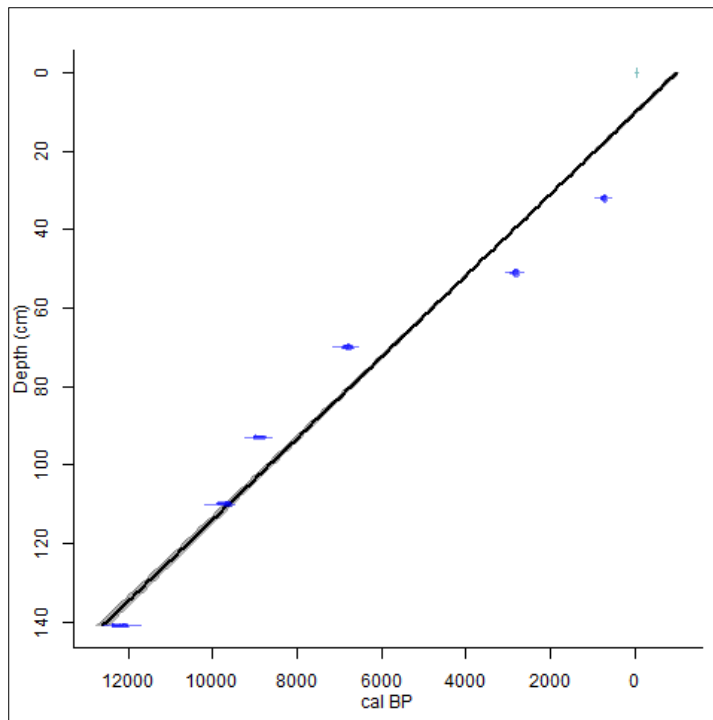
Cubic spline



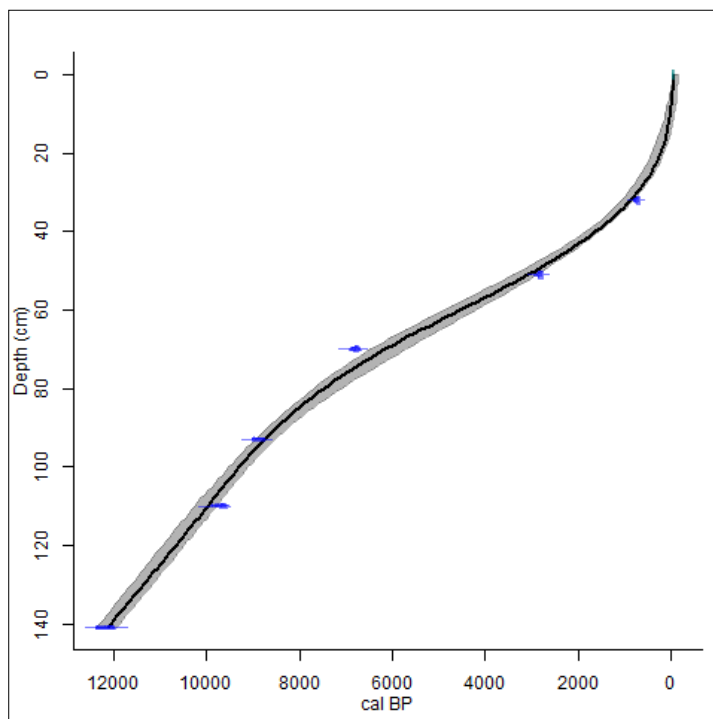
Loess



Polynomial Regression



Smooth Spline



Appendix I

Vegetation Survey – Dartmoor Vlei

Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
1	95	<i>Eriosema</i> sp.	1
		<i>Senecio isatidiodes</i>	1
		<i>Tristachya leucothrix</i>	3
		<i>Trachypogon spicatus</i>	3
		<i>Acalypha</i> sp.	1
		Unidentified Forb E	1
		<i>Sabeae natalensis</i>	1
		<i>Themeda triandra</i>	1
		Poaceae B	2
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
2	95	<i>Acalypha</i> sp.	1
		<i>Eriosema</i> sp.	2
		<i>Senecio isatidiodes</i>	2
		<i>Heteropogon contortus</i>	2
		<i>Themeda triandra</i>	1
		Poaceae B	2
		<i>Eragrostis</i> sp.	1
		<i>Tristachya leucothrix</i>	2
		Poaceae D	1
		Unidentified Forb E	1
		<i>Helichrysum adenocarpum</i>	1
		Unidentified Forb C	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
3	90	<i>Watsonia densiflora</i>	3
		<i>Senecio isatidiodes</i>	2
		<i>Helichrysum</i> spp.	2
		<i>Tristachya leucothrix</i>	1
		Poaceae B	1
		<i>Heteropogon contortus</i>	1
		Unidentified Fern A	1
		Unidentified Forb C	1
		<i>Oxalis obliquifolia</i>	1
		<i>Erica woodii</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
5	40	<i>Rhus bicolor</i>	2
		Poaceae sp.	1
		<i>Acalypha</i> sp.	1
		<i>Senecio oxyriifolius</i>	1
		<i>Trachypogon spicatus</i>	3
		<i>Geranium cafferum</i>	1
		<i>Sutera floribunda</i>	2

Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
6	100	<i>Eriosema</i> sp.	2
		<i>Protea simplex</i>	2
		<i>Monocymbium ceresiiforme</i>	2
		<i>Heteropogon contortus</i>	2
		Unidentified Forb L	1
		<i>Acalypha</i> sp.	1
		<i>Helichrysum adenocarpum</i>	1
		Unidentified Forb B	1
		<i>Eragrostis capensis</i>	2
		<i>Aristida junciformis</i>	2
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
7	100	<i>Eragrostis capensis</i>	3
		<i>Monocymbium ceresiiforme</i>	2
		<i>Protea simplex</i>	1
		<i>Trachypogon spicatus</i>	1
		<i>Acalypha</i> sp.	1
		<i>Senecio isatidioides</i>	1
		Unidentified Forb B	1
		<i>Gladiolus</i> sp.	1
		Unidentified Forb L	1
		<i>Heteropogon contortus</i>	1
		<i>Tephrosia</i> sp.	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
8	100	<i>Lotononis</i> sp.	3
		<i>Lobelia flaccida</i>	1
		<i>Aristida junciformis</i>	2
		<i>Acalypha</i> sp.	1
		<i>Eriosema</i> sp.	1
		<i>Helichrysum</i> spp.	1
		<i>Themeda triandra</i>	3
		<i>Eragrostis curvula</i>	1
		<i>Oxalis obliquifolia</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
9	100	<i>Eragrostis curvula</i>	2
		<i>Pychnostachys reticulata</i>	3
		<i>Stiburus allopecuroides</i>	2
		<i>Aristida congesta</i>	1
		<i>Aristida</i> sp.	3
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
10	100	<i>Helichrysum</i> spp.	2
		<i>Stiburus allopecuroides</i>	1
		Cyperaceae spp.	4
		<i>Eriocaulon dregii</i>	2
		Poaceae spp.	2
		<i>Eragrostis curvula</i>	1

Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
11	95	<i>Aristida sp.</i>	2
		<i>Tristachya leucothrix</i>	1
		<i>Eragrostis curvula</i>	2
		Cyperaceae spp.	4
		Unidentified Forb J	1
		Unidentified Forb K	1
		<i>Gladiolus sp.</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
12	97	<i>Acalypha sp.</i>	1
		<i>Helichrysum spp.</i>	1
		<i>Stiburus allopecuroides</i>	1
		<i>Trachypogon spicatus</i>	2
		<i>Eragrostis curvula</i>	2
		<i>Themeda triandra</i>	2
		<i>Tristachya leucothrix</i>	2
		<i>Aristida sp.</i>	2
		Unidentified Monocot. A	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
13	80	<i>Stiburus allopecuroides</i>	1
		Unidentified Monocot. A	1
		Moss (<i>Lycopodium</i> type)	1
		Cyperaceae Type F	4
		<i>Schistostephium crataegifolium</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
14	100	<i>Pychnostachys reticulata</i>	2
		<i>Lobelia flaccida</i>	1
		Cyperaceae spp.	4
		<i>Persicaria serrulata</i>	1
		<i>Carex cognata</i>	2
		<i>Juncus lamatophyllus</i>	1
		<i>Calopsis paniculata</i>	2
		<i>Eriocaulon dregii</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
15	98	<i>Rubus auneifolius</i>	3
		<i>Sateria sp.</i>	1
		<i>Geranium schlechteri</i>	2
		Cyperaceae spp.	2
		<i>Sporobolus sp.</i>	1
		<i>Eragrostis sp.</i>	1
		Unidentified Forb F	1
		<i>Aristida sp.</i>	3

Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
16	100	<i>Rubus auneifolius</i>	1
		Cyperaceae spp.	3
		<i>Mentha aquatica</i>	3
		<i>Geranium schlechteri</i>	1
		<i>Pychnostachys reticulata</i>	1
		<i>Gladiolus</i> sp.	1
		<i>Aristida</i> sp.	2
		<i>Eragrostis curvula</i>	1
		<i>Eriocaulon dregii</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
17	100	<i>Mentha aquatica</i>	2
		<i>Eriocaulon dregii</i>	2
		<i>Calopsis paniculata</i>	2
		Cyperaceae spp.	2
		Unidentified Lily type	2
		Poaceae spp.	1
		<i>Sebaea natalensis</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
18	65	<i>Carex cognata</i>	3
		<i>Eriocaulon dregii</i>	1
		Unidentified Forb H	1
		Cyperaceae spp.	2
		<i>Gladiolus</i> sp.	1
		<i>Dinekia capensis</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
19	100	<i>Themeda triandra</i>	3
		<i>Eragrostis</i> sp.	1
		<i>Eriosema</i> sp.	2
		<i>Helichrysum</i> spp.	2
		Cyperaceae spp.	2
		<i>Senecio isatidiodes</i>	1
		<i>Aristida</i> sp.	1
		<i>Stiburus allopecuroides</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
20	100	<i>Brunsvigia grandiflora</i>	2
		<i>Senecio isatidiodes</i>	1
		<i>Eriosema</i> sp.	2
		<i>Themeda triandra</i>	3
		Cyperaceae spp.	2
		<i>Eragrostis</i> sp.	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
21	100	<i>Lobelia flaccida</i>	2
		<i>Eriocaulon dregii</i>	2
		<i>Calopsis paniculata</i>	2
		<i>Eragrostis curvula</i>	1
		Cyperaceae spp.	3
		Unidentified Forb A	1
		Unidentified Lily type	1
		<i>Alectra sessiliflora</i>	1

Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
22	98	<i>Helichrysum sp.</i>	1
		<i>Stiburus allopecuroides</i>	1
		Cyperaceae Type E	4
		Unidentified Forb D	1
		Moss (<i>Lycopodium</i> type)	2
		Unidentified Monocot. B	1
		<i>Aristida sp.</i>	1
		<i>Asteraceae sp.</i>	1
		<i>Gladiolus sp.</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
23	70	<i>Helichrysum spp.</i>	3
		<i>Eragrostis sp.</i>	2
		Unidentified Forb L	1
		<i>Diclis reptans</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
24	95	<i>Lobelia flaccida</i>	1
		<i>Calopsis paniculata</i>	2
		<i>Eragrostis curvula</i>	1
		Cyperaceae spp.	4
		Unidentified Forb I	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
25	100	Cyperaceae Type D	5
		Unidentified Lily type	1
		<i>Aristida sp.</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
26	100	Unidentified Lily type	1
		<i>Helichrysum spp.</i>	2
		<i>Calopsis paniculata</i>	4
		<i>Senecio isatidioides</i>	1
		<i>Alectra sessiliflora</i>	1
		<i>Dinekia capensis</i>	2
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
27	100	Standing water channels Dominated by <i>Juncus</i> <i>lomatophyllus</i>	5
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
28	100	<i>Carex cognata</i>	1
		<i>Juncus lamatophyllus</i>	2
		<i>Schoenoplectus corymbosus</i>	5
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
29	98	Cyperaceae spp.	5
		<i>Harpocloa flax</i>	1
		<i>Diclis reptans</i>	2
		<i>Eragrostis curvula</i>	2

Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
30	98	<i>Tristachya leucothrix</i>	2
		<i>Helichrysum</i> spp.	2
		<i>Stiburus allopecuroides</i>	2
		<i>Monocymbium ceresiiforme</i>	2
		Cyperaceae sp.	2
		<i>Aristida</i> sp.	2
		<i>Heteropogon contortus</i>	2
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
31	100	<i>Eriocaulon dregii</i>	1
		Cyperaceae spp.	3
		<i>Typha capensis</i>	3
		<i>Pychnostachys reticulata</i>	2
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
32	50	<i>Eucomis</i> sp.	2
		<i>Rhus discolor</i>	2
		<i>Rubus auneifolius</i>	2
		<i>Rubus ludwigii</i>	1
		<i>Rubus x proteus</i>	1
		<i>Acalypha</i> sp.	1
		<i>Sutera floribunda</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
33	100	<i>Alectra sessiliflora</i>	1
		Cyperaceae sp.	2
		<i>Juncus lamatophyllus</i>	1
		<i>Scenecio</i> sp.	2
		<i>Typha capensis</i>	5
		<i>Carex cognata</i>	1
		Unidentified Forb H	1
		<i>Eriocaulon dregii</i>	1
		<i>Lobelia flaccida</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
34	100	<i>Scenecio</i> sp.	1
		<i>Eucomis</i> sp.	3
		<i>Pychnostachys reticulata</i>	2
		<i>Senecio isatidioides</i>	2
		Unidentified Forb 33	1
		<i>Diclis reptans</i>	1
		<i>Geranium schlechteri</i>	1
		<i>Eragrostis curvula</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
35	100	<i>Geranium schlechteri</i>	2
		<i>Carex cognata</i>	3
		<i>Scenecio</i> sp.	2
		<i>Pychnostachys reticulata</i>	1
		<i>Eragrostis curvula</i>	1
		Unidentified Forb 33	1
		Cyperaceae spp.	3
		<i>Persicaria surrulata</i>	1

Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
36	100	<i>Eragrostis curvula</i>	1
		<i>Sutera floribunda</i>	1
		<i>Pychnostachys reticulata</i>	1
		<i>Geranium schlechteri</i>	1
		<i>Agapanthus</i> sp.	2
		Cyperaceae spp.	4
		<i>Diclis reptans</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
37	100	Unidentified Forb 33	2
		Cyperaceae spp.	2
		<i>Geranium schlechteri</i>	1
		<i>Helichrysum</i> spp.	2
		<i>Pychnostachys reticulata</i>	1
		<i>Diclis reptans</i>	1
		Unidentified Lily type	1
		Asteraceae sp.	1
		<i>Aristida</i> sp.	3
		<i>Sebaea natalensis</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
38	60	<i>Rusus auneifolius</i>	2
		<i>Helichrysum</i> spp.	2
		<i>Senecio isatidiodes</i>	1
		Cyperaceae spp.	2
		<i>Eragrostis curvula</i>	1
		<i>Crussula natalensis</i>	1
		<i>Diclis reptans</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
39	100	<i>Mentha aquatica</i>	2
		Cyperaceae spp.	4
		<i>Geranium schlechteri</i>	1
		<i>Eragrostis curvula</i>	2
		<i>Persicaria serrulata</i>	2
		<i>Calopsis paniculata</i>	2
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
40	80	Cyperaceae Type G	5
		Cyperaceae spp.	1
		<i>Persicaria serrulata</i>	1
		<i>Mentha aquatica</i>	1
		<i>Calopsis paniculata</i>	2
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
41	100	<i>Juncus lamatophyllus</i>	2
		<i>Mentha aquatica</i>	2
		<i>Pychnostachys reticulata</i>	1
		<i>Scenecio</i> sp.	1
		<i>Geranium schlechteri</i>	1
		Unidentified Forb 33	1
		Cyperaceae spp.	5

Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
42	80	<i>Pychnostachys reticulata</i>	2
		<i>Sateria sp.</i>	1
		<i>Scenecio sp.</i>	1
		<i>Geranium schlechteri</i>	1
		<i>Mentha aquatica</i>	1
		<i>Calopsis paniculata</i>	2
		Cyperaceae spp.	3
		<i>Panicum sp.</i>	2
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
43	100	Cyperaceae spp.	4
		<i>Trachypogon spicatus</i>	2
		<i>Eragrostis curvula</i>	3
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
44	85	<i>Pychnostachys reticulata</i>	1
		<i>Senecio isatidioides</i>	1
		<i>Panicum sp.</i>	1
		Unidentified Forb 33	1
		<i>Trachypogon spicatus</i>	1
		Poaceae C	5
		<i>Scenecio sp.</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
45	95	<i>Rubus auneifolius</i>	1
		<i>Lobelia flaccida</i>	1
		<i>Themeda triandra</i>	2
		<i>Eragrostis curvula</i>	2
		<i>Hypochaeris radicata</i>	1
		<i>Geranium sp.</i>	1
		Unidentified Forb L	1
		<i>Commelia africana</i>	1
		Poaceae spp.	5
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
46	100	<i>Themeda triandra</i>	2
		<i>Aristida junciformis</i>	2
		<i>Eriosema distinctum</i>	2
		<i>Vernonia hirsuta</i>	1
		<i>Rhus discolor</i>	2
		<i>Berkheya achinacea</i>	1
		<i>Lotonis sp. 98</i>	1
		<i>Cyanotis speciosa</i>	1
		Unidentified Forb G	2
		<i>Sutera floribunda</i>	1
		Poaceae 67	1
		<i>Tristachya leucothrix</i>	1

Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
47	95	<i>Eriosema distinctum</i>	2
		<i>Themeda triandra</i>	4
		<i>Aristea woodii</i>	1
		<i>Lotononis</i> sp. 98	1
		<i>Tephrosia</i> sp.	1
		<i>Silene burchellii</i>	1
		<i>Tristachya leucothrix</i>	1
		Unidentified Forb B	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
48	90	<i>Agrimonia procera</i>	1
		<i>Eragrostis curvula</i>	3
		Poaceae spp.	3
		<i>Rubus auneifolius</i>	2
		Cyperaceae Type A	1
		<i>Themeda triandra</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
49	100	<i>Lobelia flaccida</i>	1
		<i>Themeda triandra</i>	3
		<i>Tristachya leucothrix</i>	3
		<i>Pteridium aquilinum</i>	1
		<i>Scenecio</i> sp. 34	1
		<i>Helichrysum spiralepis</i>	1
		<i>Habenaria dives</i>	1
		<i>Hypochaeris radicata</i>	1
		<i>Hypoxis parvula</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
50	100	<i>Helishrysum spiralepis</i>	1
		<i>Eriosema distinctum</i>	2
		<i>Tristachya leucothrix</i>	3
		<i>Eragrostis capensis</i>	2
		Poaceae spp.	3
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
51	85	Unidentified Forb G	1
		<i>Eriocema distinctum</i>	1
		<i>Tephrosia</i> sp.	1
		<i>Tristachya leucothrix</i>	1
		<i>Eragrostis capensis</i>	1
		<i>Themeda triandra</i>	1
		Poaceae spp.	4
		<i>Bherkeya rhapontica</i>	1
		<i>Acalypha</i> sp.	1
		<i>Oxalis obliquifolia</i>	1

Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
52	90	<i>Acalypha</i> sp.	1
		<i>Eriocema distinctum</i>	2
		<i>Tephrosia</i> sp.	2
		<i>Eragrostis capensis</i>	3
		<i>Eragrostis racemosa</i>	2
		<i>Eragrostis curvula</i>	2
		<i>Zornia linearis</i>	1
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
53	100	<i>Acalypha</i> sp.	2
		<i>Pteridium aquilinum</i>	2
		<i>Eragrostis curvula</i>	3
		<i>Eragrostis capensis</i>	3
		<i>Polygala hottentota</i>	1
		<i>Macowania corymbosa</i>	2
		<i>Themeda triandra</i>	2
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
54	98	Cyperaceae Type A	3
		<i>Helichrysum aureonitens</i>	2
		<i>Eriocaulon dregei</i>	2
		Cyperaceae Type B	2
		<i>Eragrostis</i> sp.	2
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
55	100	<i>Helichrysum aureonitens</i>	2
		<i>Monopsis decepiens</i>	1
		<i>Aristida junciformis</i>	2
		Cyperaceae Type B	2
		<i>Xyris capensis</i>	3
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
56	90	<i>Eriosema distinctum</i>	2
		<i>Tephrosia</i> sp.	1
		<i>Heteropogon</i> sp.	1
		<i>Themeda triandra</i>	2
		<i>Tristachya leucothrix</i>	2
		<i>Eragrostis capensis</i>	3
		<i>Acalypha</i> sp.	2
		<i>Sutera floribunda</i>	1
		Poaceae spp.	2
Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
57	90	<i>Eragrostis capensis</i>	2
		<i>Themeda triandra</i>	3
		<i>Eragrostis curvula</i>	1
		<i>Eriosema distinctum</i>	3
		<i>Kniphofia laxiflora</i>	1
		<i>Vernonia thodey</i>	1
		<i>Lotononis</i> sp. 98	1
		<i>Stachys natalensis</i>	1
		<i>Tephrosia</i> sp.	1
		<i>Cyanotis speciosa</i>	1

Quadrat no.	Total veg cover (100%)	Species	Braun-Blanquet scale
58	90	<i>Macowania corymbosa</i>	1
		<i>Hypochaenis radicata</i>	2
		<i>Eriosema distinctum</i>	2
		<i>Acalypha</i> sp.	2
		<i>Hypoxis filiformis</i>	1
		<i>Eragrostis curvula</i>	2
		<i>Eragrostis capensis</i>	2
		<i>Eragrostis racemosa</i>	2
		<i>Themeda triandra</i>	2

Quadrat no. 4

Canopy cover: 40%

Leucocidia sericea* dominated

Number of individuals	Number of stems >20cm diameter	Average height (m)
1	5	6.5
1	4	3
1	4	2.75
1	1	2
1	1	2
1	3	6
1	2	6
1	5	4.5
1	2	3
1	4	5.5

**Leucocidia sericea* dominated quadrat was measured as a 5 x 5 m quadrat

APPENDIX J

Geochemical Data (UCT)

Sample	Analysis No.	Wt (mg)	Voltage (mv)	Area	%N	d15N/14N	Std corrctd d15N/14N	Voltage (mv)	Area	%C	d13C/12C	Std corrctd d13C/12C	C:N ratio
10	66737	4.53	3884	87.5	2.24	3.26	2.98	9835	273.9	34.85	-19.50	-20.15	15.56
12	66739	6.27	5358	124.8	2.31	3.26	2.99	11669	379.9	34.92	-18.74	-19.44	15.13
14	66741	4.97	4095	91.1	2.13	3.10	2.81	10572	292.1	33.87	-18.15	-18.89	15.93
16	66743	4.89	3375	76.7	1.82	3.64	3.38	8935	246.4	29.04	-18.43	-19.15	15.97
18	66745	5.01	3607	84.4	1.95	4.07	3.84	9361	283.7	32.64	-17.78	-18.53	16.72
20	66747	4.67	3178	74.2	1.84	4.22	4.00	8779	256.6	31.67	-17.92	-18.66	17.19
22	66749	5.09	3067	68.1	1.55	3.99	3.75	9193	241.3	27.32	-17.87	-18.62	17.62
24	66751	5.52	3756	84.0	1.76	4.23	4.00	10835	303.4	31.68	-17.85	-18.60	17.96
26	66753	6.65	4459	103.5	1.80	4.36	4.15	11774	370.9	32.14	-17.84	-18.59	17.82
28	66755	6.25	4316	101.6	1.89	4.28	4.06	11011	347.6	32.05	-17.66	-18.42	17.00
30	66757	5.87	3717	84.4	1.67	4.51	4.31	11199	323.6	31.77	-18.22	-18.95	19.06
32	66759	7.38	4508	103.1	1.62	4.66	4.47	12809	404.8	31.61	-18.50	-19.21	19.52
34	66764	6.53	3615	84.1	1.49	4.86	4.68	11580	348.7	30.78	-19.13	-19.81	20.61
36	66766	9.13	4943	111.4	1.41	4.85	4.67	14815	483.1	30.50	-19.36	-20.02	21.57
38	66768	10.14	4935	113.1	1.29	5.02	4.85	14530	498.5	28.33	-20.11	-20.72	21.91
42	66770	11.16	5631	122.5	1.27	5.15	4.98	16291	548.1	28.30	-20.10	-20.71	22.24
44	66772	10.72	5338	121.8	1.32	5.47	5.32	15699	556.5	29.92	-21.01	-21.56	22.71
46	66774	11.66	5934	135.0	1.34	5.42	5.27	16952	616.4	30.46	-21.13	-21.68	22.69
48	66776	12.76	6053	133.1	1.21	5.14	4.97	17329	599.3	27.07	-21.32	-21.86	22.39
50	66778	12.1	5701	123.7	1.18	5.04	4.86	17136	579.1	27.58	-21.37	-21.90	23.28
52	66780	13.31	4987	109.5	0.95	4.82	4.64	16456	554.0	23.99	-21.96	-22.45	25.14
54	66782	13.49	3806	86.8	0.75	4.28	4.06	14684	476.7	20.37	-21.56	-22.08	27.32
56	66784	13.57	4350	98.9	0.85	4.62	4.42	16172	545.3	23.16	-21.49	-22.02	27.40
58	66786	15.88	4527	100.0	0.73	4.41	4.20	16731	564.8	20.50	-20.95	-21.51	28.09
60	66791	16.24	4318	99.5	0.71	4.50	4.29	16816	569.9	20.22	-20.73	-21.30	28.47
62	66793	16.86	4127	91.2	0.63	4.33	4.11	16581	553.4	18.92	-20.21	-20.82	30.16
64	66795	16.81	3460	80.1	0.55	4.36	4.14	14472	474.9	16.28	-19.70	-20.34	29.46
66	66797	19.99	4798	105.8	0.61	3.34	3.07	15984	529.9	15.28	-19.08	-19.76	24.90
68	66799	22.46	4345	98.5	0.51	4.24	4.02	16112	555.1	14.24	-19.24	-19.91	28.01
70	66801	22.87	3970	91.1	0.46	4.20	3.97	15603	524.1	13.21	-19.38	-20.04	28.59
72	66803	22.29	3411	80.5	0.42	4.16	3.93	14394	474.5	12.27	-19.74	-20.38	29.30
74	66805	23.33	3390	78.4	0.39	4.16	3.93	14787	475.8	11.75	-20.04	-20.66	30.16
76	66807	22.52	3586	82.4	0.42	4.75	4.56	14998	504.3	12.91	-20.63	-21.21	30.42
78	66809	23.6	3990	93.1	0.46	6.15	6.05	17801	641.2	15.66	-21.55	-22.07	34.24
80	66811	24.02	3850	92.7	0.45	5.02	4.84	18445	707.2	16.97	-21.63	-22.14	37.93

Sample	Analysis		Voltage		Std correctd		%C	Std correctd		C:N ratio
	No.	Wt (mg)	(mv)	Area	%N	d 15N/14N	(mv)	d 13C/12C	d 13C/12C	
154	67740	56.85	1558	42.4	0.08	3.69	2057	-21.20	-22.03	6.15
156	67742	55.51	1533	36.4	0.07	3.81	4924	-20.32	-21.17	17.60
158	67747	57.30	1446	35.7	0.07	3.65	4581	-20.45	-21.30	16.90
160	67749	65.65	1258	31.1	0.05	3.48	4423	-20.19	-21.05	18.14
162	67751	62.40	1495	37.9	0.07	3.51	4643	-20.84	-21.69	15.84
164	67753	67.69	1768	45.8	0.08	4.18	5109	-20.79	-21.63	15.17
166	67755	62.44	2422	58.5	0.10	4.22	7828	-20.76	-21.60	18.90
168	67757	69.86	2462	59.3	0.09	4.44	8112	-20.73	-21.57	19.45
170	67759	69.20	1560	43.5	0.07	3.25	2809	-21.12	-21.95	8.35
172	67761	68.02	1793	45.4	0.07	3.97	4798	-20.82	-21.66	14.00
174	67766	72.25	1681	43.1	0.07	6.06	2441	-20.48	-21.33	7.26
176	67800	138.57	498	13.1	0.01	3.04	2127	-21.68	-22.38	20.83
178	67802	144.09	480	12.5	0.01	3.13	1977	-21.66	-22.36	19.98
180	67804	125.31	551	13.4	0.01	3.26	2362	-21.89	-22.59	21.51
182	67806	148.46	406	11.1	0.01	3.17	1672	-21.54	-22.25	19.60
184	67811	137.71	390	10.6	0.01	2.54	1807	-22.20	-22.89	22.06
186	67783	124.34	307	8.7	0.01	1.17	1245	-22.61	-23.29	18.50
188	67785	138.42	433	10.9	0.01	3.07	1975	-21.91	-22.61	22.18
190	67790	129.20	391	10.1	0.01	2.46	1923	-22.56	-23.25	23.66

APPENDIX K

Raw Pollen Count Data

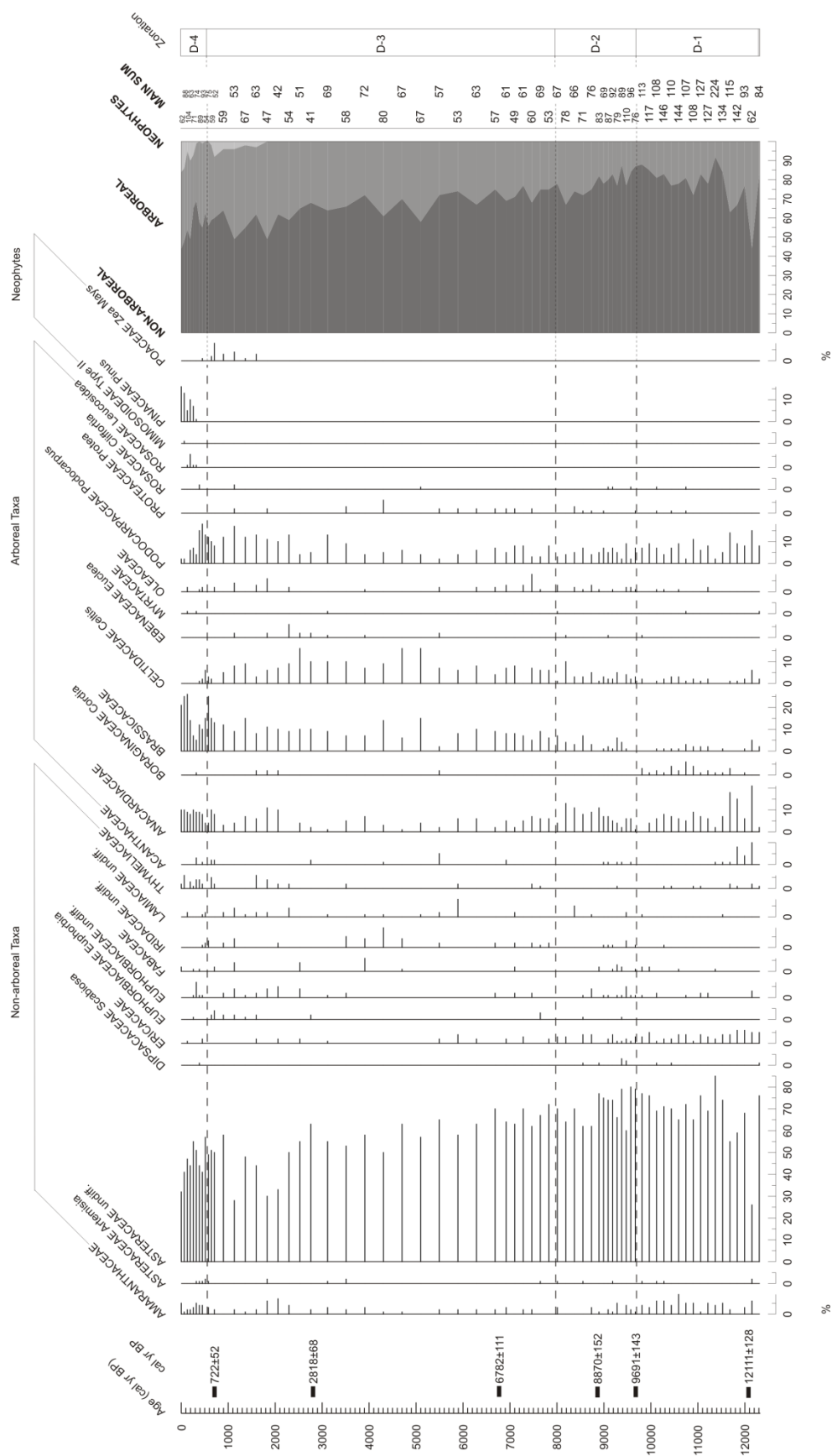
10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54
ACANTHACEAE	-	-	-	-	2	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-
AMACARDIACEAE	6	9	5	7	7	8	7	2	3	6	4	2	2	5	4	5	4	-	2	1	1	3
APIACEAE	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AQUIFOIACEAE Ilex mitis	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ARALIACEAE	1	1	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
BORAGINACEAE Cordia	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BRASSICACEAE	13	22	27	9	5	4	11	9	8	19	7	7	5	10	5	5	4	5	5	4	6	4
CELASTRACEAE	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CELTIDACEAE Celtis	-	-	-	-	-	1	2	3	2	1	-	3	4	6	2	3	3	5	8	4	7	6
CORNACEAE Cornus	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EBENACEAE Diospyros	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EBENACEAE Euclea	-	-	0	-	-	-	-	-	-	-	-	-	1	-	-	1	-	3	1	1	1	-
EBENACEAE undiff.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MYRICACEAE Myrica	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MYRTACEAE	-	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OLEACEAE	-	-	2	-	-	1	2	-	-	-	1	-	2	-	2	3	-	1	-	-	1	-
PODOCARPACEAE Podocarpus	1	2	-	4	5	3	13	17	7	9	6	7	9	8	8	5	4	7	2	2	9	5
POLYGALACEAE Polygala	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2
PROTEACEAE	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
ROSACEAE Cliffortia	-	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
ROSACEAE Leucosidea	-	-	1	4	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROSACEAE undiff.	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AMARANTHACEAE	3	1	2	1	2	4	4	4	2	-	1	-	1	1	1	3	3	2	-	1	2	1
ASTERACEAE Artemisia	-	-	-	-	-	1	1	1	1	-	-	-	-	-	-	1	-	-	-	-	1	1
ASTERACEAE Stoebe	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-	-
ASTERACEAE undiff.	20	36	49	28	39	38	39	38	31	37	30	34	15	32	28	14	14	27	28	26	38	31
ASTERACEAE Vernonia	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
BORAGINACEAE Heliotropium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COMMELINACEAE	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
DIPSACACEAE Scabiosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ERICACEAE	-	-	1	-	-	-	-	2	-	-	-	-	-	-	1	-	1	-	1	-	-	-
EUPHORBACEAE Euphorbia	-	-	-	-	1	-	-	-	-	-	1	1	1	1	1	1	-	-	-	1	-	-
EUPHORBACEAE undiff.	-	-	-	-	1	5	1	1	-	-	-	1	2	1	1	2	2	-	2	-	1	1
FABACEAE	1	-	-	-	1	-	1	-	-	-	-	-	2	-	-	-	-	-	2	-	-	-
GERANIACEAE	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HYPERICACEAE Hypericum	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IRIDACEAE undiff.	221	211	219	220	283	309	210	261	178	186	183	209	216	245	231	210	233	229	255	286	265	243
THYMELIACEAE	1	5	-	2	1	3	4	2	-	-	3	1	-	-	4	2	1	1	-	-	-	1
CYPERACEAE undiff.	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	1	-	-	1	2
ERIOCAULACEAE Eriocaulon	1	4	1	2	2	-	2	1	-	-	-	-	-	-	-	1	1	2	-	-	-	-
HALORAGACEAE	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	2	-	-	-	-
LIACEAE	7	13	6	11	9	18	14	24	30	24	26	27	36	29	44	39	49	41	25	13	31	38
POACEAE	173	138	146	188	192	211	163	219	195	168	168	201	157	194	187	215	212	183	146	141	152	177
POACEAE Zea mays	-	-	-	-	-	-	-	1	-	-	-	2	2	1	2	-	-	-	-	-	-	-
MIMOSOIDAE Type II	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PINACEAE Pinus	10	11	5	6	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MONOLETE	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
PSEUDOSCHIZAE	-	4	3	3	5	8	4	6	2	4	3	5	10	8	7	6	10	9	10	9	15	10
TRILETE	1	3	1	1	1	-	-	-	-	-	-	-	-	-	-	2	1	2	1	2	8	2
TRILETE Mohria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-pollen Palynomorphs	4	10	9	4	4	4	7	8	-	9	7	4	13	22	3	1	2	5	3	2	3	1
Undetermined	7	10	5	8	3	4	10	20	25	15	19	9	6	7	6	5	2	4	6	7	8	8
Main Sum	476	482	495	500	570	629	499	632	484	481	479	516	491	580	541	526	553	529	498	507	552	540

56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
ACANTHACEAE	-	1	-	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
ANACARDIACEAE	5	2	1	3	1	4	1	3	1	3	4	4	3	3	10	7	6	7	9	5	6	5
APIACEAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AQUIFOUACEAE Illex mitis	-	1	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
ARALIACEAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE Cordia	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BRASSICACEAE	5	11	4	10	1	6	5	5	4	4	3	6	3	5	3	2	5	2	-	1	2	1
CELASTRACEAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CELITIDACEAE Celtis	5	7	11	11	4	3	5	2	4	4	4	4	3	1	8	2	2	4	1	2	2	2
CORNACEAE Cornus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EBENACEAE Diospyros	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EBENACEAE Euclea	1	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-
EBENACEAE undiff.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MYRICACEAE Myrica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MYRTACEAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OLEACEAE	1	-	-	-	1	1	1	2	-	2	5	1	-	2	-	1	1	2	1	-	-	1
PODOCARPACEAE Podocarpus	3	4	4	3	1	4	4	3	4	5	2	2	4	2	3	3	5	3	4	5	4	6
POLYGALACEAE Polygala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROTEACEAE	-	5	-	-	1	1	1	1	1	-	1	-	-	-	-	2	1	1	-	1	-	-
ROSACEAE Cliffortia	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
ROSACEAE Leucosidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROSACEAE undiff.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AMARANTHACEAE	2	1	1	-	1	1	1	2	-	1	1	-	-	2	-	-	-	2	1	-	2	1
ASTERACEAE Artemisia	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	1	-	-	-	-	1
ASTERACEAE Stoebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ASTERACEAE undiff.	42	40	42	38	37	31	40	39	31	43	37	46	38	47	50	46	44	47	64	52	64	68
ASTERACEAE Vemonia	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE Heliotropium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COMMELINACEAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
DIPSACACEAE Scabiosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
ERICACEAE	-	-	-	-	1	2	1	1	-	2	-	-	1	2	2	-	3	3	-	-	2	4
EUPHORBIACEAE Euphorbia	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1	-	-	-	-	-
EUPHORBIACEAE undiff.	-	-	-	-	-	-	1	-	1	-	1	-	-	-	-	-	1	3	-	1	1	-
FABACEAE	4	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-	1
GERANIACEAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HYPERICACEAE Hypericum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IRIDACEAE undiff.	3	7	3	-	1	-	1	-	1	-	1	1	1	-	-	-	-	-	-	1	1	1
LAMIACEAE undiff.	1	1	-	1	1	4	-	-	1	-	-	-	-	-	-	3	-	1	-	-	-	-
LAMIACEAE Leonotis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OXALIDACEAE Oxalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THYMELACEAE	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
CYPERACEAE undiff.	206	235	120	111	162	213	238	199	204	243	243	246	234	192	221	217	184	150	204	189	167	218
ERICACEAE undiff.	5	1	1	-	2	1	1	-	-	-	-	-	-	-	1	-	-	-	-	1	3	-
ERIOCAULACEAE Eriocaulon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HALORAGACEAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LILIACEAE	33	66	66	36	37	51	70	51	18	35	39	37	34	39	38	28	35	44	20	23	54	30
POACEAE	228	243	203	254	244	218	209	225	141	369	243	213	193	198	220	202	231	238	220	244	245	240
POACEAE Zea Mays	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIMOSOIDACEAE Type II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PINACEAE Pinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MONOLETE	-	1	-	1	1	1	-	-	1	-	1	-	-	-	1	-	2	1	-	1	-	-
PSEUDOSCHIZAE	2	8	6	8	2	1	6	5	4	3	-	4	8	10	7	5	6	5	8	5	3	2
TRILETE	-	1	1	2	1	3	4	1	3	4	-	1	-	1	2	1	2	-	5	1	1	2
TRILETE Mohria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-pollen Palynomorphs	4	1	6	4	1	2	2	1	5	3	4	2	1	7	3	3	-	3	1	-	1	1
Undetermined	16	11	7	10	6	8	9	6	11	9	6	6	6	9	2	5	16	6	-	1	2	1
Main Sum	566	647	477	494	513	551	602	545	548	724	598	577	535	519	574	524	550	521	543	534	563	586

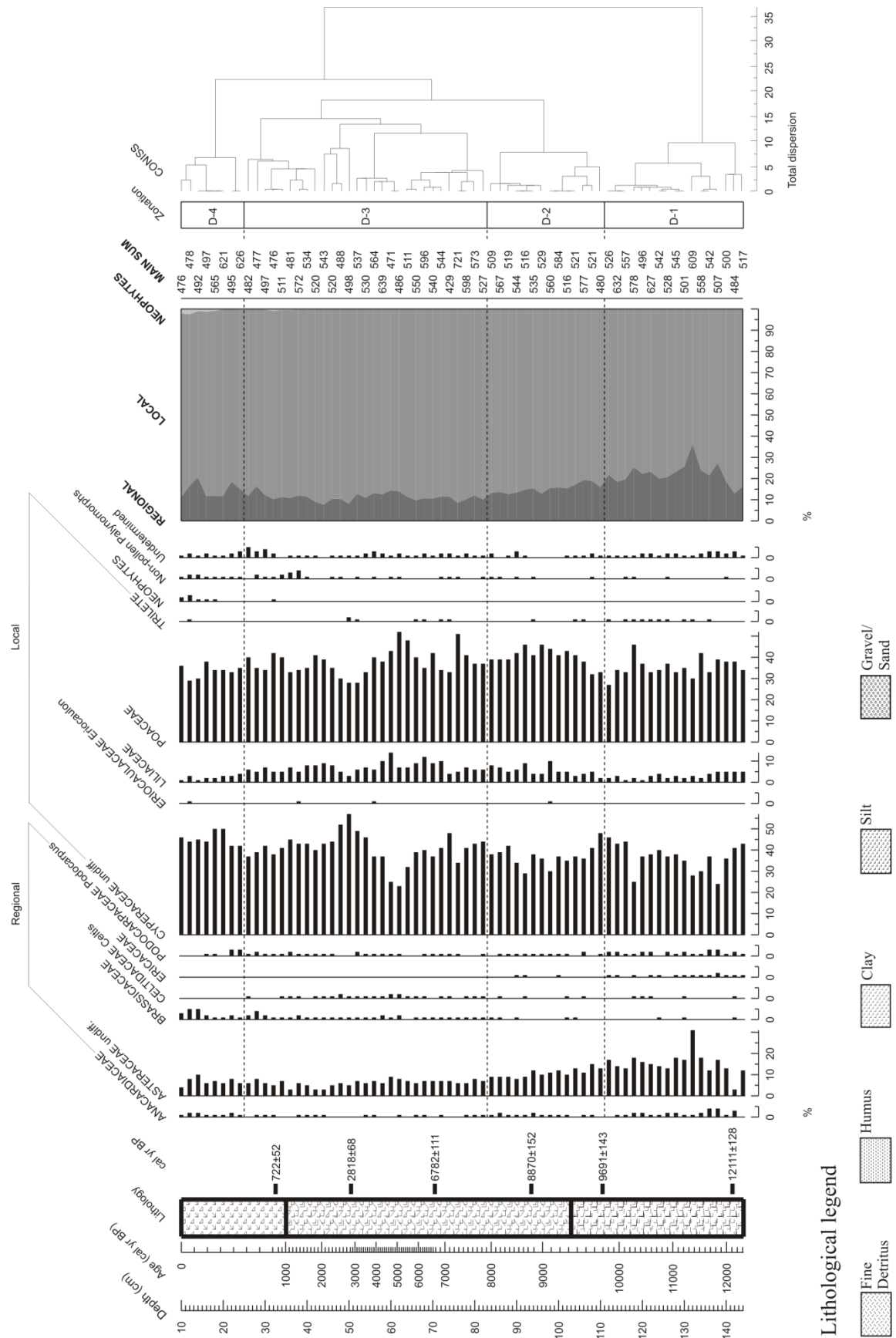
102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	134	136	138	140	142	144
ACANTHACEAE	1	1	-	-	-	-	-	-	-	-	-	-	-	-	3	1	1	12	4	6	-
ANACARDIACEAE	3	2	7	6	1	5	6	11	8	8	5	10	9	7	4	9	21	21	6	13	2
APIACEAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AQUIFOIACEAE Ilex mitis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ARALIACEAE	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
BORAGINACEAE Cordia	-	-	-	-	-	3	1	2	4	3	6	4	1	2	2	2	4	-	1	-	-
BRASSICACEAE	5	4	1	-	-	-	1	1	1	1	3	2	2	3	1	2	-	-	1	3	2
CELASTRACEAE	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CELTIACEAE Celtis	4	-	4	2	2	2	1	3	3	4	1	2	1	3	1	-	1	1	2	4	2
CORNACEAE Cornus	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EBENACEAE Diospyros	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EBENACEAE Eudea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EBENACEAE undiff.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MYRICACEAE Myrica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MYRTACEAE	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
OLEACEAE	-	-	2	2	1	-	1	1	-	2	-	-	-	2	-	-	-	-	-	-	-
PODOCARPACEAE Podocarpus	4	2	10	2	5	8	11	8	8	13	2	12	8	10	5	7	16	13	7	9	7
POLYGALACEAE Polygala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROTEACEAE	-	-	-	-	1	-	1	-	1	-	1	-	-	-	1	-	-	-	-	-	-
ROSACEAE Cliffortia	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-
ROSACEAE Leucosidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROSACEAE undiff.	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-
AMARANTHACEAE	4	-	4	2	1	4	3	7	4	13	5	5	1	6	8	7	2	-	3	4	-
ASTERACEAE Artemisia	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-
ASTERACEAE Stoebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ASTERACEAE undiff.	52	70	66	77	60	87	89	75	77	93	77	70	97	87	190	99	63	84	63	16	64
ASTERACEAE Vernonia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BORAGINACEAE Heliotropium	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
COMMELINACEAE	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DIPSACACEAE Scabiosa	3	2	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	1
ERICACEAE	1	1	2	1	2	3	6	1	3	2	6	4	1	5	4	5	5	9	6	3	4
EUPHORBIACEAE Euphorbia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EUPHORBIACEAE undiff.	1	1	5	1	1	1	2	-	-	-	1	-	2	2	1	-	-	-	-	2	-
FABACEAE	2	2	-	-	1	2	2	-	-	1	-	-	-	-	2	-	-	-	-	-	-
GERANIACEAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HYPERICACEAE Hypericum	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
IRIDACEAE undiff.	-	-	3	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
LAMIACEAE undiff.	-	-	2	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
LAMIACEAE Leonotis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OXALIDACEAE Oxalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THYMELACEAE	1	-	-	-	-	-	-	2	1	-	-	1	1	-	1	-	2	2	1	1	1
CYPERACEAE undiff.	181	191	206	215	230	244	272	247	144	237	216	194	209	173	172	170	201	124	179	197	224
ERIOCAULACEAE Eriocaulon	2	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-
HALORAGACEAE	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LILIACEAE	24	18	25	24	9	11	20	6	10	7	22	11	18	12	17	11	19	24	24	24	24
POACEAE	223	214	220	168	159	144	214	184	263	185	185	197	179	177	182	232	181	200	189	185	177
POACEAE Zea Mays	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIMOSOIDAE Type II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PINACEAE Pinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MONOLETE	-	-	1	-	-	1	-	-	-	-	-	2	1	-	1	1	-	-	1	-	1
PSEUDOSCHIZAE	3	4	1	2	1	2	6	4	6	1	3	6	11	5	15	12	10	30	9	8	4
TRILETE	1	5	6	2	-	3	3	6	3	6	3	4	1	4	5	-	8	-	2	1	1
TRILETE Mohria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-pollen Palynomorphs	-	-	2	3	-	2	2	4	3	1	1	4	-	2	-	1	-	-	3	1	2
Undetermined	6	4	6	13	6	7	4	5	6	8	8	8	9	6	8	9	18	17	9	13	4
Main Sum	519	525	578	523	341	528	638	561	584	502	545	534	556	506	624	570	552	537	509	492	521

Pollen diagrams

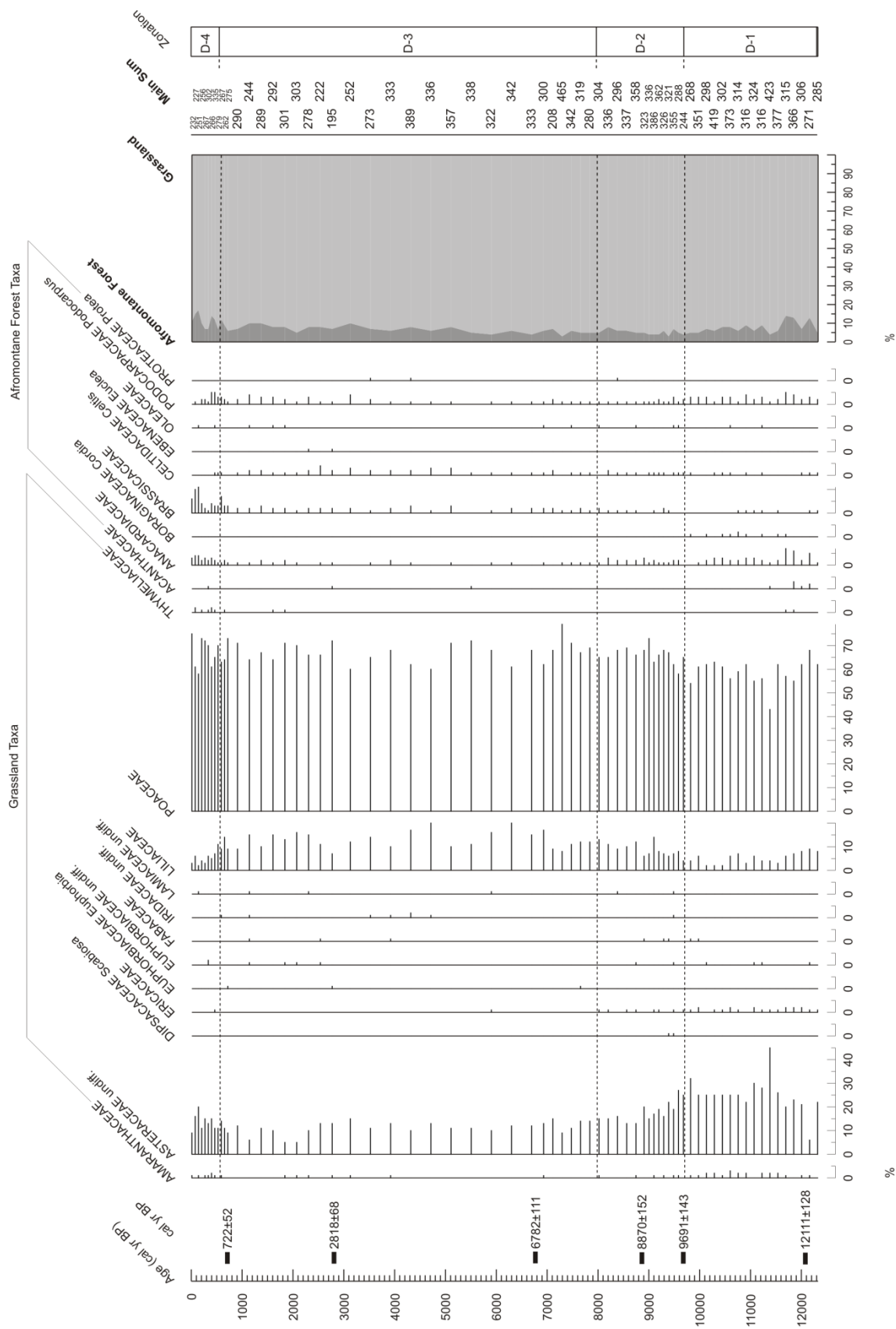
Regional pollen taxa plotted against the age-profile of the sediment core



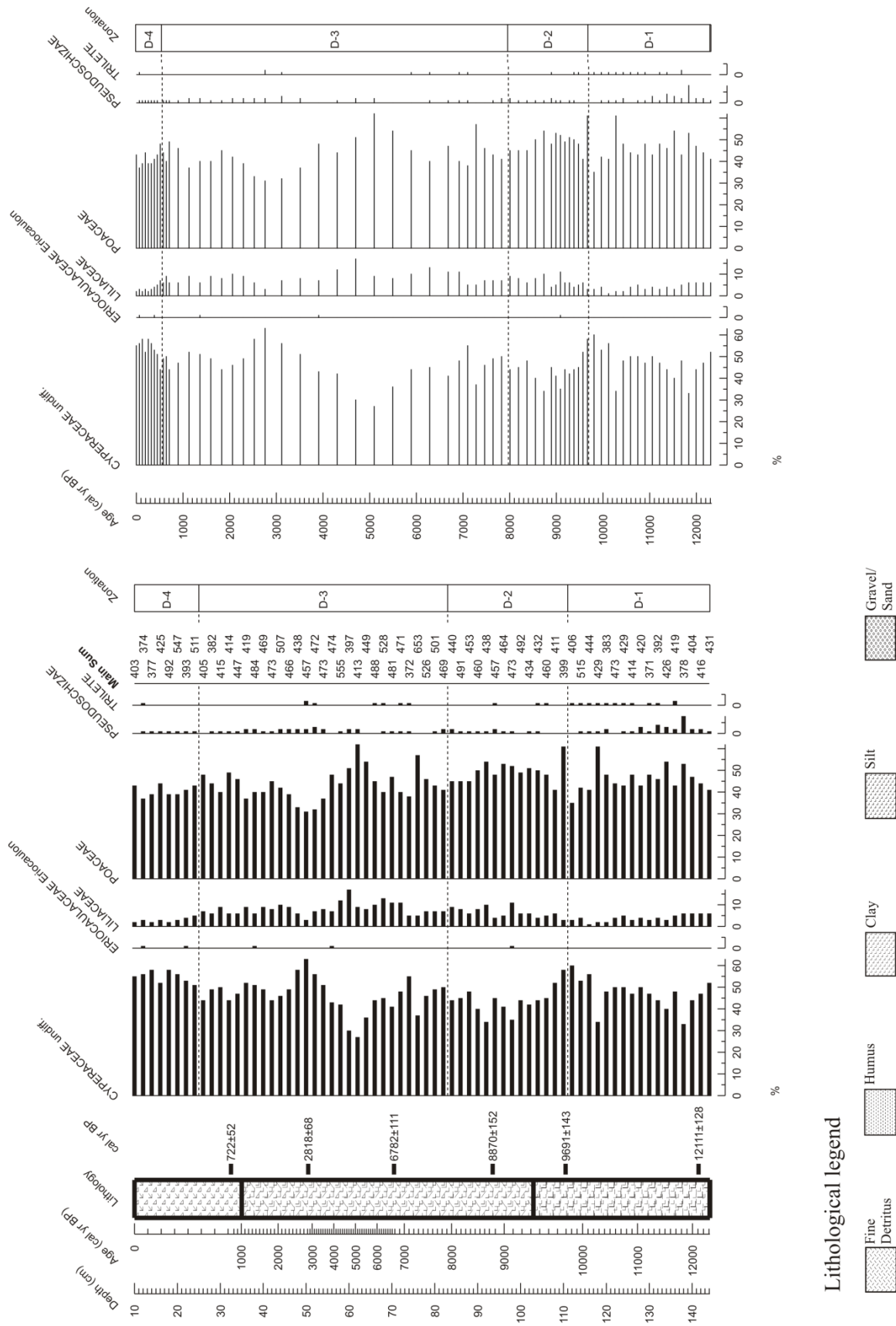
Total pollen counts plotted against the depth of the sediment core



Afromontane Forest and Grassland taxa plotted against the age profile of the sediment core



Total pollen counts plotted against the age-profile and depth of the ediment core



APPENDIX M

Raw charcoal data (Bhugeloo, 2010)

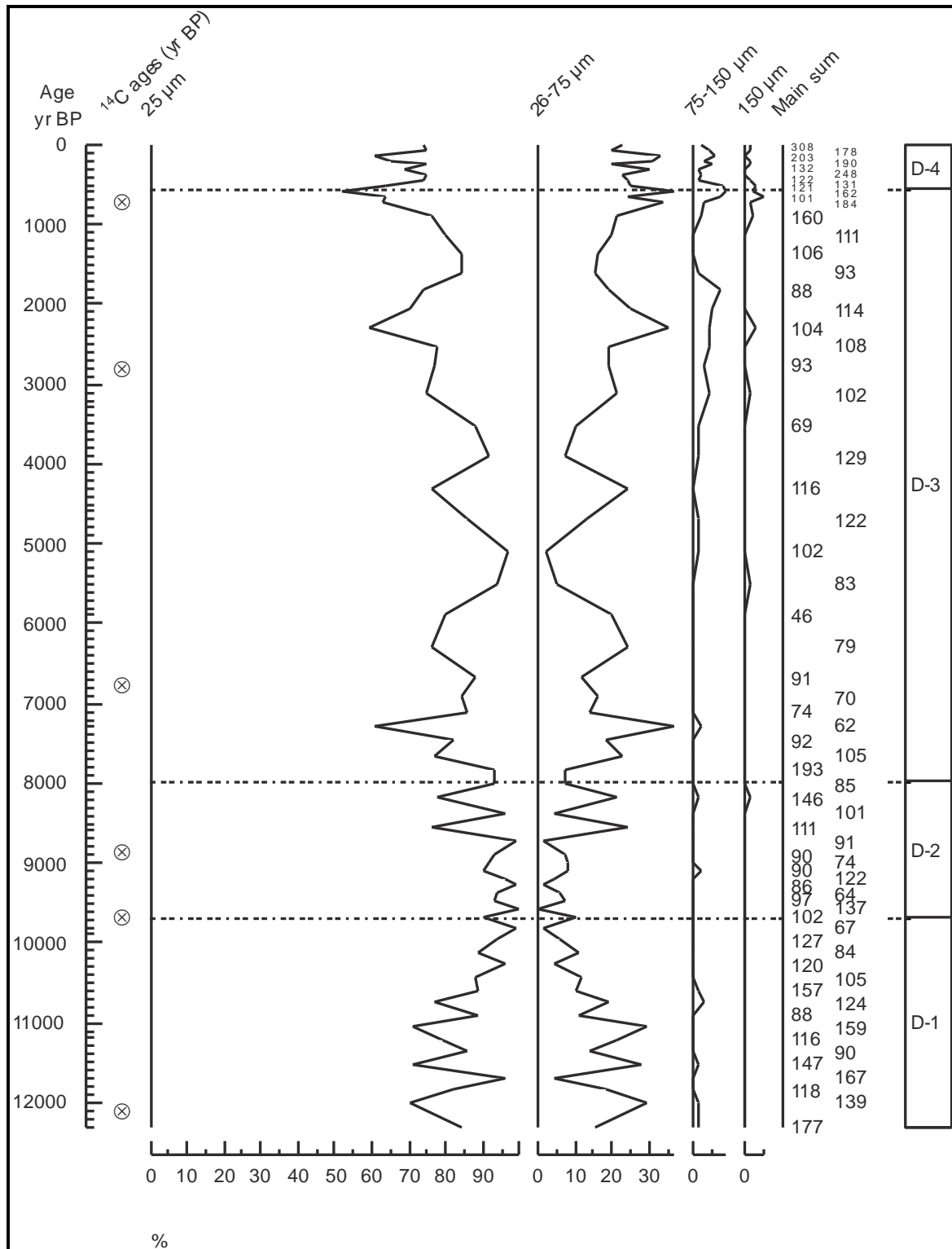
Depth (cm)	<25 µm	26-75 µm	75-150 µm	> 150 µm
10	229	71	6	2
12	133	35	8	2
14	123	67	13	0
16	124	58	6	2
18	99	26	6	1
20	171	74	2	1
22	91	28	3	0
24	97	32	1	1
26	77	30	10	4
28	85	60	14	3
30	65	24	7	5
32	115	62	5	2
34	121	33	3	3
36	89	22	0	0
38	89	17	0	0
40	78	14	1	0
42	65	17	6	0
44	80	28	6	0
46	61	36	4	3
48	84	20	4	0
50	72	18	3	0
52	76	21	4	1
54	61	7	1	0
56	119	9	1	0
58	88	28	0	0
60	105	16	1	0
62	99	2	1	0
64	78	4	0	1
66	37	9	0	0
68	60	19	0	0
70	80	11	0	0
72	59	11	0	0
74	64	10	0	0
76	38	23	1	0
78	75	17	0	0

Depth (cm)	<25 µm	26-75 µm	75-150 µm	> 150 µm
80	81	24	0	0
82	179	14	0	0
84	79	6	0	0
86	114	30	1	1
88	97	4	0	0
90	84	27	0	0
92	90	1	0	0
94	84	6	0	0
96	68	6	0	0
98	81	7	2	0
100	117	5	0	0
102	85	1	0	0
104	60	4	0	0
106	90	7	0	0
108	137	0	0	0
110	92	10	0	0
112	66	1	0	0
114	120	7	0	0
116	75	9	0	0
118	115	5	0	0
120	92	13	0	0
122	139	16	2	0
124	96	24	4	0
126	78	10	0	0
128	113	46	0	0
130	92	24	0	0
132	77	13	0	0
134	105	41	1	0
136	161	6	0	0
138	97	21	0	0
140	97	41	1	0
144	148	27	2	0
Total	6396	1415	130	32

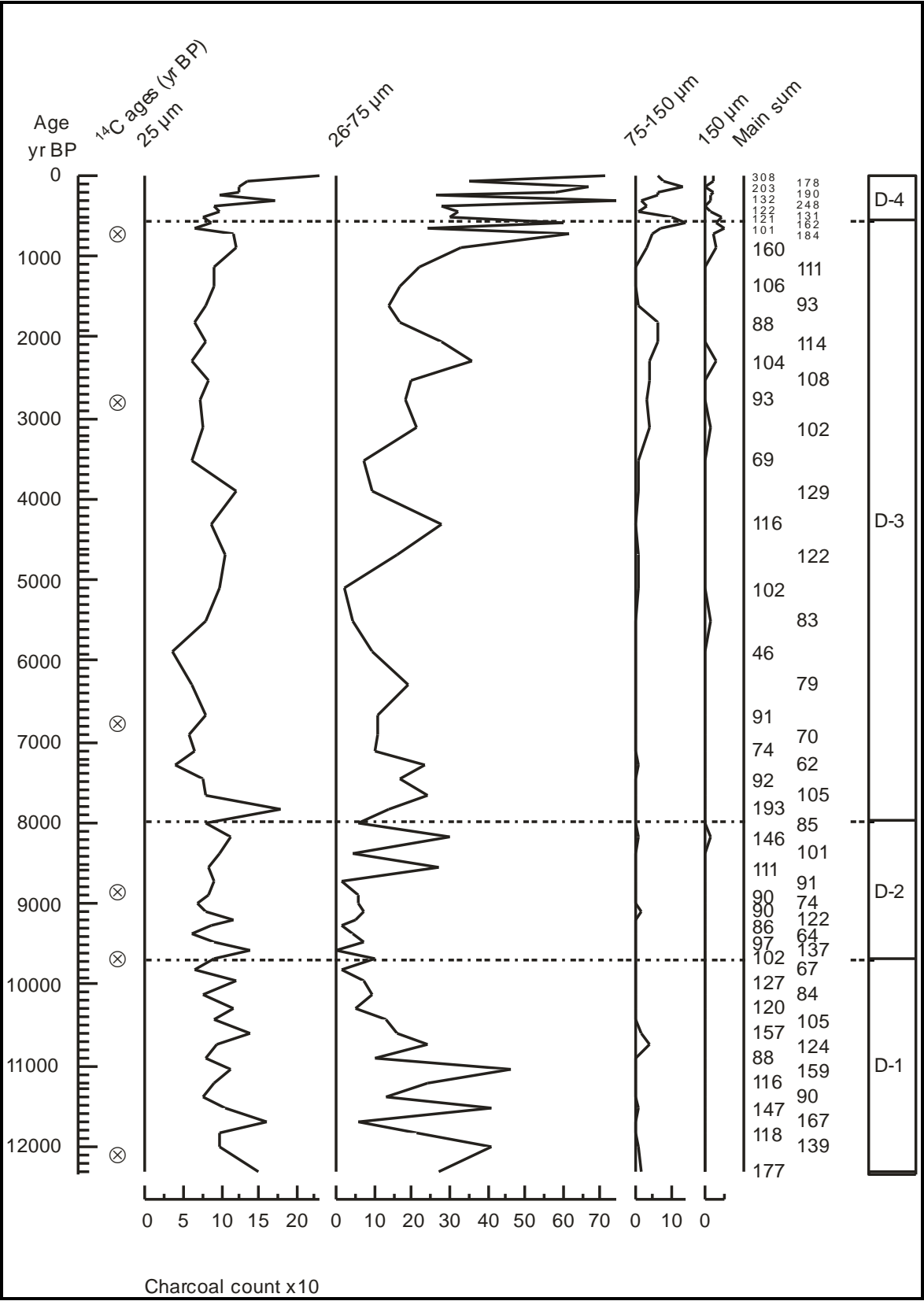
APPENDIX N

Charcoal diagrams

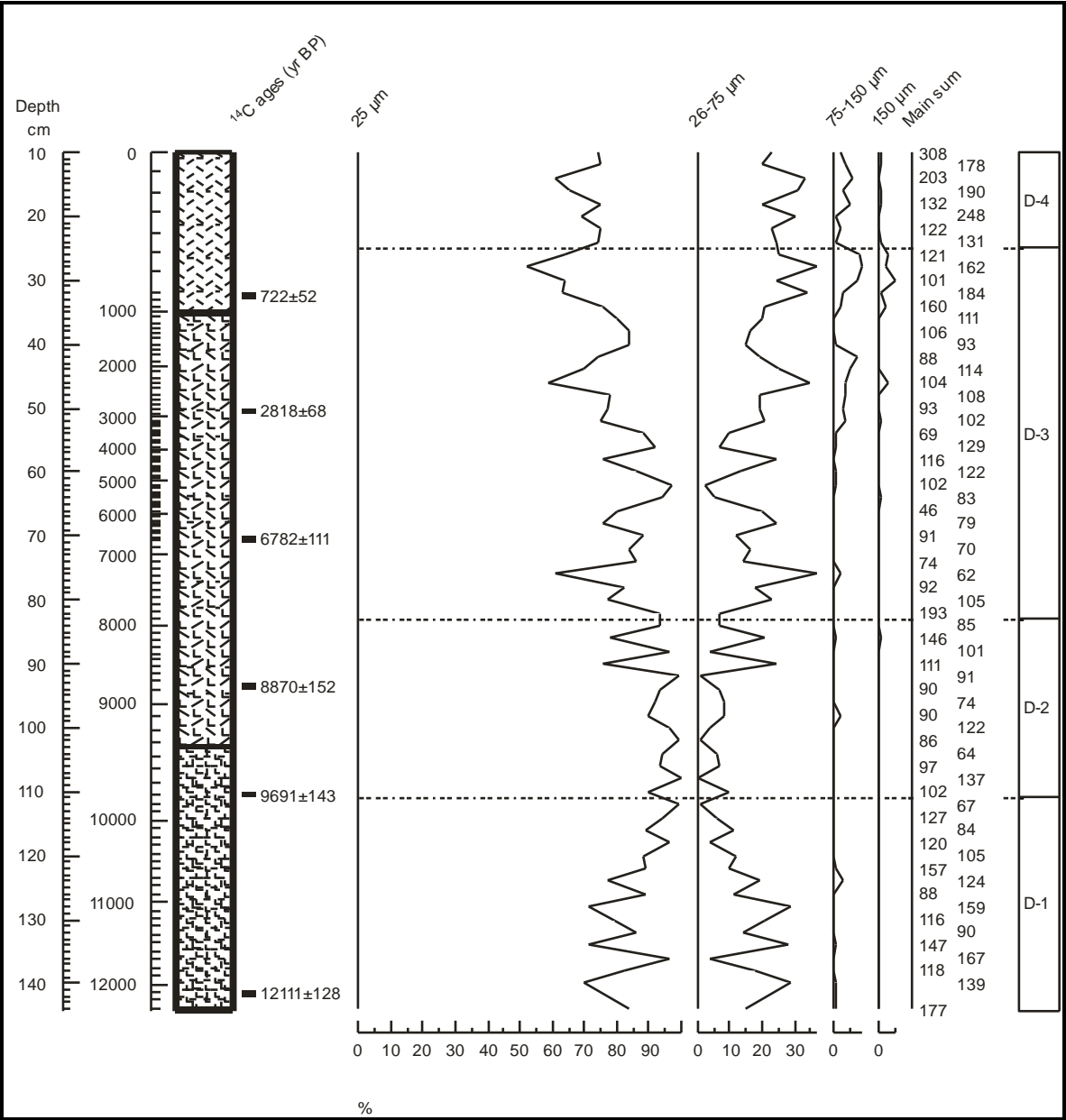
Charcoal frequencies plotted against chronology



Charcoal fragments plotted against chronology



Charcoal frequencies plotted against depth



APPENDIX O

Morphological, preservation and dispersal characteristics of major palynomorphs (adapted from Lodder, 2011)

Morphological, preservation and dispersal characteristics of major palynomorphs encountered at Dartmoor Vlei, Mt Gilboa, South Africa, palaeoecological records and associated ecological and indicator values of likely parent taxa.

ACANTHACEAE

Identified as: Undifferentiated

Genus found at Dartmoor Vlei: *Adhatoda*, *Barleria*, *Chaetacanthus*, *Crabbea*, *Dicliptera*, *Hypoestes*, *Isoglossa*, *Justica*, *Ruellia*, *Sclerochiton*, *Thunbergia*

Likely parent taxa: Unknown

Pollen morphological characteristics (on Family level): Acanthaceae pollen can be divided up into six morphological types; i) *Blepharis*, ii) *Justicia*-type, iii) *Monechma*-type, iv) *Macrorungia*-type, v) *Dicliptera*-type, vi) Acanthaceae no 462, vii) Acanthaceae no 452. Types vi and vii are rare and recorded only in the Rietvlei deposits, and no herbarium reference material of such grains is available; they are tentatively identified as Acanthaceae (Scott, 1982a).

Ecology: Acanthaceae is a large family of herbs and trees with 43 genera found in South Africa (Pooley, 2005) usually indicative of open veld environments rather than swamp environments (Scott, 1982a).

Dispersal and preservation characteristics: Acanthaceae is considered to be widely distributed (Scott, 1982a) but poorly dispersed (Hamilton, 1972).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

AMARANTHACEAE

Identified as: Undifferentiated

Genera found at Dartmoor Vlei: *Achyranthes*, *Alternanthera*, *Cyathula*, *Gomphrena*

Likely parent taxa: Amaranthaceae

Pollen morphological characteristics (on Family level): cribellate; spherical; ellipsoidal or polyhedral with rounded edges; 12-35 µm diameter. Foramina: 12-60 µm; circular, sometimes wavy margins; 2.5-8.6 µm diameter, sometimes situated in deep, straight or funnel shaped depressions; membrane has the same sculpturing as rest of exine or is flecked with granules which tend to aggregate towards centre and fuse; or with operculum; Exine: 1- 5.7 µm; thick; granulate; sexine baculate; sometimes tegillate; nexine only 0.5-1.5 µm thick (van Zinderen Bakker, 1953).

Ecology: Amaranthaceae are halophytes favouring dry, saline conditions with summer rainfall and warmer evaporative conditions (Scott *et al.*, 2005; Scott, 1993; Scott, 1982a).

Dispersal and preservation characteristics: Amaranthaceae are wind-pollinated (van Zinderen Bakker, 1953), dispersed over long distances (Hamilton, 1972) and occur in most parts of the country in a wide-range of habitats (Scott, 1982a).

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-Arboreal

ANACARDIACEAE

Identified as: *Rhus*

Genera found at Dartmoor Vlei: *Rhus* spp.

Likely parent taxa: *Rhus*

Pollen morphological characteristics: No morphological features are available for this research.

Ecology: Montane and subalpine grasslands (Killick 1963).

Dispersal and preservation characteristics: There are over 20 species of trees and shrubs belonging to the genera *Rhus* occupying a wide range of habitats. While the genus is insect pollinated, it does produce pollen in large numbers. It is considered to be moderately to well dispersed over long distances, often found in pollen samples although not in high numbers (Scott, 1982a; Hamilton, 1972).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

APIACEAE

Identified as: Undifferentiated

Genus found at Dartmoor Vlei: *Afroscidium*, *Alepidea*, *Apium*, *Cantella*, *Conium*, *Heteromorpha*, *Notobubon*, *Sanicula*, *Sium*

Likely parent taxa: Unknown

Pollen morphological characteristics (on Family level): No morphological characteristics available for this research.

Ecology: Occurs in a wide range of habitats (Palgrave, 2002)

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

AQUIFOLIACEAE

Identified as: *Ilex mitis*

Genus found at Dartmoor Vlei: *Ilex mitis*

Likely parent taxa: *Ilex mitis*

Pollen morphological characteristics (on Family level): No morphological characteristics available for this research.

Ecology: Most frequently on river banks, and in moist evergreen forests (Palgrave, 2002).

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

ARALIACEAE

Identified as: Undifferentiated

Genus found at Dartmoor Vlei: *Cussonia*, *Hydrocotyle*, *Schefflera*

Likely parent taxa: Unknown

Pollen morphological characteristics (on Family level): No morphological characteristics available for this research.

Ecology: Occurs at the margins of montane forests, in woodland, and on hill slopes (Palgrave, 2002)

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

ASTERACEAE

Identified as: *Artemisia*

Genera found at Dartmoor Vlei: *Artemisia afra*

Likely parent taxa: *Artemisia afra*

Pollen morphological characteristics (on Genus level): Low spined (Scott *et al.*, 2006).

Ecology: *Artemisia* is found in grasslands (Scott, 1982a), sandy areas under local sub-humid conditions (Scott and Nyakale, 2002) with relatively even seasonal moisture distribution (Scott, 1999). It is an indication of somewhat drier conditions (Scott, 1982a).

Dispersal and preservation characteristics: *Artemisia* occurs in a wide range of habitats in eastern South Africa. It is often rare in pollen samples although it is considered moderately well dispersed (Scott, 1982a; Hamilton, 1972) over long distances (Hamilton, 1972).

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-Arboreal

Identified as: *Stoebe*

Genera found at Dartmoor Vlei: *Stoebe vulgaris*

Likely parent taxa: *Stoebe vulgaris*

Pollen morphological characteristics (on Genus level): Low spined (Scott *et al.*, 2006).

Ecology: *Stoebe* occurs in grasslands (Scott, 1982a), shrubland, and dry karroid veld under conditions of less summer rain (Scott and Nyakale, 2002) but with a relatively even seasonal moisture distribution (Scott 1999). It is indicative of different seasonal climatic distributions with weaker summer rainfall. It is not usually dominant in summer rain regions (Scott *et al.* 2005).

Dispersal and preservation characteristics: *Stoebe* is common in disturbed habitats and suggest cooler, drier conditions. It is considered a moderately well dispersed pollen (Scott 1982a; Hamilton 1972) being dispersed over long distances (Hamilton 1972).

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-Arboreal

Identified as: *Vernonia*-type

Genera found at Dartmoor Vlei: *Vernonia dregeana*, *V. fastigiata*, *V. gerardii*, *V. hirsute*, *V. mespilifolia*, *V. natalensis*, *V. oligocephala*

Likely parent taxa: *Vernonia* species

Pollen morphological characteristics (on Genus level): highly distinctive palynomorph. Trizonocolporate, echinate, fenestrate. 25-48 µm (Finch *et al.* 2009).

Ecology: A well represented genus of herbs, shrubs and small trees commonly occurring within secondary or disturbed forest types between 2000 and 3200 m. Ecology is variable due to a large number of potential parent taxa; nevertheless, *Vernonia* pollen has been viewed as indicative of agriculturally-related disturbance (Finch *et al.* 2009).

Dispersal and preservation characteristics: This pollen type is dispersed over long distances but is considered poorly dispersed (Hamilton 1972).

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-arboreal

BORAGINACEAE

Identified as: *Cordia*

Genera found at Dartmoor Vlei: *Cynoglossum*, *Echium*, *Ehretia*, *Lithospermum*, *Myosotis*, *Tysonia*

Likely parent taxa: Unknown

Pollen morphological characteristics: No morphological description available for this research.

Ecology: *Cordia* is found typically in lowland forest (Finch *et al.* 2009) and as forest patches in edaphic grasslands (Mumbi *et al.* 2008)

Dispersal and preservation characteristics: *Cordia* is typically insect pollinated and thus produce pollen in relatively low concentrations, as a result it is generally under-represented in pollen record (Connor *et al.* 2004).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

Identified as: *Heliotropium*

Genera found at Dartmoor Vlei: *Cynoglossum*, *Echium*, *Ehretia*, *Lithospermum*, *Myosotis*, *Tysonia*

Likely parent taxa: Unknown

Pollen morphological characteristics: No morphological description available for this research.

Ecology: *Heliotropium* occurs in Lowland forest (Finch *et al.* 2009)

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-Arboreal

BRASSICACEAE

Identified as: Undifferentiated

Genera found at Dartmoor Vlei: *Heliophila*

Likely parent taxa: *Heliophila*

Pollen morphological characteristics: No morphological description available for this research.

Ecology: Brassicaceae can occur along lake edges (Darbyshire *et al.* 2003) and in the Cape Florsitic Region it is found along arid northern margins (Linder 2003). It is adapted to tolerate salt and cold conditions (van de Mortel and Aarts 2006). It commonly found on damp grassy scree slopes of in the alpine belt (Court-Picon *et al.* 2005).

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

CELASTRACEAE

Identified as: Undifferentiated

Genera found at Dartmoor Vlei: *Cassine tetragonal*, *Maytenus acuminatus*, *M.*

mossambicensis, *M. peduncularis*, *M. undata*, *Pterocelastrus galpini*

Likely parent taxa: Unknown

Pollen morphological characteristics: No morphological description available for this research.

Ecology: Celastraceae is commonly found in montane forests, woodlands, riverine forest, evergreen and coastal bushland as well as dry forest and savanna. Celastraceae are well adapted to arid conditions and thus reflect suggest drier conditions with lower precipitation (Gil-Romera *et al.* 2007; Finch *et al.* 2009; Dupont *et al.* 2008; Sangu and Bracebridge 2005).

Dispersal and preservation characteristics: This pollen is considered to be dispersed over long distances (Hamilton 1972).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

CELTIDACEAE

Identified as: *Celtis*

Genus found at Dartmoor Vlei: *Celtis africana*

Likely parent taxa: *Celtis africana*

Pollen morphological characteristics (on Family level): Mostly tripolate, spheroidal and of equatorial diameter of 17 – 27 µm. Pores nearly circular in outline, membrane with a fleck or with some granules (van Zinderen Bakker 1953).

Ecology: Occurs in various habitats. Usually associated with high rainfall area, but can be drought tolerant (Scott, 1982a).

Dispersal and preservation characteristics: Very well dispersed in East Africa, found in high numbers in surface samples from mountainous slopes near Ladybrand (Scott, 1982a)

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

COMMELINACEAE

Identified as: Undifferentiated

Genus found at Dartmoor Vlei: *Commelina*, *Cyanotis*

Likely parent taxa: *Commelina africana*, *Cyanotis speciosa*

Pollen morphological characteristics (on Family level): Grains are momosulcate, bean-shaped or ellipsoidal, 30 – 90 µm. Exine almost spilate, granulate, echinate, verrucate or areolate (van Zinderen Bakker 1953).

Ecology: Widespread herb with many species in South Africa, found in moist areas, grasslands, and forest margins (Pooley, 2005) and also recorded in open veld (Scott, 1982a).

Dispersal and preservation characteristics: Have been recorded in surface samples of the open bushveld conditions (Scott, 1982a).

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-arboreal

CORNACEAE

Identified as: *Cornus*

Genus found at Dartmoor Vlei: Unknown

Likely parent taxa: *Cornus*

Pollen morphological characteristics (on Family level): No morphological characteristics available for this research.

Ecology: Occurs over a wide altitude range, in evergreen forests and on grassy mountain slopes (Palgrave, 2002)

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

CYPERACEAE

Identified as: Undifferentiated

Genera found at Dartmoor Vlei: Large array of Cyperaceae genera and species occur

Likely parent taxa: members of the Cyperaceae family

Pollen morphological characteristics (on Family level): Pseudomonads of subglobose, ovoid /elongated ovoid shape; wedge / gourd-shaped; one irregularly defined germ spore situated on a slightly elevated or flat area in the middle of the broader end; aperture sometimes irregular perforated; 21-76µm; dry conditions cause 3-4 concavities to originate on the sides and on the broad end causing grain to become polyhedral, varying from elongated tetrahedral to more irregular shapes; after acetolysis it shows folds when supporting intine is lost; exine thin 1-2.5µm; granulate, scrobiculate or reticulate sculpturing (van Zinderen Bakker 1953).

Ecology: Cyperaceae are herbaceous plants found in aquatic (Scott 1982a) moist environments including forest margins, streamsides or swamps (Finch *et al.* 2009).

Dispersal and preservation characteristics: Due to the local nature of the parent vegetation Cyperaceae pollen often dominates the pollen sum (Finch *et al.* 2009).

Local / Regional: Local

Arboreal / Non-Arboreal: Non-Arboreal

DIPSACACEAE

Identified as: *Scabiosa*

Genus found at Dartmoor Vlei: *Cephalaria*, *Scabiosa*

Likely parent taxa: *Scabiosa columbaria*

Pollen morphological characteristics (on Family level): No morphological characteristics available for this research.

Ecology: Found in marshy damp areas, grassland and open woodland (Pooley, 2005)

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-arboreal

EBENACEAE

Identified as: *Diospyros*

Genera found at Dartmoor Vlei: *Diospyros lycioides*, *D. pallens*, *D. scabrida*, *D. whyteana*

Likely parent taxa: *Diospyros*

Pollen morphological characteristics: No morphological description available for this research.

Ecology: Found in montane and subalpine grasslands (Killick 1963).

Dispersal and preservation characteristics: Rare to common in fossil and surface samples often occurring in dry bushveld where grass pollen production is apparently low (Scott 1982a).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

Identified as: *Euclea*

Genera found at Dartmoor Vlei: *Euclea crispa*, *E. natalensis*

Likely parent taxa: *Euclea crispa*, *E. natalensis*

Pollen morphological characteristics: No morphological description available for this research.

Ecology: *Euclea* are found in montane and subalpine grasslands of Cathedral peak (Killick 1963).

Dispersal and preservation characteristics: *Euclea* are regarded as rare to common in fossil and surface samples often occurring in dry bushveld where grass pollen production is apparently low (Scott 1982a).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

ERICACEAE

Identified as: Undifferentiated

Genera found at Dartmoor Vlei: *Erica*

Likely parent taxa: *Erica*

Pollen morphological characteristics (on Genus level): An unmistakable palynomorph. Inaperturate, psilate, scabrate, fossulate, rugulate tetrad. 28-55 µm (Coetzee 1955).

Ecology: Ericaceae are found in montane and subalpine grasslands and the alpine heath environments of Cathedral Peak (Scott 1982a; Killick 1963). The presence of >5% of this taxa indicates the lowering of vegetation belts. At 23°S Ericaceae usually occurs up to 1000m (Scott 1982a). It is often associated with fynbos environments that have cool, sub humid conditions with a relatively even seasonal moisture distribution (Scott 1999).

Dispersal and preservation characteristics: Ericaceae is considered to be moderately well dispersed (Hamilton 1972)

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-Arboreal

ERIOCAULACEAE

Identified as: *Eriocaulon*

Genus found at Dartmoor Vlei: *Eriocaulon*

Likely parent taxa: *Eriocaulon*

Pollen morphological characteristics (on Family level): Grains spherical, anaperturate and of uniform size. Exine folded into a spiral creating 4 – 5 low ridges, separated by narrow grooves on the sides (van Zinderen Bakker, 1953).

Ecology: *Eriocaulon* is found in damp, marshy areas (Pooley, 2005)

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Local

Arboreal / Non-Arboreal: Non-arboreal

EUPHORBIACEAE

Identified as: *Euphorbia*

Genera found at Dartmoor Vlei: Numerous *Euphorbia* species

Likely parent taxa: Pollen morphological characteristics: No morphological description available for this research.

Ecology: Herbaceous species found in the sub-alpine grasslands (Scott 1982a; Killick 1963).

Dispersal and preservation characteristics: Herbaceous, have very well, long distance dispersal pollen (Hamilton 1972) which occur as montane forests in East Africa. They can have unrealistic over-representation and should be considered excluded from pollen sum (Scott 1982a).

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-Arboreal

Identified as: Undifferentiated

Genera found at Dartmoor Vlei: *Acalypha*, *Adenocline*, *Clutia*, *Dalechampia*, *Euphorbia*, *Excoecaria*, *Jatropha*, *Leidesia*, *Micrococca*, *Phyllanthus*, *Sclerocroton*, *Surgada*

Likely parent taxa: Unknown

Pollen morphological characteristics (on Genus level): No morphological description available for this research.

Ecology: Herbaceous, have very well, long distance dispersal pollen (Hamilton 1972) which occur as montane forests in East Africa. They can have unrealistic over-representation and should be considered excluded from pollen sum (Scott 1982a).

Dispersal and preservation characteristics: Well dispersed pollen over long distances (Hamilton 1972).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

FABACEAE

Identified as: Undifferentiated

Genus found at Dartmoor Vlei: Large array of genus and species

Likely parent taxa: Unknown

Pollen morphological characteristics (on Family level): No morphological characteristics available for this research.

Ecology: Second largest plant family. Found in grasslands, varying from damp to rocky (Pooley, 2005)

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-arboreal

GERANIACEAE

Identified as: Undifferentiated

Genus found at Dartmoor Vlei: *Geranium*, *Monsonia*, *Pelargonium*

Likely parent taxa: *Geranium*, *Monsonia*, *Pelargonium*

Pollen morphological characteristics (on Family level): No morphological description available for this research.

Ecology: Found in damp, sheltered places, and montane grassland (Pooley, 2005).

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-arboreal

HALORAGACEAE

Identified as: *Gunnera*

Genera found at Dartmoor Vlei: *Gunnera perpersa*

Likely parent taxa: *Gunnera perpersa*

Pollen morphological characteristics (on Genus level): No morphological description available for this research.

Ecology: *Gunnera* are found in the subalpine grasslands of Cathedral Peak (Killick 1963) under aquatic conditions (Scott 1982a); *Gunnera* is a large semi-aquatic, perennial herb common in marshy environments up to 2400 m growing typically on the edge of wetlands and in drier areas of the wetland. This species is thought to be highly responsive to changes in the hydrological budget (Finch *et al.* 2009).

Dispersal and preservation characteristics: Pollen is considered to be over-represented due to its local dominance at the swamp site (Finch *et al.* 2009).

Local / Regional: Local

Arboreal / Non-Arboreal: Non-Arboreal

HYPERICACEAE

Identified as: *Hypericum*

Genus found at Dartmoor Vlei: *Hypericum*

Likely parent taxa: *Hypericum*

Pollen morphological characteristics (on Family level): monad, isopolar, radio-symmetric, tricolporate, colpi lengthy and narrow, recessed, constricted at the equator, pores distinct (Heusser, 1971)

Ecology: Herb, found in grassland and marshy areas (Pooley, 2005).

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-arboreal

IRIDACEAE

Identified as: Undifferentiated

Genus found at Dartmoor Vlei: *Aristea*, *Crocsmia*, *Dierama*, *Dietes*, *Gladiolus*, *Hesperantha*, *Morea*, *Sisyrinchium*, *Tritonia*, *Watsonia*

Likely parent taxa: Unknown

Pollen morphological characteristics (on Family level): Grains generally large in size, acolpate, monosulcate, disulcate or with 1 or 2 anastomosing furrows. Exine is thin, psilate, minutely granulate, verrucate, reticulate or with blunt or spiny projections (van Zinderen Bakker, 1953).

Ecology: Found in a variety of conditions, from grassland to marshy, damp areas and stream banks (Pooley, 2005).

Dispersal and preservation characteristics: Insect pollinated, not very likely to occur in air or in geological deposits (van Zinderen Bakker, 1953).

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-arboreal

LAMIACEAE

Identified as: *Undifferentiated*

Genera found at Dartmoor Vlei: *Ajuga*, *Chlerodendrum*, *Hemizygia*, *Leonotis*, *Leucas*, *Mentha*, *Micromeria*, *Ocimum*, *Plectranthus*, *Pycnostachys*, *Rabdosiella*, *Rothea*, *Stachys*, *Syncolostemon*, *Teucrium*

Likely parent taxa: Unknown

Pollen morphological characteristics: No morphological description available for this research.

Ecology: No ecological data is available for this research.

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-Arboreal

Identified as: *Leonotis*

Genera found at Dartmoor Vlei: *Ajuga*, *Chlerodendrum*, *Hemizygia*, *Leonotis*, *Leucas*, *Mentha*, *Micromeria*, *Ocimum*, *Plectranthus*, *Pycnostachys*, *Rabdosiella*, *Rothea*, *Stachys*, *Syncolostemon*, *Teucrium*

Likely parent taxa: *Leonotis*

Pollen morphological characteristics: No morphological description available for this research.

Ecology: No ecological data is available for this research.

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-Arboreal

LILIACEAE

Identified as: Undifferentiated

Genera found at Dartmoor Vlei: *Agapanthus*, *Aloe*, *Eriospermum*, *Kniphofia*, *Scilla*

Likely parent taxa: Unknown

Pollen morphological characteristics (on Family level): mostly monosulcate, sometimes anaperturate or trichotomosulcate; exine psilate, pitted, granulate or reticulate, subchinate or echinate (van Zinderen Bakker 1953).

Ecology: Liliaceae are insect pollinated with low concentrations of pollen being produced; therefore the pollen may be under-represented in pollen rain and sediment records (van Zinderen Bakker 1953).

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Local

Arboreal / Non-Arboreal: Non-Arboreal

MIMOSOIDEAE

Identified as: Type II

Genus found at Dartmoor Vlei: Introduced species

Likely parent taxa: *Acacia*

Pollen morphological characteristics (on Family level): No morphological characteristics available for this research.

Ecology: Native to Australia, introduced to South Africa in 1964 (Sherry, 1968; Owen and van der Zel, 2000).

Dispersal and preservation characteristics: No dispersal and preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal (Neophytes)

MYRICACEAE

Identified as: *Myrica*

Genera found at Dartmoor Vlei: *Myrica*

Likely parent taxa: *Myrica*

Pollen morphological characteristics (on Genus level): usually triporate, aspidate, oblate, with equatorial diameter 22-36 µm; 2,4, or 6 pores; ambit triangular with convex sides; irregular arrangement pores; mostly circular, sometime elliptical; thickening of exine under aspis is of tarsus pattern or transition between this and club-shaped pattern; exine is two layers surface slightly roughened or minutely granulate (van Zinderen Bakker 1953).

Ecology: *Myrica* is found in montane grasslands and forests of Cathedral Peak (Killick 1963) occurring within and on the forest margins under sub-humid conditions (Scott 1982a, 1999).

Dispersal and preservation characteristics: This pollen is considered moderately well dispersed over long distances in East Africa (Scott 1982a; Hamilton 1972).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

MYRTACEAE

Identified as: Undifferentiated

Genera found at Dartmoor Vlei: *Eugenia*, *Syzigium*

Likely parent taxa: Unknown

Pollen morphological characteristics (on Family level): No morphological description available for this research.

Ecology: Eucalyptus is an exotic neophyte associated with human activity but also occurring within montane forest types (Finch *et al.* 2009).

Dispersal and preservation characteristics: The pollen is moderately well dispersed (Finch *et al.* 2009).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

OLEACEAE

Identified as: Undifferentiated

Genus found at Dartmoor Vlei: *Chionanthus*, *Jasminum*, *Olea*

Likely parent taxa: *Olea*

Pollen morphological characteristics (on Family level): May be difficult to distinguish from Celastraceae pollen (Scott, 1982a)

Ecology: Most likely pollen grains of *Olea africana*, associated with rocky slopes

Dispersal and preservation characteristics: Considered to be well dispersed in East Africa (Scott, 1982a)

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

OXALIDACEAE

Identified as: *Oxalis*

Genus found at Dartmoor Vlei: *Oxalis*

Likely parent taxa: *Oxalis*

Pollen morphological characteristics (on Family level): Monad, isopolar, radio-symmetric, tricolpate, colpi narrow and lengthy, largely subprolate (Heusser, 1971)

Ecology: Found in damp grassland, marshy areas, and rocky outcrops (Pooley, 2005).

Dispersal and preservation characteristics: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-arboreal

PINACEAE

Identified as: *Pinus*

Genera found at Dartmoor Vlei: Not native; introduced

Likely parent taxa: *Pinus*

Pollen morphological characteristics (on Genus level): No morphological description available for this research.

Ecology: Exotic neophyte associated with human activity (Finch *et al.* 2009).

Dispersal and preservation characteristic: *Pinus* is anemophilous and therefore extremely well dispersed, contributing to over-representation in the pollen signal (Finch *et al.* 2009) .

Local / Regional: Regional (neophytes)

Arboreal / Non-Arboreal: Arboreal

POACEAE

Identified as: Undifferentiated

Genera found at Dartmoor Vlei: Large array of genera and species

Likely parent taxa: Members of the Poaceae family

Pollen morphological characteristics (on Family level): spheroidal or more or less ovoidal; 22-little +100µm; single germ spore surrounded by thickened rim; psilate; wild grass usually 20-25µm; spherical / ellipsoidal; less 1µm exine; ulcus lee 2µm across; impossible to ID different grasses spp based on size (van Zinderen Bakker 1953).

Ecology: *Poaceae* are found in regional humid conditions with summer rainfall (Scott and Nyakale 2002) under strong evaporative conditions (Scott *et al.* 2005).

Dispersal and preservation characteristic: Poaceae are well dispersed (Hamilton 1972).

Local / Regional: Local

Arboreal / Non-Arboreal: Non-Arboreal

Identified as: *Zea mays*

Genera found at Dartmoor Vlei: Not native, introduced crop

Likely parent taxa: Members of the Poaceae family

Pollen morphological characteristics (on Family level): spheroidal or more or less ovoidal; cereal grass 35-40µm; exine 1-2µm; uluc 2-7µm across; most SA grass could be classified as cereal probably due to polypoidy; impossible to ID different grasses spp based on size (van Zinderen Bakker 1953).

Ecology: Introduced crop, not native. *Poaceae* are found in regional humid conditions with summer rainfall (Scott and Nyakale 2002) under strong evaporative conditions (Scott *et al.* 2005).

Dispersal and preservation characteristic: Poaceae are well dispersed (Hamilton 1972)

Local / Regional: Local (neophytes)

Arboreal / Non-Arboreal: Non-Arboreal

PODOCARPACEAE

Identified as: *Podocarpus*

Genera found at Dartmoor Vlei: *Podocarpus falcatus*, *P. henkelii*, *P. latifolius*

Likely parent taxa: *Podocarpus falcatus*, *P. henkelii*, *P. latifolius*

Pollen morphological characteristics (on Genus level): Six species in South Africa occur in mountainous regions from the Cape Peninsula coastal belt to KwaZulu-Natal and into Mpumalanga; wind pollinated; grains: monosulcate, spherical to ellipsoidal, saccate, provided with 2,3 and exceptionally 4 air-sacs; 2 sac grains range 23-45µm diameter; proximal side arched; thick exine; sulcus on distal face, sharply defined, surrounded airsacs,; Bladders: at the inside with reticulate thickenings, which merge with structure of proximal face; large, but mostly weak and flaccid (van Zinderen Bakker 1953).

Ecology: *Podocarpus* are found in the montane forests and subalpine grasslands of Cathedral Peak (Killick 1963). It is often a forest-dweller (Scott 1982a) favouring relatively moist conditions (Scott 1999).

Dispersal and preservation characteristic: Pollen grains produced large numbers, each with air bladders making the grains very buoyant with the ability to be well dispersed by wind over long distances (Scott 1982a; Hamilton 1972). As such they can be easily overrepresented in pollen sums (Scott 1982a).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

POLYGALACEAE

Identified as: *Polygala*

Genus found at Dartmoor Vlei: *Muraltia*, *Polygala*

Likely parent taxa: *Polygala*

Pollen morphological characteristics (on Family level): Grain diameter ranging from 16 – 18 µm, with or without furrows (van Zinderen Bakker 1956).

Ecology: Widespread, more common in grassland than marshy conditions (Scott, 1982a).

Dispersal and preservation characteristics: Partly insect-, partly wind-pollinated (van Zinderen Bakker 1956). Rarely recorded in peat deposits, occasionally found in surface samples (Scott, 1982a).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

PROTEACEAE

Identified as: *Protea*

Genera found at Dartmoor Vlei: *Protea*

Likely parent taxa: *Protea*

Pollen morphological characteristics (on Genus level): triporate, oblate, disc-shaped, 23-39µm equatorial diameter; ambit triangular with rounded angles; angles slightly bent towards proximal side; pores at angles slightly elliptical; thin exine 1.1-1.5µm; two layers, nearly devoid of sculpturing; some scattered granules or scrobiculate (van Zinderen Bakker 1953).

Ecology: *Protea* is found in the montane and sub-alpine grasslands and montane forests of Cathedral Peak (Killick 1963). It is also found in upland and mesic savanna under sub-humid conditions (Scott 1999).

Dispersal and preservation characteristic: *Protea* is found under wide range temperatures (Scott 1999); 100-130 spp in SA mostly SW districts of Cape Province, but extending into Natal Transvaal Basutoland, Swaziland (van Zinderen Bakker 1953).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

ROSACEAE

Identified as: *Cliffortia*

Genera found at Dartmoor Vlei: *Cliffortia linearifolia*, *C. repens*, *C. strobilifera*

Likely parent taxa: *Cliffortia linearifolia*, *C. repens*, *C. strobilifera*

Pollen morphological characteristics (on Genus level): grains 3-4 porate; spheroidal to suboblate; ambit circular; medium sized; pori: protruding; surrounded thick collar; often irregular outline; surrounded granules and small cracks in exine; exine: 2-3µm thick; nexine 0.5µm; baculate; crassitegillate; punctitegillate (van Zinderen Bakker and Coetzee 1959).

Ecology: *Cliffortia* is found in montane and sub-alpine grasslands and alpine heath environments of Cathedral Peak (Killick 1963), usually under moist but also drier conditions (Scott 1982a).

Dispersal and preservation characteristic: There are 78 species of *Cliffortia* occurring mostly in the south-west Cape but with a few species extending eastwards along the coastal belt (van Zinderen Bakker and Coetzee 1959).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

Identified as: *Leucosidea*

Genera found at Dartmoor Vlei: *Leucosidea sericea*

Likely parent taxa: *Leucosidea sericea*

Pollen morphological characteristics (on Genus level): 3 colpate; prolate to prolate spheroidal; sometimes slightly constricted at equator; fossaperturate; size: 22.4-28µm; Apertures: long, pointed end at poles; 5.5µm apart; membrane psilate; constricted at equator over distance of 4-5.5µm; equatorial area sometimes protruding;; ora oblongata; exine: 2-2.5µm thick; stratification obscure; with regular striate pattern (van Zinderen Bakker and Coetzee 1959).

Ecology: *Leucosidea* is found in the montane and sub-alpine grasslands of Cathedral Peak (Killick 1963). It is found at high altitudes, in grasslands, on mountain slopes and often near water. May become invasive in overgrazed or eroded areas (Pooley, 2005).

Dispersal and preservation characteristic: *Leucosidea* is endemic with one species occurring from Limpopo through to the mountains of the eastern escarpment as far south as Queenstown in the Eastern Cape (van Zinderen Bakker and Coetzee 1959).

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

Identified as: Undifferentiated

Genera found at Dartmoor Vlei: *Agrimonia*, *Alchemilla*, *Cliffortia*, *Duchesnea*, *Leucosidea*, *Prunus*, *Rubus*

Likely parent taxa: *Agrimonia*, *Alchemilla*, *Cliffortia*, *Duchesnea*, *Leucosidea*, *Prunus*, *Rubus*

Pollen morphological characteristics (on Genus level): No morphological description available for this research.

Ecology: No ecological description is found for this research.

Dispersal and preservation characteristic: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Arboreal

THYMELEACEAE

Identified as: Undifferentiated

Genera found at Dartmoor Vlei: *Englerodaphne*, *Gnidia*, *Passerina*, *Peddiea*

Likely parent taxa: Unknown

Pollen morphological characteristics: No morphological description available for this research.

Ecology: Occurs in grasslands (Scott 1982a)

Dispersal and preservation characteristic: No dispersal or preservation characteristics available for this research.

Local / Regional: Regional

Arboreal / Non-Arboreal: Non-Arboreal

Appendix P

Species list of Dartmoor Vlei (adapted from SANBI Integrated Biodiversity Information System)

Family	Scientific Name	CollectionCode
ACANTHACEAE	<i>Adhatoda densiflora</i>	PRECIS (KZN)
ACANTHACEAE	<i>Barleria elegans</i>	PRECIS
ACANTHACEAE	<i>Barleria ovata</i>	PRECIS
ACANTHACEAE	<i>Chaetacanthus burchellii</i>	PRECIS
ACANTHACEAE	<i>Chaetacanthus setiger</i>	PRECIS
ACANTHACEAE	<i>Crabbea hirsuta</i>	PRECIS
ACANTHACEAE	<i>Dicliptera clinopodia</i>	Acocks
ACANTHACEAE	<i>Dicliptera extenta</i>	PRECIS
ACANTHACEAE	<i>Dicliptera quintasii</i>	Acocks
ACANTHACEAE	<i>Dicliptera zeylanica</i>	Acocks
ACANTHACEAE	<i>Hypoestes aristata</i> var. <i>aristata</i>	PRECIS
ACANTHACEAE	<i>Hypoestes forskoolii</i>	PRECIS
ACANTHACEAE	<i>Isoglossa eckloniana</i>	PRECIS
ACANTHACEAE	<i>Isoglossa grantii</i>	PRECIS (KZN)
ACANTHACEAE	<i>Isoglossa woodii</i>	PRECIS
ACANTHACEAE	<i>Justicia campylostemon</i>	PRECIS
ACANTHACEAE	<i>Justicia protracta</i> subsp. <i>protracta</i>	PRECIS
ACANTHACEAE	<i>Ruellia baurii</i>	PRECIS (KZN)
ACANTHACEAE	<i>Ruellia cordata</i>	PRECIS
ACANTHACEAE	<i>Ruellia woodii</i>	PRECIS
ACANTHACEAE	<i>Sclerochiton harveyanus</i>	Acocks
ACANTHACEAE	<i>Sclerochiton odoratissimus</i>	PRECIS
ACANTHACEAE	<i>Thunbergia atriplicifolia</i>	PRECIS
ACANTHACEAE	<i>Thunbergia natalensis</i>	PRECIS
ACANTHACEAE	<i>Thunbergia venosa</i>	PRECIS
ACHARIACEAE	<i>Ceratiosicyos laevis</i>	PRECIS
ACHARIACEAE	<i>Kiggelaria africana</i>	Acocks
ACROBOLBACEAE	<i>Tylimanthus africanus</i>	PRECIS
AGAPANTHACEAE	<i>Agapanthus campanulatus</i> subsp. <i>Campanulatus</i> *	PRECIS
AGAPANTHACEAE	<i>Agapanthus campanulatus</i> subsp. <i>patens</i>	PRECIS
AGAPANTHACEAE	<i>Agapanthus praecox</i> subsp. <i>praecox</i>	Gardens (KBG)
AIZOACEAE	<i>Delosperma lineare</i>	Bolus Herbarium
AIZOACEAE	<i>Delosperma</i> spp*	Anel Geer
ALLIACEAE	<i>Alepdea setifera</i> *	Anel Geer
ALLIACEAE	<i>Tulbaghia acutiloba</i>	PRECIS (KZN)
ALLIACEAE	<i>Tulbaghia ludwigiana</i>	PRECIS
ALLIACEAE	<i>Tulbaghia natalensis</i>	PRECIS
AMARANTHACEAE	<i>Achyranthes aspera</i> var. <i>aspera</i>	Acocks
AMARANTHACEAE	<i>Alternanthera pungens</i>	Acocks
AMARANTHACEAE	<i>Cyathula cylindrica</i> var. <i>cylindrica</i>	PRECIS
AMARANTHACEAE	<i>Gomphrena celosioides</i>	Acocks
AMARYLLIDACEAE	<i>Apodolirion buchananii</i>	PRECIS (KZN)
AMARYLLIDACEAE	<i>Boophone disticha</i>	PRECIS
AMARYLLIDACEAE	<i>Brunsvigia grandiflora</i>	PRECIS
AMARYLLIDACEAE	<i>Brunsvigia natalensis</i>	PRECIS
AMARYLLIDACEAE	<i>Brunsvigia radulosa</i>	PRECIS
AMARYLLIDACEAE	<i>Brunsvigia undulata</i>	PRECIS
AMARYLLIDACEAE	<i>Crinum bulbispermum</i>	PRECIS
AMARYLLIDACEAE	<i>Cyrtanthus breviflorus</i> *	PRECIS
AMARYLLIDACEAE	<i>Cyrtanthus contractus</i>	PRECIS
AMARYLLIDACEAE	<i>Cyrtanthus falcatus</i>	PRECIS
AMARYLLIDACEAE	<i>Cyrtanthus galpinii</i>	PRECIS
AMARYLLIDACEAE	<i>Cyrtanthus</i> sp.	PRECIS
AMARYLLIDACEAE	<i>Cyrtanthus stenanthus</i> var. <i>stenanthus</i>	PRECIS (KZN)

Family	ScientificName	CollectionCode
AMARYLLIDACEAE	<i>Cyrtanthus tuckii</i> var. <i>transvaalensis</i>	PRECIS
AMARYLLIDACEAE	<i>Cyrtanthus tuckii</i> var. <i>tuckii</i>	Gardens (KBG)
AMARYLLIDACEAE	<i>Cyrtanthus tuckii</i> var. <i>viridilobus</i>	PRECIS
AMARYLLIDACEAE	<i>Nerine appendiculata</i>	PRECIS
AMARYLLIDACEAE	<i>Nerine pancratioides</i> *	PRECIS
AMARYLLIDACEAE	<i>Nerine</i> sp.	PRECIS
AMARYLLIDACEAE	<i>Scadoxus puniceus</i>	PRECIS
ANACARDIACEAE	<i>Protorhus longifolia</i>	Acocks
ANACARDIACEAE	<i>Rhus species</i> *	Anel Geer
ANACARDIACEAE	<i>Rhus chirindensis</i>	Acocks
ANACARDIACEAE	<i>Rhus discolor</i> *	Acocks
ANACARDIACEAE	<i>Rhus lucida</i> forma <i>lucida</i>	Acocks
ANACARDIACEAE	<i>Rhus transvaalensis</i>	Acocks
ANACARDIACEAE	<i>Searsia dentata</i>	PRECIS
ANACARDIACEAE	<i>Searsia discolor</i>	PRECIS
ANACARDIACEAE	<i>Searsia leptodictya</i> forma <i>leptodictya</i>	PRECIS
ANACARDIACEAE	<i>Searsia lucida</i> forma <i>lucida</i>	PRECIS
ANACARDIACEAE	<i>Searsia pentheri</i>	PRECIS
ANACARDIACEAE	<i>Searsia pyroides</i> var. <i>gracilis</i>	PRECIS
ANACARDIACEAE	<i>Searsia pyroides</i> var. <i>integrifolia</i>	PRECIS (KZN)
ANACARDIACEAE	<i>Searsia rehmanniana</i> var. <i>glabrata</i>	PRECIS
ANEMIACEAE	<i>Anemia dregeana</i>	PRECIS
ANEMIACEAE	<i>Mohria caffrorum</i> *	Acocks
ANEMIACEAE	<i>Mohria vestita</i>	PRECIS
ANEURACEAE	<i>Riccardia fastigiata</i>	PRECIS
ANNONACEAE	<i>Monanthotaxis caffra</i>	Acocks
ANNONACEAE	<i>Uvaria caffra</i>	Acocks
ANOMODONTACEAE	<i>Anomodon pseudotristis</i>	PRECIS
ANTHERICACEAE	<i>Anthericum fasciculatum</i>	PRECIS (KZN)
ANTHERICACEAE	<i>Chlorophytum comosum</i>	PRECIS (KZN)
ANTHERICACEAE	<i>Chlorophytum cooperi</i>	PRECIS
ANTHERICACEAE	<i>Chlorophytum krookianum</i>	PRECIS
ANTHOCEROTACEAE	<i>Anthoceros natalensis</i>	PRECIS
APIACEAE	<i>Afrosciadium caffrum</i>	PRECIS
APIACEAE	<i>Alepidea amatymbica</i> var. <i>amatymbica</i>	PRECIS (KZN)
APIACEAE	<i>Alepidea peduncularis</i>	PRECIS
APIACEAE	<i>Apium</i> sp.	PRECIS
APIACEAE	<i>Centella asiatica</i>	Acocks
APIACEAE	<i>Centella</i> sp.	PRECIS
APIACEAE	<i>Conium fontanum</i> var. <i>silvaticum</i>	PRECIS
APIACEAE	<i>Conium</i> sp.	PRECIS
APIACEAE	<i>Heteromorpha arborescens</i> var. <i>abyssinica</i>	PRECIS
APIACEAE	<i>Notobubon laevigatum</i>	PRECIS
APIACEAE	<i>Sanicula elata</i>	Acocks
APIACEAE	<i>Sium repandum</i>	PRECIS
APOCYNACEAE	<i>Asclepias albens</i>	PRECIS
APOCYNACEAE	<i>Asclepias bicuspis</i>	PRECIS (KZN)
APOCYNACEAE	<i>Asclepias brevicuspis</i>	PRECIS
APOCYNACEAE	<i>Asclepias cucullata</i> subsp. <i>cucullata</i>	PRECIS
APOCYNACEAE	<i>Asclepias cultriformis</i>	PRECIS
APOCYNACEAE	<i>Asclepias dregeana</i> var. <i>calceola</i>	PRECIS
APOCYNACEAE	<i>Asclepias macropus</i>	PRECIS
APOCYNACEAE	<i>Asclepias</i> sp.	PRECIS
APOCYNACEAE	<i>Asclepias woodii</i>	PRECIS
APOCYNACEAE	<i>Aspidoglossum araneiferum</i>	PRECIS
APOCYNACEAE	<i>Aspidoglossum biflorum</i>	PRECIS
APOCYNACEAE	<i>Aspidoglossum fasciculare</i>	PRECIS
APOCYNACEAE	<i>Aspidoglossum glanduliferum</i>	PRECIS
APOCYNACEAE	<i>Aspidoglossum ovalifolium</i>	PRECIS
APOCYNACEAE	<i>Aspidoglossum woodii</i>	Acocks

Family	Scientific Name	CollectionCode
APOCYNACEAE	<i>Aspidonepsis diploglossa</i>	PRECIS
APOCYNACEAE	<i>Aspidonepsis flava</i>	PRECIS
APOCYNACEAE	<i>Carissa bispinosa</i>	Acocks
APOCYNACEAE	<i>Ceropegia linearis subsp. linearis</i>	PRECIS
APOCYNACEAE	<i>Ceropegia linearis subsp. woodii</i>	PRECIS
APOCYNACEAE	<i>Cryptolepis capensis</i>	PRECIS (KZN)
APOCYNACEAE	<i>Cynanchum ellipticum</i>	PRECIS
APOCYNACEAE	<i>Fanninia caloglossa</i>	PRECIS (KZN)
APOCYNACEAE	<i>Miraglossum pilosum</i>	PRECIS
APOCYNACEAE	<i>Miraglossum pulchellum</i>	PRECIS
APOCYNACEAE	<i>Pachycarpus campanulatus var. campanulatus*</i>	PRECIS
APOCYNACEAE	<i>Pachycarpus campanulatus var. sutherlandii</i>	PRECIS
APOCYNACEAE	<i>Pachycarpus grandiflorus subsp. grandiflorus</i>	PRECIS
APOCYNACEAE	<i>Pachycarpus natalensis</i>	PRECIS
APOCYNACEAE	<i>Pentarrhinum insipidum</i>	PRECIS
APOCYNACEAE	<i>Periglossum angustifolium</i>	PRECIS
APOCYNACEAE	<i>Raphionacme hirsuta</i>	Acocks
APOCYNACEAE	<i>Raphionacme palustris</i>	PRECIS
APOCYNACEAE	<i>Riocreuxia torulosa var. torulosa</i>	PRECIS
APOCYNACEAE	<i>Schizoglossum flavum</i>	PRECIS (KZN)
APOCYNACEAE	<i>Schizoglossum hamatum</i>	PRECIS
APOCYNACEAE	<i>Schizoglossum stenoglossum subsp. stenoglossum</i>	PRECIS
APOCYNACEAE	<i>Secamone alpini</i>	Acocks
APOCYNACEAE	<i>Secamone filiformis</i>	PRECIS
APOCYNACEAE	<i>Sisyranthus trichostomus</i>	PRECIS
APOCYNACEAE	<i>Strophanthus speciosus</i>	Acocks
APOCYNACEAE	<i>Woodia verruculosa</i>	PRECIS
APOCYNACEAE	<i>Xysmalobium gerrardii</i>	PRECIS (KZN)
APOCYNACEAE	<i>Xysmalobium involucratum*</i>	PRECIS
APOCYNACEAE	<i>Xysmalobium stockenstromense</i>	PRECIS (KZN)
APOCYNACEAE	<i>Xysmalobium undulatum var. undulatum</i>	PRECIS
APONOGETONACEAE	<i>Aponogeton junceus*</i>	PRECIS
APONOGETONACEAE	<i>Aponogeton junceus subsp. natalense</i>	PRECIS (KZN)
APONOGETONACEAE	<i>Aponogeton natalensis</i>	PRECIS
APONOGETONACEAE	<i>Aponogeton sp.</i>	PRECIS
AQUIFOLIACEAE	<i>Ilex mitis var. mitis</i>	PRECIS
ARACEAE	<i>Zantedeschia aethiopica</i>	PRECIS
ARACEAE	<i>Zantedeschia albomaculata subsp. albomaculata</i>	PRECIS
ARALIACEAE	<i>Cussonia nicholsonii</i>	PRECIS
ARALIACEAE	<i>Cussonia spicata</i>	Acocks
ARALIACEAE	<i>Hydrocotyle sibthorpioides</i>	PRECIS
ARALIACEAE	<i>Schefflera umbellifera</i>	Acocks
ARTHONACEAE	<i>Arthonia trilocularis</i>	PRECIS
ASPARAGACEAE	<i>Asparagus africanus</i>	PRECIS
ASPARAGACEAE	<i>Asparagus asparagoides</i>	PRECIS
ASPARAGACEAE	<i>Asparagus cooperi</i>	PRECIS (KZN)
ASPARAGACEAE	<i>Asparagus devenishii</i>	PRECIS (KZN)
ASPARAGACEAE	<i>Asparagus larinus</i>	PRECIS
ASPARAGACEAE	<i>Asparagus ramosissimus</i>	PRECIS
ASPARAGACEAE	<i>Asparagus setaceus</i>	PRECIS
ASPARAGACEAE	<i>Asparagus virgatus</i>	Acocks
ASPARAGACEAE	<i>Asparagus volubilis</i>	Acocks
ASPHODELACEAE	<i>Aloe arborescens</i>	PRECIS
ASPHODELACEAE	<i>Aloe cooperi subsp. cooperi</i>	PRECIS
ASPHODELACEAE	<i>Aloe ecklonis</i>	PRECIS
ASPHODELACEAE	<i>Aloe linearifolia</i>	PRECIS
ASPHODELACEAE	<i>Aloe maculata</i>	PRECIS
ASPHODELACEAE	<i>Aloe micracantha</i>	PRECIS
ASPHODELACEAE	<i>Aloe mudenensis</i>	PRECIS
ASPHODELACEAE	<i>Bulbine abyssinica</i>	PRECIS
ASPHODELACEAE	<i>Kniphofia brachystachya</i>	PRECIS (KZN)

Family	Scientific Name	CollectionCode
ASPHODELACEAE	<i>Kniphofia buchananii</i>	PRECIS
ASPHODELACEAE	<i>Kniphofia fluviatilis</i>	PRECIS
ASPHODELACEAE	<i>Kniphofia ichopensis</i> var. <i>aciformis</i>	PRECIS (KZN)
ASPHODELACEAE	<i>Kniphofia ichopensis</i> var. <i>ichopensis</i>	PRECIS
ASPHODELACEAE	<i>Kniphofia latifolia</i>	PRECIS
ASPHODELACEAE	<i>Kniphofia laxiflora</i> *	PRECIS (KZN)
ASPHODELACEAE	<i>Kniphofia linearifolia</i>	Gardens (KBG)
ASPHODELACEAE	<i>Kniphofia</i> sp.*	Gardens (KBG)
ASPHODELACEAE	<i>Kniphofia tysonii</i> subsp. <i>tysonii</i>	PRECIS
ASPHODELACEAE	<i>Trachyandra asperata</i> *	Anel Geer
ASPHODELACEAE	<i>Trachyandra asperata</i> var. <i>stenophylla</i>	PRECIS (KZN)
ASPHODELACEAE	<i>Trachyandra gerrardii</i>	PRECIS
ASPHODELACEAE	<i>Trachyandra saltii</i> var. <i>saltii</i> *	PRECIS
ASPHODELACEAE	<i>Trachyandra</i> sp.	PRECIS
ASPLENIACEAE	<i>Asplenium aethiopicum</i>	PRECIS
ASPLENIACEAE	<i>Asplenium aethiopicum</i> subsp. <i>aethiopicum</i>	Acocks
ASPLENIACEAE	<i>Asplenium boltonii</i>	PRECIS
ASPLENIACEAE	<i>Asplenium dregeanum</i>	PRECIS
ASPLENIACEAE	<i>Asplenium erectum</i>	PRECIS (KZN)
ASPLENIACEAE	<i>Asplenium erectum</i> var. <i>erectum</i>	PRECIS
ASPLENIACEAE	<i>Asplenium gemmiferum</i>	PRECIS
ASPLENIACEAE	<i>Asplenium inaequilaterale</i>	PRECIS
ASPLENIACEAE	<i>Asplenium lobatum</i>	PRECIS (KZN)
ASPLENIACEAE	<i>Asplenium lobatum</i> var. <i>lobatum</i>	PRECIS
ASPLENIACEAE	<i>Asplenium lunulatum</i>	Acocks
ASPLENIACEAE	<i>Asplenium monanthes</i>	Acocks
ASPLENIACEAE	<i>Asplenium preussii</i>	PRECIS
ASPLENIACEAE	<i>Asplenium protensum</i>	Gardens (KBG)
ASPLENIACEAE	<i>Asplenium rutifolium</i>	PRECIS
ASPLENIACEAE	<i>Asplenium sandersonii</i>	PRECIS
ASPLENIACEAE	<i>Asplenium simii</i>	PRECIS (KZN)
ASPLENIACEAE	<i>Asplenium splendens</i> subsp. <i>splendens</i>	PRECIS
ASPLENIACEAE	<i>Asplenium stoloniferum</i>	PRECIS
ASPLENIACEAE	<i>Asplenium theciferum</i> var. <i>concinnum</i>	PRECIS
ASPLENIACEAE	<i>Asplenium trichomanes</i> subsp. <i>quadrivalens</i>	PRECIS
ASPLENIACEAE	<i>Asplenium varians</i> subsp. <i>fimbriatum</i>	PRECIS
ASTERACEAE	<i>Acanthospermum australe</i>	Acocks
ASTERACEAE	<i>Adenostemma caffrum</i> var. <i>caffrum</i>	PRECIS
ASTERACEAE	<i>Arctotis arctotoides</i>	PRECIS
ASTERACEAE	<i>Artemisia afra</i> var. <i>afra</i>	PRECIS
ASTERACEAE	<i>Aster bakerianus</i> *	PRECIS
ASTERACEAE	<i>Aster bakerianus</i> subsp. <i>intermedius</i>	PRECIS
ASTERACEAE	<i>Aster pleiocephalus</i>	PRECIS
ASTERACEAE	<i>Athanasia</i> sp.	PRECIS
ASTERACEAE	<i>Athrixia fontana</i>	PRECIS
ASTERACEAE	<i>Berkheya acanthopoda</i>	PRECIS
ASTERACEAE	<i>Berkheya echinacea</i> *	Anel Geer
ASTERACEAE	<i>Berkheya erysithales</i>	PRECIS
ASTERACEAE	<i>Berkheya maritima</i>	PRECIS
ASTERACEAE	<i>Berkheya rhapontica</i> *	Anel Geer
ASTERACEAE	<i>Berkheya rhapontica</i> subsp. <i>platyptera</i>	PRECIS (KZN)
ASTERACEAE	<i>Berkheya setifera</i>	PRECIS
ASTERACEAE	<i>Berkheya speciosa</i> subsp. <i>ovata</i>	PRECIS
ASTERACEAE	<i>Berkheya speciosa</i> subsp. <i>speciosa</i>	PRECIS
ASTERACEAE	<i>Bidens bipinnata</i>	Acocks
ASTERACEAE	<i>Bidens pilosa</i>	PRECIS
ASTERACEAE	<i>Brachylaena elliptica</i>	PRECIS
ASTERACEAE	<i>Brachylaena huillensis</i>	Gardens (KBG)
ASTERACEAE	<i>Centaurea melitensis</i>	PRECIS
ASTERACEAE	<i>Cineraria deltoidea</i>	PRECIS
ASTERACEAE	<i>Cineraria grandibracteata</i>	PRECIS

Family	Scientific Name	CollectionCode
ASTERACEAE	<i>Cineraria</i> sp.	PRECIS
ASTERACEAE	<i>Cirsium vulgare</i> *	Acocks
ASTERACEAE	<i>Conyza albida</i>	PRECIS (KZN)
ASTERACEAE	<i>Conyza bonariensis</i>	Acocks
ASTERACEAE	<i>Conyza canadensis</i>	PRECIS
ASTERACEAE	<i>Conyza pinnata</i>	PRECIS
ASTERACEAE	<i>Conyza scabrida</i>	PRECIS
ASTERACEAE	<i>Conyza sumatrensis</i> var. <i>sumatrensis</i>	PRECIS
ASTERACEAE	<i>Conyza ulmifolia</i>	PRECIS
ASTERACEAE	<i>Cotula australis</i>	PRECIS
ASTERACEAE	<i>Cotula hispida</i>	PRECIS
ASTERACEAE	<i>Cotula nigellifolia</i> var. <i>nigellifolia</i>	PRECIS
ASTERACEAE	<i>Cotula nigellifolia</i> var. <i>tenuior</i>	PRECIS
ASTERACEAE	<i>Crepis hypochaeridea</i>	PRECIS
ASTERACEAE	<i>Delairea odorata</i>	Acocks
ASTERACEAE	<i>Denekia capensis</i> *	PRECIS
ASTERACEAE	<i>Dimorphotheca caulescens</i>	PRECIS
ASTERACEAE	<i>Dimorphotheca jucunda</i>	PRECIS
ASTERACEAE	<i>Euryops laxus</i> *	PRECIS
ASTERACEAE	<i>Euryops transvaalensis</i> subsp. <i>setilobus</i>	PRECIS
ASTERACEAE	<i>Felicia muricata</i> subsp. <i>muricata</i>	PRECIS
ASTERACEAE	<i>Felicia quinquenervia</i>	PRECIS
ASTERACEAE	<i>Felicia wrightii</i> *	Anel Geer
ASTERACEAE	<i>Galinsoga parviflora</i>	PRECIS
ASTERACEAE	<i>Gamochaeta pensylvanica</i>	PRECIS
ASTERACEAE	<i>Gamochaeta subfalcata</i>	PRECIS
ASTERACEAE	<i>Garuleum sonchifolium</i>	PRECIS
ASTERACEAE	<i>Gazania krebsiana</i> subsp. <i>krebsiana</i>	PRECIS (KZN)
ASTERACEAE	<i>Gazania linearis</i> var. <i>linearis</i>	PRECIS
ASTERACEAE	<i>Gazania rigens</i> var. <i>uniflora</i>	PRECIS
ASTERACEAE	<i>Gazania rigens</i> *	Anel Geer
ASTERACEAE	<i>Gerbera ambigua</i> *	PRECIS
ASTERACEAE	<i>Gerbera aurantiaca</i>	PRECIS (KZN)
ASTERACEAE	<i>Gerbera natalensis</i>	PRECIS (KZN)
ASTERACEAE	<i>Gerbera piloselloides</i>	PRECIS
ASTERACEAE	<i>Gnaphalium austroafricanum</i>	PRECIS
ASTERACEAE	<i>Gnaphalium confine</i>	PRECIS
ASTERACEAE	<i>Gnaphalium declinatum</i>	Acocks
ASTERACEAE	<i>Gnaphalium griquense</i>	PRECIS
ASTERACEAE	<i>Gymnanthemum corymbosum</i>	PRECIS
ASTERACEAE	<i>Gymnanthemum crataegifolium</i>	PRECIS
ASTERACEAE	<i>Gymnanthemum mespilifolium</i>	PRECIS
ASTERACEAE	<i>Haplocarpha scaposa</i>	PRECIS
ASTERACEAE	<i>Helichrysum acutatum</i>	PRECIS (KZN)
ASTERACEAE	<i>Helichrysum adenocarpum</i> subsp. <i>Adenocarpum</i> *	PRECIS
ASTERACEAE	<i>Helichrysum allioides</i> *	PRECIS
ASTERACEAE	<i>Helichrysum appendiculatum</i> *	PRECIS
ASTERACEAE	<i>Helichrysum argentissimum</i>	PRECIS
ASTERACEAE	<i>Helichrysum argyrolepis</i>	PRECIS
ASTERACEAE	<i>Helichrysum aureonitens</i> *	PRECIS
ASTERACEAE	<i>Helichrysum aureum</i> *	Anel Geer
ASTERACEAE	<i>Helichrysum aureum</i> var. <i>monocephalum</i>	PRECIS
ASTERACEAE	<i>Helichrysum auriceps</i>	PRECIS
ASTERACEAE	<i>Helichrysum caespititium</i>	PRECIS
ASTERACEAE	<i>Helichrysum callicomum</i>	PRECIS
ASTERACEAE	<i>Helichrysum cooperi</i>	PRECIS
ASTERACEAE	<i>Helichrysum glomeratum</i>	PRECIS
ASTERACEAE	<i>Helichrysum herbaceum</i>	PRECIS
ASTERACEAE	<i>Helichrysum krebsianum</i>	PRECIS
ASTERACEAE	<i>Helichrysum melanacme</i>	PRECIS
ASTERACEAE	<i>Helichrysum natalitium</i>	PRECIS

Family	Scientific Name	CollectionCode
ASTERACEAE	<i>Helichrysum nudifolium</i> var. <i>nudifolium</i>	PRECIS
ASTERACEAE	<i>Helichrysum nudifolium</i> var. <i>pilosellum</i>	PRECIS
ASTERACEAE	<i>Helichrysum oligopappum</i>	PRECIS (KZN)
ASTERACEAE	<i>Helichrysum pallidum</i>	PRECIS
ASTERACEAE	<i>Helichrysum pilosellum</i> *	PRECIS (KZN)
ASTERACEAE	<i>Helichrysum platypterum</i>	PRECIS
ASTERACEAE	<i>Helichrysum rugulosum</i>	PRECIS
ASTERACEAE	<i>Helichrysum simillimum</i>	Acocks
ASTERACEAE	<i>Helichrysum spiralepis</i> *	PRECIS
ASTERACEAE	<i>Helichrysum spodiophyllum</i>	PRECIS
ASTERACEAE	<i>Helichrysum spp</i> *	Anel Geer
ASTERACEAE	<i>Helichrysum sutherlandii</i>	PRECIS
ASTERACEAE	<i>Helichrysum umbraculigerum</i>	Acocks
ASTERACEAE	<i>Helichrysum vernum</i>	PRECIS (KZN)
ASTERACEAE	<i>Hilliardia zuurbergensis</i>	Acocks
ASTERACEAE	<i>Hilliardiella aristata</i>	PRECIS
ASTERACEAE	<i>Hilliardiella hirsuta</i>	PRECIS
ASTERACEAE	<i>Hilliardiella nudicaulis</i>	PRECIS
ASTERACEAE	<i>Hilliardiella oligocephala</i>	PRECIS
ASTERACEAE	<i>Hirpicium armerioides</i>	PRECIS
ASTERACEAE	<i>Hypochaeris radicata</i> *	PRECIS
ASTERACEAE	<i>Inulanthera dregeana</i>	PRECIS
ASTERACEAE	<i>Inulanthera tridens</i>	PRECIS
ASTERACEAE	<i>Lactuca inermis</i>	Acocks
ASTERACEAE	<i>Lactuca tysonii</i>	PRECIS
ASTERACEAE	<i>Laggera crispata</i>	Acocks
ASTERACEAE	<i>Launaea nana</i>	PRECIS
ASTERACEAE	<i>Leucanthemum vulgare</i>	PRECIS
ASTERACEAE	<i>Macowania corymbosa</i> *	Anel Geer
ASTERACEAE	<i>Matricaria sp.</i>	PRECIS
ASTERACEAE	<i>Mikania capensis</i>	PRECIS
ASTERACEAE	<i>Mikania cordata</i>	PRECIS
ASTERACEAE	<i>Nidorella anomala</i>	PRECIS
ASTERACEAE	<i>Nidorella auriculata</i>	PRECIS (KZN)
ASTERACEAE	<i>Nidorella hottentotica</i>	PRECIS
ASTERACEAE	<i>Nidorella resedifolia</i> subsp. <i>resedifolia</i>	PRECIS
ASTERACEAE	<i>Oligocarpus calendulaceus</i>	PRECIS
ASTERACEAE	<i>Othonna natalensis</i>	PRECIS
ASTERACEAE	<i>Phymaspermum acerosum</i>	Acocks
ASTERACEAE	<i>Plecostachys serpyllifolia</i>	Acocks
ASTERACEAE	<i>Printzia auriculata</i>	PRECIS (KZN)
ASTERACEAE	<i>Printzia pyrifolia</i>	Acocks
ASTERACEAE	<i>Pseudognaphalium luteo-album</i>	PRECIS
ASTERACEAE	<i>Pseudognaphalium oligandrum</i>	PRECIS
ASTERACEAE	<i>Pulicaria scabra</i>	Acocks
ASTERACEAE	<i>Senecio oxyriifolius</i> *	Anel Geer
ASTERACEAE	<i>Schistostephium crataegifolium</i> *	PRECIS
ASTERACEAE	<i>Schkuhria pinnata</i>	Acocks
ASTERACEAE	<i>Senecio affinis</i>	PRECIS
ASTERACEAE	<i>Senecio albanensis</i> var. <i>albanensis</i>	PRECIS
ASTERACEAE	<i>Senecio albanensis</i> var. <i>doroniciflorus</i>	PRECIS
ASTERACEAE	<i>Senecio barbatus</i>	PRECIS
ASTERACEAE	<i>Senecio breviscapus</i>	PRECIS
ASTERACEAE	<i>Senecio bupleuroides</i>	Acocks
ASTERACEAE	<i>Senecio burchellii</i>	Acocks
ASTERACEAE	<i>Senecio cathcartensis</i>	PRECIS
ASTERACEAE	<i>Senecio caudatus</i>	Acocks
ASTERACEAE	<i>Senecio coronatus</i>	PRECIS
ASTERACEAE	<i>Senecio decurrens</i>	PRECIS
ASTERACEAE	<i>Senecio deltoideus</i>	Acocks

Family	Scientific Name	CollectionCode
ASTERACEAE	<i>Senecio discodregeanus</i>	PRECIS
ASTERACEAE	<i>Senecio dregeanus</i>	PRECIS (KZN)
ASTERACEAE	<i>Senecio erubescens</i> var. <i>erubescens</i>	PRECIS
ASTERACEAE	<i>Senecio glaberrimus</i>	PRECIS
ASTERACEAE	<i>Senecio harveianus</i> *	PRECIS
ASTERACEAE	<i>Senecio heliopsis</i>	PRECIS
ASTERACEAE	<i>Senecio helminthioides</i>	PRECIS
ASTERACEAE	<i>Senecio inaequidens</i>	PRECIS
ASTERACEAE	<i>Senecio inornatus</i>	Acocks
ASTERACEAE	<i>Senecio isatideus</i>	PRECIS
ASTERACEAE	<i>Senecio isatidiodes</i> *	Anel Geer
ASTERACEAE	<i>Senecio lydenburgensis</i>	PRECIS
ASTERACEAE	<i>Senecio macrocephalus</i>	PRECIS (KZN)
ASTERACEAE	<i>Senecio macroglossoides</i>	PRECIS
ASTERACEAE	<i>Senecio madagascariensis</i>	PRECIS
ASTERACEAE	<i>Senecio oxyriifolius</i> subsp. <i>oxyriifolius</i>	PRECIS
ASTERACEAE	<i>Senecio paludaffinis</i>	PRECIS
ASTERACEAE	<i>Senecio panduriformis</i>	Acocks
ASTERACEAE	<i>Senecio paucicalyculatus</i>	PRECIS
ASTERACEAE	<i>Senecio polyodon</i> var. <i>polyodon</i>	PRECIS
ASTERACEAE	<i>Senecio polyodon</i> var. <i>subglaber</i>	PRECIS
ASTERACEAE	<i>Senecio pterophorus</i>	Acocks
ASTERACEAE	<i>Senecio quinquelobus</i>	PRECIS
ASTERACEAE	<i>Senecio retrorsus</i>	PRECIS
ASTERACEAE	<i>Senecio serratuloides</i>	PRECIS
ASTERACEAE	<i>Senecio</i> sp.	PRECIS
ASTERACEAE	<i>Senecio speciosus</i>	PRECIS
ASTERACEAE	<i>Senecio spp</i> *	Anel Geer
ASTERACEAE	<i>Senecio striatifolius</i>	PRECIS
ASTERACEAE	<i>Senecio subcoriaceus</i>	PRECIS
ASTERACEAE	<i>Senecio submontanus</i>	PRECIS
ASTERACEAE	<i>Senecio tamoides</i>	Acocks
ASTERACEAE	<i>Seriphium plumosum</i>	Acocks
ASTERACEAE	<i>Sonchus dregeanus</i>	Acocks
ASTERACEAE	<i>Sonchus jacottetianus</i>	PRECIS
ASTERACEAE	<i>Sonchus nanus</i>	PRECIS
ASTERACEAE	<i>Sonchus wilmsii</i>	PRECIS
ASTERACEAE	<i>Spilanthes mauritiana</i>	PRECIS
ASTERACEAE	<i>Tagetes minuta</i>	Acocks
ASTERACEAE	<i>Taraxacum officinale</i>	Acocks
ASTERACEAE	<i>Tenrynea phyllicifolia</i>	Acocks
ASTERACEAE	<i>Tolpis capensis</i>	PRECIS
ASTERACEAE	<i>Tragopogon</i> sp.	PRECIS
ASTERACEAE	<i>Ursinia</i> sp.	PRECIS
ASTERACEAE	<i>Ursinia tenuiloba</i>	PRECIS
ASTERACEAE	<i>Ursinia tenuiloba</i>	PRECIS
ASTERACEAE	<i>Vernonia dregeana</i>	Acocks
ASTERACEAE	<i>Vernonia fastigiata</i>	PRECIS
ASTERACEAE	<i>Vernonia gerrardii</i>	PRECIS
ASTERACEAE	<i>Vernonia hirsuta</i> *	Anel Geer
ASTERACEAE	<i>Vernonia mespilifolia</i>	Acocks
ASTERACEAE	<i>Vernonia natalensis</i>	Acocks
ASTERACEAE	<i>Vernonia oligocephala</i> *	Anel Geer
ASTERACEAE	<i>Vernonia</i> sp.	PRECIS
ASTERACEAE	<i>Vernonia thodei</i> *	PRECIS
ASTERACEAE	<i>Xanthium strumarium</i>	PRECIS
AYTONIACEAE	<i>Asterella bachmannii</i>	PRECIS
AYTONIACEAE	<i>Asterella marginata</i>	PRECIS
AYTONIACEAE	<i>Plagiochasma rupestre</i> var. <i>rupestre</i>	PRECIS
AYTONIACEAE	<i>Plagiochasma rupestre</i> var. <i>volkii</i>	PRECIS
BAEOMYCETACEAE	<i>Baeomyces roseus</i>	PRECIS

Family	Scientific Name	CollectionCode
BALSAMINACEAE	<i>Impatiens hochstetteri</i> subsp. <i>hochstetteri</i>	Acocks
BARTRAMIACEAE	<i>Bartramia capensis</i>	PRECIS
BARTRAMIACEAE	<i>Breutelia diffracta</i>	PRECIS
BARTRAMIACEAE	<i>Philonotis dregeana</i>	PRECIS
BARTRAMIACEAE	<i>Philonotis falcata</i>	PRECIS
BARTRAMIACEAE	<i>Philonotis globosa</i>	PRECIS
BARTRAMIACEAE	<i>Philonotis hastata</i>	PRECIS
BEGONIACEAE	<i>Begonia geranioides</i>	PRECIS
BEGONIACEAE	<i>Begonia sutherlandii</i>	PRECIS
BEGONIACEAE	<i>Begonia sutherlandii</i> subsp. <i>sutherlandii</i>	PRECIS
BEHNIACEAE	<i>Behnia reticulata</i>	PRECIS (KZN)
BLECHNACEAE	<i>Blechnum attenuatum</i>	PRECIS (KZN)
BLECHNACEAE	<i>Blechnum australe</i> subsp. <i>australe</i>	PRECIS
BLECHNACEAE	<i>Blechnum inflexum</i>	PRECIS
BLECHNACEAE	<i>Blechnum punctulatum</i> var. <i>atherstonei</i>	PRECIS (KZN)
BORAGINACEAE	<i>Cynoglossum hispidum</i>	PRECIS
BORAGINACEAE	<i>Cynoglossum lanceolatum</i>	PRECIS
BORAGINACEAE	<i>Echium plantagineum</i>	PRECIS
BORAGINACEAE	<i>Ehretia rigida</i> subsp. <i>rigida</i>	PRECIS
BORAGINACEAE	<i>Lithospermum papillosum</i>	PRECIS (KZN)
BORAGINACEAE	<i>Myosotis afropalustris</i>	PRECIS
BORAGINACEAE	<i>Myosotis sylvatica</i>	PRECIS
BRACHYTHECIACEAE	<i>Brachythecium implicatum</i>	PRECIS
BRACHYTHECIACEAE	<i>Brachythecium subrutabulum</i>	PRECIS
BRACHYTHECIACEAE	<i>Palamocladium leskeoides</i>	PRECIS
BRACHYTHECIACEAE	<i>Rhynchostegiella zeyheri</i>	PRECIS
BRACHYTHECIACEAE	<i>Rhynchostegium raphidorrhynchum</i>	PRECIS
BRASSICACEAE	<i>Cardamine flexuosa</i>	PRECIS
BRASSICACEAE	<i>Cardamine trichocarpa</i> subsp. <i>trichocarpa</i>	PRECIS
BRASSICACEAE	<i>Heliophila rigidiuscula</i>	PRECIS
BRASSICACEAE	<i>Nasturtium officinale</i>	PRECIS
BRASSICACEAE	<i>Raphanus raphanistrum</i>	PRECIS
BRUCHIACEAE	<i>Trematodon intermedius</i>	PRECIS
BRUCHIACEAE	<i>Trematodon longicollis</i>	PRECIS
BRYACEAE	<i>Anomobryum julaceum</i>	PRECIS
BRYACEAE	<i>Brachymenium acuminatum</i>	PRECIS
BRYACEAE	<i>Brachymenium leptophyllum</i>	PRECIS
BRYACEAE	<i>Brachymenium pulchrum</i>	PRECIS
BRYACEAE	<i>Brachymenium</i> sp.	PRECIS
BRYACEAE	<i>Bryum alpinum</i>	PRECIS
BRYACEAE	<i>Bryum andicola</i>	PRECIS
BRYACEAE	<i>Bryum argenteum</i>	PRECIS
BRYACEAE	<i>Bryum aubertii</i>	PRECIS
BRYACEAE	<i>Bryum</i> sp.	PRECIS
BRYACEAE	<i>Bryum subapiculatum</i>	PRECIS
BRYACEAE	<i>Rhodobryum umbraculum</i>	PRECIS
BUDDLEJACEAE	<i>Buddleja auriculata</i>	PRECIS
BUDDLEJACEAE	<i>Buddleja dysophylla</i>	Acocks
BUDDLEJACEAE	<i>Buddleja dysophylla</i>	Acocks
BUDDLEJACEAE	<i>Buddleja dysophylla</i>	Gardens (KBG)
BUDDLEJACEAE	<i>Buddleja dysophylla</i>	PRECIS
BUDDLEJACEAE	<i>Buddleja loricata</i>	PRECIS
BUDDLEJACEAE	<i>Buddleja pulchella</i>	Acocks
BUDDLEJACEAE	<i>Buddleja salviifolia</i>	Acocks
BUDDLEJACEAE	<i>Gomphostigma virgatum</i>	PRECIS
BUDDLEJACEAE	<i>Nuxia floribunda</i>	PRECIS
CALYMPERACEAE	<i>Syrrophodon gaudichaudii</i>	PRECIS
CALYPOGEIACEAE	<i>Calypogeia fusca</i>	PRECIS
CAMPANULACEAE	<i>Craterocapsa tarsodes</i>	PRECIS
CAMPANULACEAE	<i>Wahlenbergia krebsii</i> subsp. <i>Krebsii</i> *	PRECIS
CAMPANULACEAE	<i>Wahlenbergia pallidiflora</i>	PRECIS

Family	Scientific Name	CollectionCode
CAMPANULACEAE	<i>Wahlenbergia paucidentata</i>	PRECIS
CAMPANULACEAE	<i>Wahlenbergia sp.</i>	PRECIS
CAMPANULACEAE	<i>Wahlenbergia undulata</i>	PRECIS
CAPPARACEAE	<i>Cadaba natalensis</i>	PRECIS (KZN)
CAPPARACEAE	<i>Capparis fascicularis var. fascicularis</i>	Acocks
CARYOPHYLLACEAE	<i>Cerastium arabis</i>	PRECIS
CARYOPHYLLACEAE	<i>Cerastium capense</i>	PRECIS
CARYOPHYLLACEAE	<i>Dianthus crenatus</i>	PRECIS (KZN)
CARYOPHYLLACEAE	<i>Dianthus zeyheri subsp. natalensis</i>	PRECIS
CARYOPHYLLACEAE	<i>Drymaria cordata subsp. diandra</i>	Acocks
CARYOPHYLLACEAE	<i>Scleranthus annuus</i>	PRECIS
CARYOPHYLLACEAE	<i>Silene bellidioides</i>	PRECIS (KZN)
CARYOPHYLLACEAE	<i>Silene burchellii var. angustifolia</i>	PRECIS
CARYOPHYLLACEAE	<i>Silene undulata</i>	PRECIS
CARYOPHYLLACEAE	<i>Stellaria pallida</i>	PRECIS
CELASTRACEAE	<i>Elaeodendron croceum</i>	Acocks
CELASTRACEAE	<i>Gymnosporia buxifolia</i>	PRECIS
CELASTRACEAE	<i>Gymnosporia glaucophylla</i>	PRECIS
CELASTRACEAE	<i>Gymnosporia grandifolia</i>	PRECIS
CELASTRACEAE	<i>Gymnosporia harveyana</i>	PRECIS (KZN)
CELASTRACEAE	<i>Gymnosporia harveyana subsp. harveyana</i>	Acocks
CELASTRACEAE	<i>Gymnosporia mossambicensis</i>	Gardens (KBG)
CELASTRACEAE	<i>Gymnosporia rubra</i>	Acocks
CELASTRACEAE	<i>Gymnosporia sp.</i>	PRECIS (KZN)
CELASTRACEAE	<i>Lauridia tetragona</i>	Acocks
CELASTRACEAE	<i>Maytenus acuminata var. acuminata</i>	PRECIS
CELASTRACEAE	<i>Maytenus heterophylla subsp. heterophylla</i>	Acocks
CELASTRACEAE	<i>Maytenus peduncularis</i>	PRECIS
CELASTRACEAE	<i>Maytenus sp.</i>	Gardens (KBG)
CELASTRACEAE	<i>Maytenus undata</i>	PRECIS
CELASTRACEAE	<i>Mystroxydon aethiopicum subsp. aethiopicum</i>	Acocks
CELASTRACEAE	<i>Pristimera bojeri var. leioclada</i>	PRECIS
CELTIDACEAE	<i>Celtis africana</i>	Acocks
CELTIDACEAE	<i>Trema orientalis</i>	Acocks
CEPHALOZIACEAE	<i>Alobiella sp.</i>	PRECIS
CEPHALOZIACEAE	<i>Cylindrocolea atroviridis</i>	PRECIS
CERATOPHYLLACEAE	<i>Ceratophyllum demersum var. demersum</i>	PRECIS
COLCHICACEAE	<i>Colchicum longipes</i>	PRECIS
COLCHICACEAE	<i>Gloriosa modesta</i>	PRECIS
COLCHICACEAE	<i>Gloriosa superba</i>	PRECIS
COLCHICACEAE	<i>Littonia modesta</i>	PRECIS
COLCHICACEAE	<i>Sandersonia aurantiaca</i>	Gardens (KBG)
COLCHICACEAE	<i>Wurmbea kraussii</i>	PRECIS (KZN)
COMBRETACEAE	<i>Combretum apiculatum subsp. apiculatum</i>	PRECIS
COMBRETACEAE	<i>Combretum edwardsii</i>	PRECIS
COMBRETACEAE	<i>Combretum erythrophyllum</i>	PRECIS
COMBRETACEAE	<i>Combretum kraussii</i>	Acocks
COMMELINACEAE	<i>Commelina africana var. africana*</i>	Acocks
COMMELINACEAE	<i>Commelina africana var. krebsiana</i>	PRECIS
COMMELINACEAE	<i>Commelina africana var. lancispatha</i>	PRECIS
COMMELINACEAE	<i>Commelina benghalensis</i>	Acocks
COMMELINACEAE	<i>Commelina diffusa subsp. diffusa</i>	PRECIS
COMMELINACEAE	<i>Cyanotis speciosa*</i>	PRECIS
CONVOLVULACEAE	<i>Convolvulus farinosus</i>	PRECIS
CONVOLVULACEAE	<i>Convolvulus natalensis</i>	PRECIS
CONVOLVULACEAE	<i>Convolvulus sagittatus</i>	PRECIS
CONVOLVULACEAE	<i>Cuscuta campestris</i>	PRECIS
CONVOLVULACEAE	<i>Ipomoea crassipes var. crassipes</i>	Acocks
CONVOLVULACEAE	<i>Ipomoea indica</i>	Acocks
CONVOLVULACEAE	<i>Ipomoea pellita</i>	PRECIS
CONVOLVULACEAE	<i>Ipomoea purpurea</i>	PRECIS

Family	Scientific Name	CollectionCode
CRASSULACEAE	<i>Cotyledon orbiculata</i> var. <i>oblonga</i>	PRECIS
CRASSULACEAE	<i>Crassula alba</i> var. <i>alba</i>	PRECIS
CRASSULACEAE	<i>Crassula brachypetala</i> *	Anel Geer
CRASSULACEAE	<i>Crassula expansa</i> subsp. <i>fragilis</i>	PRECIS
CRASSULACEAE	<i>Crassula lanceolata</i> subsp. <i>transvaalensis</i>	PRECIS (KZN)
CRASSULACEAE	<i>Crassula lanceolata</i> *	Anel Geer
CRASSULACEAE	<i>Crassula natalensis</i> *	Anel Geer
CRASSULACEAE	<i>Crassula obovata</i> var. <i>obovata</i>	PRECIS
CRASSULACEAE	<i>Crassula pellucida</i> subsp. <i>brachypetala</i>	PRECIS
CRASSULACEAE	<i>Crassula perfoliata</i> var. <i>heterotricha</i>	PRECIS (KZN)
CRASSULACEAE	<i>Crassula sarcocaulis</i> subsp. <i>rupicola</i>	PRECIS (KZN)
CRASSULACEAE	<i>Crassula sarmentosa</i> var. <i>sarmentosa</i>	PRECIS
CRASSULACEAE	<i>Crassula setulosa</i> Harv. var. <i>rubra</i>	PRECIS
CRASSULACEAE	<i>Crassula setulosa</i> var. <i>setulosa</i> forma <i>setulosa</i>	PRECIS
CRASSULACEAE	<i>Crassula spathulata</i>	Acocks
CRASSULACEAE	<i>Crassula vaginata</i> subsp. <i>vaginata</i> *	PRECIS
CRASSULACEAE	<i>Kalanchoe crenata</i> subsp. <i>bieensis</i>	PRECIS (KZN)
CRASSULACEAE	<i>Kalanchoe rotundifolia</i>	PRECIS
CRASSULACEAE	<i>Kalanchoe thyrsiflora</i>	PRECIS
CUCURBITACEAE	<i>Coccinia hirtella</i>	PRECIS
CUCURBITACEAE	<i>Coccinia rehmannii</i>	PRECIS
CUCURBITACEAE	<i>Cucumis hirsutus</i>	PRECIS
CUCURBITACEAE	<i>Cucumis zeyheri</i>	PRECIS
CUCURBITACEAE	<i>Gerrardanthus macrorhizus</i>	Gardens (KBG)
CUCURBITACEAE	<i>Kedrostis foetidissima</i>	PRECIS
CUCURBITACEAE	<i>Momordica foetida</i>	PRECIS
CUCURBITACEAE	<i>Zehneria scabra</i> subsp. <i>scabra</i>	PRECIS
CUNONIACEAE	<i>Cunonia capensis</i>	Acocks
CYATHEACEAE	<i>Cyathea capensis</i> var. <i>capensis</i>	PRECIS
CYATHEACEAE	<i>Cyathea dregei</i> *	PRECIS
CYPERACEAE	<i>Abildgaardia ovata</i>	PRECIS
CYPERACEAE	<i>Ascolepis capensis</i> *	PRECIS
CYPERACEAE	<i>Bolboschoenus maritimus</i>	Acocks
CYPERACEAE	<i>Bulbostylis humilis</i>	PRECIS
CYPERACEAE	<i>Bulbostylis oritrephes</i>	PRECIS
CYPERACEAE	<i>Bulbostylis oritrephes</i>	PRECIS
CYPERACEAE	<i>Bulbostylis schoenoides</i>	PRECIS
CYPERACEAE	<i>Bulbostylis scleropus</i>	PRECIS
CYPERACEAE	<i>Carex austro-africana</i>	PRECIS
CYPERACEAE	<i>Carex cognata</i> *	Anel Geer
CYPERACEAE	<i>Carex mossii</i>	PRECIS
CYPERACEAE	<i>Carex spicato-paniculata</i>	Acocks
CYPERACEAE	<i>Carex zuluensis</i>	PRECIS
CYPERACEAE	<i>Costularia natalensis</i>	PRECIS
CYPERACEAE	<i>Cyperus albostratus</i>	Acocks
CYPERACEAE	<i>Cyperus albostratus</i>	Acocks
CYPERACEAE	<i>Cyperus bellus</i>	Acocks
CYPERACEAE	<i>Cyperus capensis</i>	PRECIS
CYPERACEAE	<i>Cyperus congestus</i>	Acocks
CYPERACEAE	<i>Cyperus cyperoides</i> subsp. <i>cyperoides</i>	Acocks
CYPERACEAE	<i>Cyperus denudatus</i> var. <i>denudatus</i>	PRECIS
CYPERACEAE	<i>Cyperus esculentus</i> var. <i>esculentus</i>	Acocks
CYPERACEAE	<i>Cyperus fastigiatus</i>	PRECIS
CYPERACEAE	<i>Cyperus indecorus</i> var. <i>indecorus</i>	PRECIS
CYPERACEAE	<i>Cyperus keniensis</i>	PRECIS
CYPERACEAE	<i>Cyperus latifolius</i>	PRECIS (KZN)
CYPERACEAE	<i>Cyperus longus</i> var. <i>longus</i>	Acocks
CYPERACEAE	<i>Cyperus obtusiflorus</i> var. <i>flavissimus</i>	PRECIS
CYPERACEAE	<i>Cyperus obtusiflorus</i> var. <i>obtusiflorus</i>	PRECIS
CYPERACEAE	<i>Cyperus owanii</i>	PRECIS
CYPERACEAE	<i>Cyperus rupestris</i> var. <i>rupestris</i>	PRECIS

Family	Scientific Name	CollectionCode
CYPERACEAE	<i>Cyperus sp.</i>	PRECIS
CYPERACEAE	<i>Cyperus sphaerospermus*</i>	PRECIS
CYPERACEAE	<i>Cyperus textilis</i>	PRECIS
CYPERACEAE	<i>Eleocharis dregeana</i>	PRECIS
CYPERACEAE	<i>Ficinia cinnamomea</i>	PRECIS
CYPERACEAE	<i>Ficinia gracilis</i>	PRECIS
CYPERACEAE	<i>Ficinia stolonifera</i>	PRECIS
CYPERACEAE	<i>Fimbristylis complanata</i>	Acocks
CYPERACEAE	<i>Fimbristylis dichotoma</i>	PRECIS
CYPERACEAE	<i>Fuirena pubescens var. pubescens</i>	PRECIS
CYPERACEAE	<i>Isolepis costata</i>	PRECIS
CYPERACEAE	<i>Isolepis costata var. macra</i>	PRECIS (KZN)
CYPERACEAE	<i>Isolepis fluitans var. fluitans</i>	PRECIS
CYPERACEAE	<i>Isolepis natans</i>	PRECIS
CYPERACEAE	<i>Isolepis sepulcralis</i>	PRECIS
CYPERACEAE	<i>Kyllinga alata</i>	Acocks
CYPERACEAE	<i>Kyllinga erecta var. erecta</i>	PRECIS
CYPERACEAE	<i>Kyllinga melanosperma</i>	Acocks
CYPERACEAE	<i>Kyllinga odorata</i>	PRECIS
CYPERACEAE	<i>Kyllinga pauciflora</i>	PRECIS
CYPERACEAE	<i>Kyllinga pulchella</i>	PRECIS
CYPERACEAE	<i>Mariscus sumatrensis</i>	PRECIS (KZN)
CYPERACEAE	<i>Mariscus uitenhagensis</i>	PRECIS
CYPERACEAE	<i>Pycnus cooperi</i>	PRECIS
CYPERACEAE	<i>Pycnus intactus</i>	PRECIS
CYPERACEAE	<i>Pycnus macranthus</i>	PRECIS
CYPERACEAE	<i>Pycnus niger subsp. elegantulus</i>	PRECIS
CYPERACEAE	<i>Pycnus nitidus</i>	PRECIS
CYPERACEAE	<i>Pycnus polystachyos var. laxiflorus</i>	Acocks
CYPERACEAE	<i>Pycnus rehmannianus</i>	PRECIS
CYPERACEAE	<i>Schoenoplectus corymbosus*</i>	Anel Geer
CYPERACEAE	<i>Schoenoplectus paludicola</i>	PRECIS
CYPERACEAE	<i>Schoenoxiphium lehmannii</i>	PRECIS
CYPERACEAE	<i>Schoenoxiphium sp.</i>	PRECIS
CYPERACEAE	<i>Schoenoxiphium sparteum</i>	PRECIS (KZN)
CYPERACEAE	<i>Scleria bulbifera</i>	PRECIS
CYPERACEAE	<i>Scleria dregeana</i>	PRECIS
CYPERACEAE	<i>Scleria welwitschii</i>	PRECIS
CYPERACEAE	<i>Scleria woodii</i>	PRECIS
DENNSTAEDTIACEAE	<i>Pteridium aquilinum subsp. Aquilinum*</i>	PRECIS
DENNSTAEDTIACEAE	<i>Pteridium aquilinum subsp. centrali-africanum</i>	Acocks
DICRANACEAE	<i>Campylopus bicolor subsp. atroluteus</i>	PRECIS
DICRANACEAE	<i>Campylopus hensii</i>	PRECIS
DICRANACEAE	<i>Campylopus pyriformis</i>	PRECIS
DICRANACEAE	<i>Campylopus robillardii</i>	PRECIS
DICRANACEAE	<i>Campylopus stenopelma</i>	PRECIS
DICRANACEAE	<i>Leucoloma rehmannii</i>	PRECIS
DIOSCOREACEAE	<i>Dioscorea diversifolia</i>	PRECIS
DIOSCOREACEAE	<i>Dioscorea rupicola</i>	PRECIS
DIOSCOREACEAE	<i>Dioscorea sp.</i>	Gardens (KBG)
DIPSACACEAE	<i>Cephalaria humilis</i>	PRECIS (KZN)
DIPSACACEAE	<i>Cephalaria natalensis</i>	PRECIS
DIPSACACEAE	<i>Scabiosa columbaria*</i>	PRECIS
DIPSACACEAE	<i>Scabiosa tysonii</i>	PRECIS
DITRICHACEAE	<i>Ditrichum brachypodum</i>	PRECIS
DRACAENACEAE	<i>Dracaena aletiformis</i>	Acocks
DROSERACEAE	<i>Drosera natalensis*</i>	PRECIS
DRYOPTERIDACEAE	<i>Arachniodes foliosa</i>	PRECIS
DRYOPTERIDACEAE	<i>Arachniodes webbiana subsp. foliosa</i>	Gardens (KBG)
DRYOPTERIDACEAE	<i>Cyrtomium caryotideum var. caryotideum</i>	PRECIS (KZN)
DRYOPTERIDACEAE	<i>Cyrtomium caryotideum var. micropterum</i>	PRECIS

Family	Scientific Name	CollectionCode
DRYOPTERIDACEAE	<i>Cyrtomium micropterum</i>	Gardens (KBG)
DRYOPTERIDACEAE	<i>Didymochlaena truncatula</i>	PRECIS
DRYOPTERIDACEAE	<i>Dryopteris athamantica</i>	PRECIS
DRYOPTERIDACEAE	<i>Dryopteris inaequalis</i>	PRECIS
DRYOPTERIDACEAE	<i>Dryopteris pentheri</i>	PRECIS
DRYOPTERIDACEAE	<i>Nothoperanema squamiseta</i>	PRECIS
DRYOPTERIDACEAE	<i>Polystichum incongruum</i>	Gardens (KBG)
DRYOPTERIDACEAE	<i>Polystichum luctuosum</i>	Acocks
DRYOPTERIDACEAE	<i>Polystichum pungens</i>	PRECIS
DRYOPTERIDACEAE	<i>Polystichum sp.</i>	Gardens (KBG)
DRYOPTERIDACEAE	<i>Polystichum transkeiense</i>	PRECIS
DRYOPTERIDACEAE	<i>Polystichum transvaalense</i>	PRECIS
EBENACEAE	<i>Diospyros lycioides subsp. sericea</i>	PRECIS
EBENACEAE	<i>Diospyros pallens</i>	Acocks
EBENACEAE	<i>Diospyros scabrida var. cordata</i>	Acocks
EBENACEAE	<i>Diospyros whyteana</i>	PRECIS
EBENACEAE	<i>Euclea crispa subsp. crispa</i>	Acocks
EBENACEAE	<i>Euclea natalensis subsp. angustifolia</i>	Acocks
ELAPHOGLOSSACEAE	<i>Elaphoglossum acrostichoides</i>	PRECIS
ELAPHOGLOSSACEAE	<i>Elaphoglossum aubertii</i>	PRECIS
ELAPHOGLOSSACEAE	<i>Elaphoglossum hybridum</i>	PRECIS
ELATINACEAE	<i>Elatine ambigua</i>	PRECIS
ENTODONTACEAE	<i>Entodon macropodus</i>	PRECIS
ERICACEAE	<i>Erica alopecurus var. alopecurus</i>	PRECIS
ERICACEAE	<i>Erica binaria</i>	Acocks
ERICACEAE	<i>Erica caffrorum var. caffrorum</i>	PRECIS
ERICACEAE	<i>Erica cooperi var. cooperi</i>	PRECIS
ERICACEAE	<i>Erica trichoclada</i>	PRECIS
ERICACEAE	<i>Erica woodii var. woodii*</i>	PRECIS
ERIOCAULACEAE	<i>Eriocaulon dregei*</i>	PRECIS
ERIOCAULACEAE	<i>Eriocaulon sonderianum</i>	Acocks
ERIOSPERMACEAE	<i>Eriospermum cooperi var. natalense</i>	PRECIS
ERIOSPERMACEAE	<i>Eriospermum mackenii subsp. mackenii</i>	PRECIS
ERYTHROXYLACEAE	<i>Erythroxylum pictum</i>	PRECIS
ESCALLONACEAE	<i>Choristylis rhamnoides</i>	Acocks
EUPHORBIACEAE	<i>Acalypha angustata</i>	PRECIS
EUPHORBIACEAE	<i>Acalypha caperonioides var. caperonioides</i>	PRECIS
EUPHORBIACEAE	<i>Acalypha depressinerva</i>	PRECIS
EUPHORBIACEAE	<i>Acalypha ecklonii</i>	PRECIS
EUPHORBIACEAE	<i>Acalypha glabrata var. glabrata</i>	PRECIS
EUPHORBIACEAE	<i>Acalypha peduncularis</i>	PRECIS
EUPHORBIACEAE	<i>Acalypha punctata var. punctata</i>	PRECIS
EUPHORBIACEAE	<i>Acalypha sp.</i>	PRECIS
EUPHORBIACEAE	<i>Acalypha wilmsii</i>	PRECIS
EUPHORBIACEAE	<i>Adenocline pauciflora</i>	PRECIS (KZN)
EUPHORBIACEAE	<i>Clutia cordata</i>	PRECIS
EUPHORBIACEAE	<i>Clutia monticola var. monticola</i>	Acocks
EUPHORBIACEAE	<i>Clutia natalensis</i>	Acocks
EUPHORBIACEAE	<i>Clutia pulchella var. pulchella</i>	Acocks
EUPHORBIACEAE	<i>Clutia sp.</i>	PRECIS
EUPHORBIACEAE	<i>Dalechampia capensis</i>	PRECIS (KZN)
EUPHORBIACEAE	<i>Euphorbia cooperi var. cooperi</i>	Gardens (KBG)
EUPHORBIACEAE	<i>Euphorbia epicyparissias</i>	PRECIS (KZN)
EUPHORBIACEAE	<i>Euphorbia gueinzii var. albovillosa</i>	PRECIS
EUPHORBIACEAE	<i>Euphorbia helioscopia</i>	PRECIS
EUPHORBIACEAE	<i>Euphorbia inaequilatera var. inaequilatera</i>	Acocks
EUPHORBIACEAE	<i>Euphorbia kraussiana var. erubescens</i>	Acocks
EUPHORBIACEAE	<i>Euphorbia kraussiana var. kraussiana</i>	PRECIS
EUPHORBIACEAE	<i>Euphorbia natalensis</i>	PRECIS
EUPHORBIACEAE	<i>Euphorbia striata var. striata</i>	PRECIS
EUPHORBIACEAE	<i>Euphorbia woodii</i>	PRECIS

Family	Scientific Name	CollectionCode
EUPHORBIACEAE	<i>Excoecaria simii</i>	PRECIS
EUPHORBIACEAE	<i>Jatropha hirsuta</i> var. <i>hirsuta</i>	PRECIS
EUPHORBIACEAE	<i>Leidesia procumbens</i>	Acocks
EUPHORBIACEAE	<i>Micrococca capensis</i>	PRECIS
EUPHORBIACEAE	<i>Phyllanthus maderaspatensis</i>	PRECIS (KZN)
EUPHORBIACEAE	<i>Sclerocroton integerrimus</i>	PRECIS
EUPHORBIACEAE	<i>Suregada procera</i>	PRECIS
FABACEAE	<i>Abrus laevigatus</i>	PRECIS
FABACEAE	<i>Acacia ataxacantha</i>	PRECIS (KZN)
FABACEAE	<i>Acacia dealbata</i>	PRECIS
FABACEAE	<i>Acacia farnesiana</i>	PRECIS
FABACEAE	<i>Acacia gerrardii</i> subsp. <i>gerrardii</i> var. <i>gerrardii</i>	PRECIS (KZN)
FABACEAE	<i>Acacia luederitzii</i> var. <i>retinens</i>	PRECIS (KZN)
FABACEAE	<i>Acacia melanoxylon</i>	PRECIS (KZN)
FABACEAE	<i>Acacia nilotica</i> subsp. <i>kraussiana</i>	PRECIS
FABACEAE	<i>Acacia robusta</i> subsp. <i>clavigera</i>	PRECIS (KZN)
FABACEAE	<i>Acacia sieberiana</i> var. <i>woodii</i>	PRECIS (KZN)
FABACEAE	<i>Acacia</i> sp.*	PRECIS
FABACEAE	<i>Adenopodia spicata</i>	PRECIS (KZN)
FABACEAE	<i>Aeschynomene micrantha</i>	Acocks
FABACEAE	<i>Alysicarpus rugosus</i> subsp. <i>perennirufus</i>	Acocks
FABACEAE	<i>Argyrolobium amplexicaule</i>	PRECIS
FABACEAE	<i>Argyrolobium harveyanum</i>	PRECIS
FABACEAE	<i>Argyrolobium humile</i>	PRECIS
FABACEAE	<i>Argyrolobium molle</i>	PRECIS
FABACEAE	<i>Argyrolobium sericosemium</i>	PRECIS (KZN)
FABACEAE	<i>Argyrolobium</i> sp.	PRECIS
FABACEAE	<i>Argyrolobium speciosum</i>	PRECIS (KZN)
FABACEAE	<i>Argyrolobium stipulaceum</i>	PRECIS
FABACEAE	<i>Argyrolobium sutherlandii</i>	PRECIS (KZN)
FABACEAE	<i>Argyrolobium tomentosum</i>	Acocks
FABACEAE	<i>Argyrolobium tuberosum</i>	PRECIS
FABACEAE	<i>Baphia racemosa</i>	PRECIS
FABACEAE	<i>Calpurnia aurea</i> subsp. <i>aurea</i>	Acocks
FABACEAE	<i>Calpurnia intrusa</i>	PRECIS (KZN)
FABACEAE	<i>Calpurnia villosa</i> var. <i>intrusa</i>	PRECIS
FABACEAE	<i>Canavalia virosa</i>	PRECIS (KZN)
FABACEAE	<i>Chamaecrista capensis</i> var. <i>flavescens</i>	PRECIS
FABACEAE	<i>Chamaecrista mimosoides</i>	Acocks
FABACEAE	<i>Chamaecrista stricta</i>	PRECIS
FABACEAE	<i>Crotalaria capensis</i>	Acocks
FABACEAE	<i>Crotalaria dura</i> subsp. <i>dura</i>	PRECIS
FABACEAE	<i>Crotalaria globifera</i>	PRECIS
FABACEAE	<i>Crotalaria pallida</i> var. <i>pallida</i>	PRECIS
FABACEAE	<i>Crotalaria</i> sp.	PRECIS
FABACEAE	<i>Cytisus scoparius</i>	PRECIS
FABACEAE	<i>Dalbergia obovata</i>	Acocks
FABACEAE	<i>Desmodium repandum</i>	PRECIS (KZN)
FABACEAE	<i>Dichrostachys cinerea</i> subsp. <i>nyassana</i>	Acocks
FABACEAE	<i>Dolichos angustifolius</i>	PRECIS (KZN)
FABACEAE	<i>Dumasia villosa</i> var. <i>villosa</i>	PRECIS (KZN)
FABACEAE	<i>Eriosema cordatum</i>	Acocks
FABACEAE	<i>Eriosema cordatum</i> E.Mey. x <i>E. salignum</i> E.Mey.	PRECIS
FABACEAE	<i>Eriosema distinctum</i> *	PRECIS
FABACEAE	<i>Eriosema kraussianum</i>	Acocks
FABACEAE	<i>Eriosema populifolium</i> subsp. <i>capensis</i>	PRECIS
FABACEAE	<i>Eriosema psoraleoides</i>	PRECIS
FABACEAE	<i>Eriosema salignum</i>	PRECIS
FABACEAE	<i>Flemingia</i> sp.	PRECIS (KZN)
FABACEAE	<i>Hoffmannseggia sandersonii</i>	PRECIS (KZN)
FABACEAE	<i>Indigastrum fastigiatum</i>	Acocks

Family	Scientific Name	CollectionCode
FABACEAE	<i>Indigofera arrecta</i>	Acocks
FABACEAE	<i>Indigofera dimidiata</i>	PRECIS
FABACEAE	<i>Indigofera eriocarpa</i>	PRECIS
FABACEAE	<i>Indigofera foliosa*</i>	PRECIS (KZN)
FABACEAE	<i>Indigofera hedyantha</i>	PRECIS
FABACEAE	<i>Indigofera hiliaris</i> var. <i>hiliaris</i>	PRECIS
FABACEAE	<i>Indigofera natalensis</i>	PRECIS (KZN)
FABACEAE	<i>Indigofera ormocarpoides</i>	PRECIS
FABACEAE	<i>Indigofera oxytropis</i>	PRECIS
FABACEAE	<i>Indigofera rostrata</i>	PRECIS
FABACEAE	<i>Indigofera</i> sp.	PRECIS
FABACEAE	<i>Indigofera torulosa</i> var. <i>torulosa</i>	PRECIS
FABACEAE	<i>Indigofera tristis*</i>	PRECIS (KZN)
FABACEAE	<i>Indigofera tristoides</i>	PRECIS (KZN)
FABACEAE	<i>Indigofera woodii</i> var. <i>woodii</i>	PRECIS
FABACEAE	<i>Lablab purpureus</i> subsp. <i>purpureus</i>	PRECIS (KZN)
FABACEAE	<i>Lessertia perennans</i> var. <i>perennans</i>	PRECIS
FABACEAE	<i>Lotononis calycina</i>	PRECIS
FABACEAE	<i>Lotononis corymbosa</i>	PRECIS
FABACEAE	<i>Lotononis eriantha*</i>	PRECIS
FABACEAE	<i>Lotononis pulchra</i>	PRECIS
FABACEAE	<i>Lotonotis lotononoides*</i>	Anel Geer
FABACEAE	<i>Lotus discolor</i> subsp. <i>discolor</i>	PRECIS (KZN)
FABACEAE	<i>Macrotyloma axillare</i> var. <i>axillare</i>	PRECIS
FABACEAE	<i>Medicago lupulina</i>	PRECIS
FABACEAE	<i>Medicago polymorpha</i>	PRECIS (KZN)
FABACEAE	<i>Otholobium caffrum</i>	PRECIS
FABACEAE	<i>Otholobium polyphyllum</i>	PRECIS
FABACEAE	<i>Otholobium polystictum</i>	PRECIS
FABACEAE	<i>Pearsonia grandifolia</i> subsp. <i>grandifolia</i>	PRECIS
FABACEAE	<i>Pearsonia grandifolia</i> subsp. <i>latibracteolata</i>	PRECIS
FABACEAE	<i>Pseudarthria hookeri</i> var. <i>hookeri</i>	Acocks
FABACEAE	<i>Psoralea glabra</i>	PRECIS
FABACEAE	<i>Psoralea pinnata</i>	PRECIS (KZN)
FABACEAE	<i>Rhynchosia adenodes</i>	PRECIS
FABACEAE	<i>Rhynchosia caribaea</i>	PRECIS
FABACEAE	<i>Rhynchosia cooperi</i>	PRECIS
FABACEAE	<i>Rhynchosia harmsiana</i> var. <i>harmsiana</i>	PRECIS
FABACEAE	<i>Rhynchosia minima*</i>	Anel Geer
FABACEAE	<i>Rhynchosia nervosa</i> var. <i>nervosa</i>	PRECIS
FABACEAE	<i>Rhynchosia pentheri</i> var. <i>pentheri</i>	PRECIS
FABACEAE	<i>Rhynchosia reptabunda</i>	PRECIS (KZN)
FABACEAE	<i>Rhynchosia sordida</i>	PRECIS
FABACEAE	<i>Rhynchosia villosa</i>	PRECIS
FABACEAE	<i>Robinia pseudoacacia</i>	PRECIS
FABACEAE	<i>Senna septemtrionalis</i>	PRECIS
FABACEAE	<i>Smithia erubescens</i>	PRECIS
FABACEAE	<i>Tephrosia capensis</i> var. <i>acutifolia</i>	Acocks
FABACEAE	<i>Tephrosia capensis</i> var. <i>capensis</i>	PRECIS
FABACEAE	<i>Tephrosia macropoda</i> var. <i>diffusa</i>	PRECIS (KZN)
FABACEAE	<i>Tephrosia macropoda</i> var. <i>macropoda</i>	PRECIS
FABACEAE	<i>Tephrosia multijuga</i>	PRECIS
FABACEAE	<i>Tephrosia natalensis</i> subsp. <i>natalensis</i>	PRECIS
FABACEAE	<i>Tephrosia polystachya</i> var. <i>hirta</i>	PRECIS (KZN)
FABACEAE	<i>Tephrosia polystachya</i> var. <i>latifolia</i>	PRECIS (KZN)
FABACEAE	<i>Tephrosia polystachya</i> var. <i>polystachya</i>	PRECIS
FABACEAE	<i>Tephrosia purpurea</i> subsp. <i>leptostachya</i>	PRECIS (KZN)
FABACEAE	<i>Tephrosia semiglabra</i>	PRECIS
FABACEAE	<i>Tephrosia shilwanensis</i>	PRECIS (KZN)
FABACEAE	<i>Tephrosia</i> sp.*	Anel Geer
FABACEAE	<i>Teramnus labialis</i> subsp. <i>labialis</i>	Acocks

Family	Scientific Name	CollectionCode
FABACEAE	<i>Trifolium africanum</i> var. <i>africanum</i>	PRECIS
FABACEAE	<i>Trifolium burchellianum</i> subsp. <i>johnstonii</i>	PRECIS
FABACEAE	<i>Trifolium dubium</i>	PRECIS
FABACEAE	<i>Trifolium repens</i>	PRECIS (KZN)
FABACEAE	<i>Vigna marina</i>	PRECIS
FABACEAE	<i>Vigna nervosa</i>	Acocks
FABACEAE	<i>Vigna oblongifolia</i> var. <i>oblongifolia</i>	PRECIS (KZN)
FABACEAE	<i>Vigna schlechteri</i>	PRECIS
FABACEAE	<i>Vigna</i> sp.	PRECIS
FABACEAE	<i>Vigna unguiculata</i> subsp. <i>protracta</i>	PRECIS
FABACEAE	<i>Vigna vexillata</i> var. <i>vexillata</i>	PRECIS
FABACEAE	<i>Zornia capensis</i> subsp. <i>capensis</i>	PRECIS
FABRONIACEAE	<i>Fabronia pilifera</i>	PRECIS
FABRONIACEAE	<i>Levierella neckeroides</i>	PRECIS
FISSIDENTACEAE	<i>Fissidens asplenioides</i>	PRECIS
FISSIDENTACEAE	<i>Fissidens bogosicus</i>	PRECIS
FISSIDENTACEAE	<i>Fissidens bryoides</i>	PRECIS
FISSIDENTACEAE	<i>Fissidens curvatus</i> var. <i>curvatus</i>	PRECIS
FISSIDENTACEAE	<i>Fissidens enervis</i>	PRECIS
FISSIDENTACEAE	<i>Fissidens erosulus</i>	PRECIS
FISSIDENTACEAE	<i>Fissidens ovatus</i>	PRECIS
FISSIDENTACEAE	<i>Fissidens palmifolius</i>	PRECIS
FISSIDENTACEAE	<i>Fissidens submarginatus</i>	PRECIS
FLACOURTIACEAE	<i>Gerrardina foliosa</i>	PRECIS
FUMARIACEAE	<i>Fumaria muralis</i> subsp. <i>muralis</i>	PRECIS
FUNARIACEAE	<i>Funaria bergiana</i>	PRECIS
FUNARIACEAE	<i>Funaria hygrometrica</i>	PRECIS
FUNARIACEAE	<i>Funaria limbata</i>	PRECIS
FUNARIACEAE	<i>Physcomitrium spathulatum</i> var. <i>spathulatum</i>	PRECIS
GENTIANACEAE	<i>Chironia krebsii</i> *	PRECIS
GENTIANACEAE	<i>Chironia purpurascens</i> subsp. <i>humilis</i>	PRECIS
GENTIANACEAE	<i>Chironia purpurascens</i> subsp. <i>purpurascens</i>	PRECIS (KZN)
GENTIANACEAE	<i>Sabaea leiostyla</i> *	Anel Geer
GENTIANACEAE	<i>Sabaea natalensis</i> *	Anel Geer
GENTIANACEAE	<i>Sebaea filiformis</i>	PRECIS
GENTIANACEAE	<i>Sebaea junodii</i>	PRECIS
GENTIANACEAE	<i>Sebaea natalensis</i>	PRECIS
GENTIANACEAE	<i>Sebaea sedoides</i> var. <i>confertiflora</i>	PRECIS
GENTIANACEAE	<i>Sebaea sedoides</i> var. <i>schoenlandii</i>	Acocks
GENTIANACEAE	<i>Sebaea sedoides</i> var. <i>sedoides</i>	PRECIS
GENTIANACEAE	<i>Sebaea</i> sp.	PRECIS (KZN)
GEOCALYCACEAE	<i>Leptoscyphus expansus</i>	PRECIS
GEOCALYCACEAE	<i>Lophocolea cuspidata</i>	PRECIS
GEOCALYCACEAE	<i>Lophocolea difformis</i>	PRECIS
GEOCALYCACEAE	<i>Lophocolea martiana</i>	PRECIS
GEOCALYCACEAE	<i>Lophocolea</i> sp.	PRECIS
GERANIACEAE	<i>Geranium caffrum</i>	PRECIS
GERANIACEAE	<i>Geranium flanaganii</i>	PRECIS
GERANIACEAE	<i>Geranium natalense</i>	PRECIS
GERANIACEAE	<i>Geranium ornithopodioides</i>	Acocks
GERANIACEAE	<i>Geranium ornithopodon</i>	PRECIS
GERANIACEAE	<i>Geranium schlechteri</i> *	PRECIS
GERANIACEAE	<i>Geranium wakkerstroomianum</i>	PRECIS
GERANIACEAE	<i>Monsonia attenuata</i> *	Anel Geer
GERANIACEAE	<i>Monsonia burkeana</i>	PRECIS
GERANIACEAE	<i>Monsonia grandifolia</i>	PRECIS
GERANIACEAE	<i>Pelargonium alchemilloides</i>	PRECIS
GERANIACEAE	<i>Pelargonium dispar</i>	PRECIS
GERANIACEAE	<i>Pelargonium luridum</i> *	Acocks
GERANIACEAE	<i>Pelargonium schlechteri</i>	PRECIS
GESNERIACEAE	<i>Streptocarpus fanniniae</i>	PRECIS

Family	Scientific Name	CollectionCode
GESNERIACEAE	<i>Streptocarpus gardenii</i>	Gardens (KBG)
GESNERIACEAE	<i>Streptocarpus grandis</i> subsp. <i>grandis</i>	PRECIS (KZN)
GESNERIACEAE	<i>Streptocarpus polyanthus</i> subsp. <i>polyanthus</i>	Gardens (KBG)
GESNERIACEAE	<i>Streptocarpus silvaticus</i>	PRECIS (KZN)
GESNERIACEAE	<i>Streptocarpus wendlandii</i>	Acocks
GLEICHENIACEAE	<i>Gleichenia polypodioides</i>	PRECIS
GLEICHENIACEAE	<i>Gleichenia umbraculifera</i> *	PRECIS
GRIMMIACEAE	<i>Schistidium apocarpum</i>	PRECIS
GUNNERACEAE	<i>Gunnera perpensa</i> *	PRECIS
GUTTIFERAE	<i>Hypericum aethiopicum</i> *	Anel Geer
HAEMODORACEAE	<i>Barberetta aurea</i>	PRECIS
HEDWIGIACEAE	<i>Hedwigia ciliata</i>	PRECIS
HYACINTHACEAE	<i>Albuca humilis</i>	PRECIS (KZN)
HYACINTHACEAE	<i>Albuca setosa</i>	PRECIS (KZN)
HYACINTHACEAE	<i>Albuca</i> sp.	PRECIS
HYACINTHACEAE	<i>Dipcadi marlothii</i>	PRECIS
HYACINTHACEAE	<i>Dipcadi viride</i>	PRECIS
HYACINTHACEAE	<i>Drimia calcarata</i>	PRECIS
HYACINTHACEAE	<i>Drimia delagoensis</i>	PRECIS
HYACINTHACEAE	<i>Drimia depressa</i>	PRECIS
HYACINTHACEAE	<i>Drimia elata</i>	PRECIS
HYACINTHACEAE	<i>Drimia macrocentra</i>	PRECIS
HYACINTHACEAE	<i>Drimia multisetosa</i>	PRECIS
HYACINTHACEAE	<i>Drimiopsis burkei</i> subsp. <i>burkei</i>	PRECIS
HYACINTHACEAE	<i>Eucomis pallidiflora</i> subsp. <i>pallidiflora</i>	PRECIS
HYACINTHACEAE	<i>Galtonia princeps</i>	PRECIS (KZN)
HYACINTHACEAE	<i>Ledebouria cooperi</i> *	PRECIS
HYACINTHACEAE	<i>Ledebouria floribunda</i>	PRECIS
HYACINTHACEAE	<i>Ledebouria marginata</i>	PRECIS
HYACINTHACEAE	<i>Ledebouria ovatifolia</i>	PRECIS
HYACINTHACEAE	<i>Ledebouria revoluta</i>	Acocks
HYACINTHACEAE	<i>Ledebouria sandersonii</i>	PRECIS
HYACINTHACEAE	<i>Merwillia dracomontana</i>	PRECIS (KZN)
HYACINTHACEAE	<i>Merwillia natalensis</i>	PRECIS (KZN)
HYACINTHACEAE	<i>Merwillia plumbea</i>	PRECIS
HYACINTHACEAE	<i>Ornithogalum graminifolium</i>	PRECIS
HYACINTHACEAE	<i>Ornithogalum juncifolium</i> var. <i>juncifolium</i>	PRECIS
HYACINTHACEAE	<i>Ornithogalum paludosum</i>	PRECIS
HYACINTHACEAE	<i>Ornithogalum tenuifolium</i> subsp. <i>tenuifolium</i>	PRECIS
HYACINTHACEAE	<i>Schizocarpus nervosus</i>	PRECIS (KZN)
HYACINTHACEAE	<i>Urginea macrocentra</i> *	Anel Geer
HYDROCHARITACEAE	<i>Lagarosiphon major</i>	PRECIS
HYDROCHARITACEAE	<i>Lagarosiphon muscoides</i>	PRECIS
HYDROCHARITACEAE	<i>Lagarosiphon</i> sp.	PRECIS
HYDROSTACHYACEAE	<i>Hydrostachys polymorpha</i>	PRECIS
HYMENOPHYLLACEAE	<i>Crepidomanes inopinatum</i>	PRECIS
HYMENOPHYLLACEAE	<i>Crepidomanes melanotrichum</i>	PRECIS (KZN)
HYMENOPHYLLACEAE	<i>Didymoglossum reptans</i>	PRECIS
HYPERICACEAE	<i>Hypericum aethiopicum</i> subsp. <i>sonderi</i>	PRECIS
HYPERICACEAE	<i>Hypericum lalandii</i>	PRECIS
HYPERICACEAE	<i>Hypericum natalense</i>	PRECIS
HYPNACEAE	<i>Chryso-hypnum cavifolium</i>	PRECIS
HYPNACEAE	<i>Ectropothecium regulare</i>	PRECIS
HYPNACEAE	<i>Hypnum cupressiforme</i> var. <i>cupressiforme</i>	PRECIS
HYPNACEAE	<i>Mittenothamnium horridulum</i>	PRECIS
HYPNACEAE	<i>Mittenothamnium patens</i>	PRECIS
HYPNACEAE	<i>Mittenothamnium pseudoreptans</i>	PRECIS
HYPNACEAE	<i>Mittenothamnium</i> sp.	PRECIS
HYPNACEAE	<i>Vesicularia galerulata</i>	PRECIS
HYOPTERYGIACEAE	<i>Hypopterygium tamarisci</i>	PRECIS
HYPOXIDACEAE	<i>Hypoxis acuminata</i>	PRECIS

Family	Scientific Name	CollectionCode
HYPOXIDACEAE	<i>Hypoxis angustifolia</i> var. <i>angustifolia</i>	PRECIS
HYPOXIDACEAE	<i>Hypoxis angustifolia</i> var. <i>buchananii</i>	PRECIS
HYPOXIDACEAE	<i>Hypoxis argentea</i> var. <i>argentea</i> *	PRECIS
HYPOXIDACEAE	<i>Hypoxis argentea</i> var. <i>sericea</i>	PRECIS
HYPOXIDACEAE	<i>Hypoxis colchicifolia</i>	PRECIS (KZN)
HYPOXIDACEAE	<i>Hypoxis decumbens</i>	PRECIS
HYPOXIDACEAE	<i>Hypoxis filiformis</i>	PRECIS
HYPOXIDACEAE	<i>Hypoxis galpinii</i>	PRECIS
HYPOXIDACEAE	<i>Hypoxis gerrardii</i>	PRECIS
HYPOXIDACEAE	<i>Hypoxis hemerocallidea</i>	PRECIS (KZN)
HYPOXIDACEAE	<i>Hypoxis multiceps</i>	PRECIS
HYPOXIDACEAE	<i>Hypoxis neliana</i>	PRECIS
HYPOXIDACEAE	<i>Hypoxis parvula</i> var. <i>albiflora</i>	Acocks
HYPOXIDACEAE	<i>Hypoxis parvula</i> var. <i>parvula</i> *	PRECIS
HYPOXIDACEAE	<i>Hypoxis rigidula</i> var. <i>pilosissima</i>	Acocks
HYPOXIDACEAE	<i>Hypoxis rigidula</i> var. <i>rigidula</i> *	PRECIS
HYPOXIDACEAE	<i>Hypoxis</i> sp.	PRECIS
HYPOXIDACEAE	<i>Hypoxis villosa</i> var. <i>obliqua</i>	PRECIS
HYPOXIDACEAE	<i>Rhodohypoxis baurii</i> var. <i>baurii</i>	PRECIS
HYPOXIDACEAE	<i>Rhodohypoxis milloides</i> *	PRECIS
HYSINTHACEAE	<i>Ledebouria</i> spp*	Anel Geer
ICACINACEAE	<i>Apodytes dimidiata</i> subsp. <i>dimidiata</i>	Acocks
ICACINACEAE	<i>Cassinopsis ilicifolia</i>	Acocks
ILLECEBRACEAE	<i>Silene burchellii</i> *	Anel Geer
IRIDACEAE	<i>Aristea abyssinica</i>	PRECIS
IRIDACEAE	<i>Aristea angolensis</i> subsp. <i>angolensis</i>	PRECIS (KZN)
IRIDACEAE	<i>Aristea ecklonii</i>	Acocks
IRIDACEAE	<i>Aristea</i> sp.	PRECIS
IRIDACEAE	<i>Aristea torulosa</i>	PRECIS
IRIDACEAE	<i>Aristea woodii</i> *	Anel Geer
IRIDACEAE	<i>Crocoshmia aurea</i> subsp. <i>aurea</i>	PRECIS
IRIDACEAE	<i>Crocoshmia aurea</i> var. <i>aurea</i>	PRECIS (KZN)
IRIDACEAE	<i>Crocoshmia paniculata</i>	PRECIS
IRIDACEAE	<i>Crocoshmia pottsii</i>	PRECIS
IRIDACEAE	<i>Dierama floriferum</i> *	Gardens (KBG)
IRIDACEAE	<i>Dierama luteoalbidum</i> *	MSB
IRIDACEAE	<i>Dierama medium</i>	PRECIS
IRIDACEAE	<i>Dierama pauciflorum</i>	PRECIS (KZN)
IRIDACEAE	<i>Dierama pumilum</i>	PRECIS
IRIDACEAE	<i>Dierama reynoldsii</i>	PRECIS
IRIDACEAE	<i>Dierama robustum</i>	PRECIS (KZN)
IRIDACEAE	<i>Dierama trichorhizum</i>	PRECIS (KZN)
IRIDACEAE	<i>Dierama tysonii</i>	PRECIS (KZN)
IRIDACEAE	<i>Dietes butcheriana</i>	PRECIS
IRIDACEAE	<i>Dietes iridioides</i>	Acocks
IRIDACEAE	<i>Dietes</i> sp.	Gardens (KBG)
IRIDACEAE	<i>Gladiolus aurantiacus</i>	PRECIS (KZN)
IRIDACEAE	<i>Gladiolus crassifolius</i>	PRECIS (KZN)
IRIDACEAE	<i>Gladiolus dalenii</i> subsp. <i>dalenii</i>	PRECIS
IRIDACEAE	<i>Gladiolus ecklonii</i>	PRECIS
IRIDACEAE	<i>Gladiolus longicollis</i> subsp. <i>longicollis</i>	PRECIS
IRIDACEAE	<i>Gladiolus longicollis</i> subsp. <i>platypetalus</i>	PRECIS
IRIDACEAE	<i>Gladiolus papilio</i>	PRECIS
IRIDACEAE	<i>Gladiolus pubigerus</i>	PRECIS
IRIDACEAE	<i>Gladiolus sericeovillosus</i> subsp. <i>sericeovillosus</i>	PRECIS (KZN)
IRIDACEAE	<i>Gladiolus woodii</i>	PRECIS
IRIDACEAE	<i>Hesperantha baurii</i> subsp. <i>Baurii</i> *	PRECIS
IRIDACEAE	<i>Hesperantha coccinea</i>	PRECIS
IRIDACEAE	<i>Hesperantha inconspicua</i>	PRECIS
IRIDACEAE	<i>Hesperantha radiata</i>	PRECIS
IRIDACEAE	<i>Moraea brevistyla</i> *	PRECIS

Family	Scientific Name	CollectionCode
IRIDACEAE	<i>Moraea graminicola</i> subsp. <i>graminicola</i>	PRECIS
IRIDACEAE	<i>Moraea hiemalis</i>	PRECIS
IRIDACEAE	<i>Moraea huttonii</i>	PRECIS
IRIDACEAE	<i>Moraea inclinata</i> *	PRECIS
IRIDACEAE	<i>Moraea natalensis</i>	PRECIS
IRIDACEAE	<i>Moraea pallida</i>	Acocks
IRIDACEAE	<i>Moraea spathulata</i>	PRECIS
IRIDACEAE	<i>Moraea trifida</i>	PRECIS
IRIDACEAE	<i>Moraea unibracteata</i>	PRECIS
IRIDACEAE	<i>Morea</i> *	Anel Geer
IRIDACEAE	<i>Sisyrinchium micranthum</i>	PRECIS
IRIDACEAE	<i>Tritonia disticha</i>	PRECIS
IRIDACEAE	<i>Tritonia disticha</i> subsp. <i>rubrolucens</i>	PRECIS
IRIDACEAE	<i>Tritonia gladiolaris</i>	PRECIS
IRIDACEAE	<i>Tritonia nelsonii</i>	PRECIS (KZN)
IRIDACEAE	<i>Watsonia canaliculata</i>	PRECIS
IRIDACEAE	<i>Watsonia densiflora</i>	Acocks
IRIDACEAE	<i>Watsonia lepida</i> *	Anel Geer
IRIDACEAE	<i>Watsonia pillansii</i>	PRECIS
IRIDACEAE	<i>Watsonia spp</i> *	Anel Geer
JUBULACEAE	<i>Frullania arecae</i>	PRECIS
JUBULACEAE	<i>Frullania caffraria</i>	PRECIS
JUBULACEAE	<i>Frullania ericoides</i>	PRECIS
JUBULACEAE	<i>Frullania trinervis</i>	PRECIS
JUNCACEAE	<i>Juncus dregeanus</i> subsp. <i>dregeanus</i>	PRECIS
JUNCACEAE	<i>Juncus effusus</i>	PRECIS
JUNCACEAE	<i>Juncus exsertus</i>	PRECIS
JUNCACEAE	<i>Juncus lomatoxyllus</i> *	PRECIS
JUNCACEAE	<i>Juncus oxycarpus</i>	PRECIS
JUNCACEAE	<i>Luzula africana</i>	PRECIS
JUNCAGINACEAE	<i>Triglochin bulbosa</i>	PRECIS (KZN)
LABIATAE	<i>Stachys natalensis</i> *	Anel Geer
LAMIACEAE	<i>Ajuga ophrydis</i> *	PRECIS
LAMIACEAE	<i>Clerodendrum glabrum</i>	Acocks
LAMIACEAE	<i>Clerodendrum hirsutum</i>	PRECIS (KZN)
LAMIACEAE	<i>Hemizygia teucrifolia</i>	PRECIS (KZN)
LAMIACEAE	<i>Leonotis leonurus</i>	Acocks
LAMIACEAE	<i>Leonotis ocyimifolia</i>	Acocks
LAMIACEAE	<i>Leonotis ocyimifolia</i> var. <i>raineriana</i>	PRECIS
LAMIACEAE	<i>Leucas martinicensis</i>	PRECIS
LAMIACEAE	<i>Mentha aquatica</i> *	PRECIS
LAMIACEAE	<i>Micromeria pilosa</i>	PRECIS
LAMIACEAE	<i>Ocimum labiatum</i>	PRECIS
LAMIACEAE	<i>Ocimum obovatum</i> subsp. <i>obovatum</i> var. <i>obovatum</i>	PRECIS
LAMIACEAE	<i>Ocimum sp.</i>	PRECIS
LAMIACEAE	<i>Plectranthus ambiguus</i>	PRECIS
LAMIACEAE	<i>Plectranthus candelabriflorus</i>	PRECIS
LAMIACEAE	<i>Plectranthus ciliatus</i>	PRECIS
LAMIACEAE	<i>Plectranthus dolichopodus</i>	Gardens (KBG)
LAMIACEAE	<i>Plectranthus ecklonii</i>	PRECIS
LAMIACEAE	<i>Plectranthus elegantulus</i>	Gardens (KBG)
LAMIACEAE	<i>Plectranthus fruticosus</i>	PRECIS
LAMIACEAE	<i>Plectranthus grallatus</i>	PRECIS
LAMIACEAE	<i>Plectranthus grandidentatus</i>	PRECIS
LAMIACEAE	<i>Plectranthus hadiensis</i> var. <i>hadiensis</i>	PRECIS
LAMIACEAE	<i>Plectranthus laxiflorus</i>	Acocks
LAMIACEAE	<i>Plectranthus madagascariensis</i> var. <i>ramosior</i>	PRECIS
LAMIACEAE	<i>Plectranthus rehmannii</i>	Gardens (KBG)
LAMIACEAE	<i>Pycnostachys reticulata</i>	PRECIS
LAMIACEAE	<i>Rabdosiella calycina</i> *	Gardens (KBG)
LAMIACEAE	<i>Rothea hirsuta</i>	PRECIS

Family	Scientific Name	CollectionCode
LAMIACEAE	<i>Stachys aethiopica</i>	Acocks
LAMIACEAE	<i>Stachys caffra</i>	Acocks
LAMIACEAE	<i>Stachys cymbalaria</i>	PRECIS
LAMIACEAE	<i>Stachys grandifolia</i>	PRECIS
LAMIACEAE	<i>Stachys sessilis</i>	PRECIS (KZN)
LAMIACEAE	<i>Stachys tubulosa</i>	PRECIS
LAMIACEAE	<i>Syncolostemon parviflorus</i> var. <i>parviflorus</i>	PRECIS
LAMIACEAE	<i>Syncolostemon teucrifolius</i>	PRECIS
LAMIACEAE	<i>Teucrium kraussii</i>	PRECIS
LAURACEAE	<i>Cryptocarya myrtifolia</i>	PRECIS
LAURACEAE	<i>Cryptocarya woodii</i>	Acocks
LAURACEAE	<i>Ocotea bullata</i>	PRECIS
LEJEUNEACEAE	<i>Lejeunea eckloniana</i>	PRECIS
LEJEUNEACEAE	<i>Lejeunea flava</i>	PRECIS
LEJEUNEACEAE	<i>Phragmilejeunea molleri</i>	PRECIS
LEJEUNEACEAE	<i>Ptychanthus striatus</i>	PRECIS
LENTIBULARIACEAE	<i>Utricularia gibba</i>	PRECIS
LENTIBULARIACEAE	<i>Utricularia prehensilis</i> *	PRECIS
LENTIBULARIACEAE	<i>Utricularia stellaris</i>	PRECIS
LEPIDOZIACEAE	<i>Bazzania molleri</i>	PRECIS
LESKEACEAE	<i>Pseudoleskeopsis claviramea</i>	PRECIS
LETROUITIACEAE	<i>Letrouitia flavocrocea</i>	PRECIS
LEUCOBRYACEAE	<i>Leucobryum acutifolium</i>	PRECIS
LEUCODONTACEAE	<i>Pterogoniadelphus assimilis</i>	PRECIS
LINACEAE	<i>Linum thunbergii</i> *	PRECIS
LOBARIACEAE	<i>Sticta sylvatica</i>	PRECIS
LOBELIACEAE	<i>Cyphia corylifolia</i>	PRECIS
LOBELIACEAE	<i>Cyphia elata</i> var. <i>elata</i>	PRECIS
LOBELIACEAE	<i>Cyphia elata</i> var. <i>glabra</i>	PRECIS
LOBELIACEAE	<i>Cyphia elata</i> var. <i>oblongifolia</i>	PRECIS
LOBELIACEAE	<i>Cyphia longifolia</i>	PRECIS
LOBELIACEAE	<i>Cyphia longifolia</i> var. <i>baurii</i>	PRECIS (KZN)
LOBELIACEAE	<i>Lobelia angolensis</i>	PRECIS
LOBELIACEAE	<i>Lobelia erinus</i>	Acocks
LOBELIACEAE	<i>Lobelia flaccida</i> *	Anel Geer
LOBELIACEAE	<i>Lobelia laxa</i>	PRECIS
LOBELIACEAE	<i>Lobelia preslii</i>	PRECIS (KZN)
LOBELIACEAE	<i>Lobelia</i> sp.	PRECIS
LOBELIACEAE	<i>Lobelia stenosiphon</i>	Acocks
LOBELIACEAE	<i>Monopsis decipiens</i> *	Acocks
LOBELIACEAE	<i>Monopsis stellarioides</i> subsp. <i>stellarioides</i>	PRECIS
LORANTHACEAE	<i>Erianthemum dregei</i>	PRECIS (KZN)
LYCOPODIACEAE	<i>Huperzia dacrydioides</i>	PRECIS
LYCOPODIACEAE	<i>Lycopodium clavatum</i>	Acocks
MAESACEAE	<i>Maesa lanceolata</i>	Acocks
MALPIGHIACEAE	<i>Acridocarpus natalitius</i> var. <i>natalitius</i>	PRECIS
MALVACEAE	<i>Abutilon sonneratianum</i>	PRECIS
MALVACEAE	<i>Cola natalensis</i>	PRECIS
MALVACEAE	<i>Corchorus confusus</i>	PRECIS
MALVACEAE	<i>Dombeya tiliacea</i>	PRECIS
MALVACEAE	<i>Grewia hispida</i>	PRECIS
MALVACEAE	<i>Grewia occidentalis</i> var. <i>occidentalis</i>	Acocks
MALVACEAE	<i>Hermannia cristata</i>	PRECIS
MALVACEAE	<i>Hermannia depressa</i>	PRECIS
MALVACEAE	<i>Hermannia gerrardii</i>	PRECIS
MALVACEAE	<i>Hermannia oligosperma</i>	PRECIS
MALVACEAE	<i>Hermannia sandersonii</i>	PRECIS
MALVACEAE	<i>Hermannia transvaalensis</i>	PRECIS
MALVACEAE	<i>Hermannia woodii</i> *	PRECIS
MALVACEAE	<i>Hibiscus aethiopicus</i> var. <i>ovatus</i>	PRECIS
MALVACEAE	<i>Hibiscus pedunculatus</i>	Acocks

Family	Scientific Name	CollectionCode
MALVACEAE	<i>Hibiscus pusillus</i>	PRECIS
MALVACEAE	<i>Hibiscus trionum</i>	PRECIS
MALVACEAE	<i>Pavonia burchellii</i>	PRECIS
MALVACEAE	<i>Pavonia columella</i>	PRECIS
MALVACEAE	<i>Sida rhombifolia</i> subsp. <i>rhombifolia</i>	Acocks
MALVACEAE	<i>Sida spinosa</i> var. <i>spinosa</i>	PRECIS
MALVACEAE	<i>Sida ternata</i>	Acocks
MALVACEAE	<i>Sparrmannia ricinocarpa</i> var. <i>ricinocarpa</i>	PRECIS
MALVACEAE	<i>Triumfetta annua</i> forma <i>annua</i>	PRECIS
MALVACEAE	<i>Triumfetta pilosa</i> var. <i>tomentosa</i>	PRECIS
MARATTIACEAE	<i>Marattia fraxinea</i>	Acocks
MARCHANTACEAE	<i>Dumortiera hirsuta</i>	PRECIS
MARCHANTACEAE	<i>Marchantia debilis</i>	PRECIS
MELASTOMACEAE	<i>Dissotis canescens</i>	PRECIS
MELIACEAE	<i>Ekebergia capensis</i>	PRECIS
MENISPERMACEAE	<i>Cissampelos torulosa</i>	Acocks
MENISPERMACEAE	<i>Stephania abyssinica</i> var. <i>abyssinica</i>	PRECIS
MENISPERMACEAE	<i>Stephania abyssinica</i> var. <i>tomentella</i>	PRECIS
MENYANTHACEAE	<i>Nymphoides thunbergiana</i> *	PRECIS
MESEMBRYANTHACEAE	<i>Aptenia cordifolia</i>	PRECIS
MESEMBRYANTHACEAE	<i>Delosperma galpinii</i>	PRECIS
METEORACEAE	<i>Aerobryopsis capensis</i>	PRECIS
METEORACEAE	<i>Floribundaria floribunda</i>	PRECIS
METZGERIACEAE	<i>Metzgeria limbato-setosa</i>	PRECIS
METZGERIACEAE	<i>Metzgeria nudifrons</i>	PRECIS
METZGERIACEAE	<i>Metzgeria tabularis</i>	PRECIS
METZGERIACEAE	<i>Metzgeria violacea</i>	PRECIS
MIMOSOIDEAE	<i>Acacia mearnsii</i> *	Anel Geer
MNIACEAE	<i>Plagiomnium rhynchophorum</i> var. <i>reidii</i>	PRECIS
MOLLUGINACEAE	<i>Psammotropha myriantha</i>	PRECIS
MONIMACEAE	<i>Xymalos monospora</i>	Acocks
MORACEAE	<i>Ficus burtt-davyi</i>	PRECIS
MORACEAE	<i>Ficus craterostoma</i>	PRECIS
MORACEAE	<i>Ficus ingens</i>	PRECIS
MORACEAE	<i>Ficus ingens</i> var. <i>ingens</i>	PRECIS (KZN)
MORACEAE	<i>Ficus natalensis</i> subsp. <i>natalensis</i>	Acocks
MORACEAE	<i>Ficus sur</i>	Acocks
MYRICACEAE	<i>Morella serrata</i>	PRECIS
MYRSINACEAE	<i>Myrsine africana</i>	Acocks
MYRSINACEAE	<i>Rapanea melanophloeos</i>	Acocks
MYRTACEAE	<i>Eugenia capensis</i> subsp. <i>a</i>	PRECIS
MYRTACEAE	<i>Eugenia zuluensis</i>	Acocks
MYRTACEAE	<i>Syzygium cordatum</i> subsp. <i>cordatum</i>	Acocks
MYRTACEAE	<i>Syzygium gerrardii</i>	Acocks
NECKERACEAE	<i>Neckera valentiniana</i>	PRECIS
NECKERACEAE	<i>Porothamnium stipitatum</i>	PRECIS
NECKERACEAE	<i>Porotrichum madagassum</i>	PRECIS
OCHNACEAE	<i>Ochna arborea</i> var. <i>arborea</i>	Acocks
OCHNACEAE	<i>Ochna gamostigmata</i>	PRECIS
OCHNACEAE	<i>Ochna natalitia</i>	Acocks
OCHNACEAE	<i>Ochna serrulata</i>	Acocks
OCHNACEAE	<i>Ochna serrulata</i>	PRECIS
OLEACEAE	<i>Chionanthus peglerae</i>	PRECIS
OLEACEAE	<i>Jasminum multipartitum</i>	PRECIS
OLEACEAE	<i>Jasminum</i> sp.	PRECIS
OLEACEAE	<i>Olea capensis</i> subsp. <i>enervis</i>	PRECIS
OLEACEAE	<i>Olea capensis</i> subsp. <i>macrocarpa</i>	PRECIS
OLEACEAE	<i>Olea europaea</i> subsp. <i>africana</i>	PRECIS
OLEANDRACEAE	<i>Oleandra distenta</i>	PRECIS
OLINIACEAE	<i>Olinia emarginata</i>	PRECIS
OLINIACEAE	<i>Olinia ventosa</i>	Acocks

Family	Scientific Name	CollectionCode
ONAGRACEAE	<i>Epilobium hirsutum</i>	PRECIS
ONAGRACEAE	<i>Epilobium salignum</i>	PRECIS
ONAGRACEAE	<i>Ludwigia palustris</i>	PRECIS
ONAGRACEAE	<i>Oenothera glazioviana</i>	PRECIS (KZN)
ONAGRACEAE	<i>Oenothera laciniata</i>	PRECIS
ONAGRACEAE	<i>Oenothera rosea</i>	PRECIS
ONAGRACEAE	<i>Oenothera stricta</i> subsp. <i>stricta</i>	PRECIS
ORCHIDACEAE	<i>Angraecum conchiferum</i>	PRECIS
ORCHIDACEAE	<i>Angraecum pusillum</i>	PRECIS
ORCHIDACEAE	<i>Corycium nigrescens</i>	PRECIS
ORCHIDACEAE	<i>Diaphananthe caffra</i>	PRECIS
ORCHIDACEAE	<i>Disa aconitoides</i> subsp. <i>aconitoides</i>	PRECIS
ORCHIDACEAE	<i>Disa crassicornis</i>	PRECIS
ORCHIDACEAE	<i>Disa fragrans</i> subsp. <i>fragrans</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Disa nervosa</i>	PRECIS
ORCHIDACEAE	<i>Disa patula</i> var. <i>transvaalensis</i>	PRECIS
ORCHIDACEAE	<i>Disa pulchra</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Disa stachyoides</i>	PRECIS
ORCHIDACEAE	<i>Disa versicolor</i>	PRECIS
ORCHIDACEAE	<i>Disperis anthoceros</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Disperis cardiophora</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Disperis cooperi</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Disperis fanniniae</i>	Gardens (KBG)
ORCHIDACEAE	<i>Disperis lindleyana</i>	PRECIS
ORCHIDACEAE	<i>Disperis oxyglossa</i>	PRECIS
ORCHIDACEAE	<i>Disperis stenoplectron</i>	PRECIS
ORCHIDACEAE	<i>Disperis tysonii</i>	PRECIS
ORCHIDACEAE	<i>Eulophia aculeata</i> subsp. <i>huttonii</i>	PRECIS
ORCHIDACEAE	<i>Eulophia clavicornis</i> var. <i>clavicornis</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Eulophia clavicornis</i> var. <i>nutans</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Eulophia foliosa</i>	PRECIS
ORCHIDACEAE	<i>Eulophia hians</i> var. <i>hians</i>	PRECIS
ORCHIDACEAE	<i>Eulophia hians</i> var. <i>inaequalis</i>	PRECIS
ORCHIDACEAE	<i>Eulophia hians</i> var. <i>nutans</i>	PRECIS
ORCHIDACEAE	<i>Eulophia leontoglossa</i>	PRECIS
ORCHIDACEAE	<i>Eulophia odontoglossa</i>	PRECIS
ORCHIDACEAE	<i>Eulophia ovalis</i> subsp. <i>ovalis</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Eulophia ovalis</i> var. <i>bainesii</i>	PRECIS
ORCHIDACEAE	<i>Eulophia ovalis</i> var. <i>ovalis</i>	Acocks
ORCHIDACEAE	<i>Eulophia parviflora</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Eulophia</i> sp.	PRECIS (KZN)
ORCHIDACEAE	<i>Eulophia welwitschii</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Eulophia zeyheri</i>	PRECIS
ORCHIDACEAE	<i>Eulophia zeyheriana</i>	PRECIS
ORCHIDACEAE	<i>Habenaria culveri</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Habenaria dives</i> *	PRECIS
ORCHIDACEAE	<i>Habenaria dregeana</i>	PRECIS
ORCHIDACEAE	<i>Habenaria epipactidea</i>	PRECIS
ORCHIDACEAE	<i>Habenaria malacophylla</i>	PRECIS
ORCHIDACEAE	<i>Habenaria pseudociliiosa</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Holothrix scopularia</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Liparis bowkeri</i>	PRECIS (KZN)
ORCHIDACEAE	<i>Mystacidium flanaganii</i>	PRECIS
ORCHIDACEAE	<i>Mystacidium gracile</i>	PRECIS
ORCHIDACEAE	<i>Polystachya cultriformis</i>	PRECIS
ORCHIDACEAE	<i>Pterygodium hastatum</i>	PRECIS
ORCHIDACEAE	<i>Pterygodium magnum</i>	PRECIS
ORCHIDACEAE	<i>Satyrrium cristatum</i> var. <i>cristatum</i>	PRECIS
ORCHIDACEAE	<i>Satyrrium hallackii</i> subsp. <i>ocellatum</i>	PRECIS
ORCHIDACEAE	<i>Satyrrium longicauda</i> var. <i>longicauda</i> *	PRECIS
ORCHIDACEAE	<i>Satyrrium neglectum</i> subsp. <i>woodii</i>	PRECIS

Family	Scientific Name	CollectionCode
ORCHIDACEAE	<i>Satyrium parviflorum</i>	PRECIS
ORCHIDACEAE	<i>Satyrium stenopetalum</i> subsp. <i>brevicalcaratum</i>	PRECIS
ORCHIDACEAE	<i>Schizochilus flexuosus</i>	PRECIS
ORCHIDACEAE	<i>Schizochilus zeyheri</i>	PRECIS
ORCHIDACEAE	<i>Stenoglottis fimbriata</i> subsp. <i>fimbriata</i>	PRECIS
OROBANCHACEAE	<i>Alectra sessiliflora</i> var. <i>sessiliflora</i> *	PRECIS
OROBANCHACEAE	<i>Buchnera simplex</i>	PRECIS
OROBANCHACEAE	<i>Cynium adonense</i>	PRECIS
OROBANCHACEAE	<i>Cynium racemosum</i> *	PRECIS
OROBANCHACEAE	<i>Cynium tubulosum</i> subsp. <i>tubulosum</i>	PRECIS
OROBANCHACEAE	<i>Graderia scabra</i> *	PRECIS
OROBANCHACEAE	<i>Melasma scabrum</i> var. <i>scabrum</i>	PRECIS
OROBANCHACEAE	<i>Sopubia cana</i> var. <i>cana</i>	PRECIS
OROBANCHACEAE	<i>Sopubia simplex</i>	PRECIS
OROBANCHACEAE	<i>Striga asiatica</i>	PRECIS
OROBANCHACEAE	<i>Striga bilabiata</i> subsp. <i>bilabiata</i>	Acocks
OROBANCHACEAE	<i>Striga elegans</i>	PRECIS
ORTHOTRICHACEAE	<i>Macrocoma tenuis</i> subsp. <i>tenuis</i>	PRECIS
ORTHOTRICHACEAE	<i>Macromitrium lebomboense</i>	PRECIS
ORTHOTRICHACEAE	<i>Schlotheimia ferruginea</i>	PRECIS
OSMUNDACEAE	<i>Osmunda regalis</i>	PRECIS
OXALIDACEAE	<i>Oxalis corniculata</i>	PRECIS
OXALIDACEAE	<i>Oxalis depressa</i>	PRECIS
OXALIDACEAE	<i>Oxalis obliquifolia</i> *	PRECIS
OXALIDACEAE	<i>Oxalis smithiana</i> *	PRECIS (KZN)
PAPAVERACEAE	<i>Argemone mexicana</i> forma <i>mexicana</i>	PRECIS
PAPAVERACEAE	<i>Argemone ochroleuca</i> subsp. <i>ochroleuca</i>	PRECIS
PAPILIONOIDEAE	<i>Eriosema simulans/krausianum</i> *	Anel Geer
PAPILIONOIDEAE	<i>Zornia linearis</i> *	Anel Geer
PARMELIACEAE	<i>Lichen</i> sp.	PRECIS
PARMELIACEAE	<i>Parmotrema reticulatum</i>	PRECIS
PASSIFLORACEAE	<i>Basananthe sandersonii</i>	Acocks
PEDALIACEAE	<i>Ceratotheca triloba</i>	Acocks
PERTUSARIACEAE	<i>Porina epiphylla</i> var. <i>epiphylla</i>	PRECIS
PHYLLANTHACEAE	<i>Andrachne ovalis</i>	Acocks
PHYLLANTHACEAE	<i>Margaritaria discoidea</i> var. <i>nitida</i>	PRECIS
PHYTOLACCACEAE	<i>Phytolacca dioica</i>	PRECIS
PHYTOLACCACEAE	<i>Phytolacca octandra</i>	PRECIS
PILOTRICHACEAE	<i>Callicostella tristis</i>	PRECIS
PILOTRICHACEAE	<i>Hookeriopsis utacamundiana</i>	PRECIS
PIPERACEAE	<i>Peperomia tetraphylla</i>	Acocks
PIPERACEAE	<i>Piper capense</i> var. <i>capense</i>	Acocks
PITTOSPORACEAE	<i>Pittosporum viridiflorum</i>	Acocks
PLAGIOCHILACEAE	<i>Plagiochila capensis</i>	PRECIS
PLAGIOCHILACEAE	<i>Plagiochila crispulo-caudata</i>	PRECIS
PLAGIOCHILACEAE	<i>Plagiochila heterostipa</i>	PRECIS
PLANTAGINACEAE	<i>Plantago lanceolata</i>	Acocks
PLANTAGINACEAE	<i>Plantago longissima</i>	PRECIS
PLANTAGINACEAE	<i>Plantago major</i>	PRECIS
POACEAE	<i>Agrostis bergiana</i> var. <i>bergiana</i>	PRECIS
POACEAE	<i>Agrostis continuata</i>	PRECIS
POACEAE	<i>Agrostis lachnantha</i> var. <i>lachnantha</i>	PRECIS
POACEAE	<i>Alloteropsis semialata</i> subsp. <i>eckloniana</i>	Acocks
POACEAE	<i>Andropogon appendiculatus</i> *	PRECIS
POACEAE	<i>Andropogon eucomus</i>	PRECIS
POACEAE	<i>Andropogon schirensis</i> *	Acocks
POACEAE	<i>Aristida diffusa</i> subsp. <i>burkei</i>	PRECIS
POACEAE	<i>Aristida junciformis</i> subsp. <i>galpinii</i>	Acocks
POACEAE	<i>Aristida junciformis</i> subsp. <i>Junciformis</i> *	PRECIS (KZN)
POACEAE	<i>Arrhenatherum elatius</i>	PRECIS
POACEAE	<i>Arundinella nepalensis</i>	PRECIS

Family	Scientific Name	CollectionCode
POACEAE	<i>Axonopus affinis</i>	PRECIS
POACEAE	<i>Bothriochloa bladhii</i>	Acocks
POACEAE	<i>Bothriochloa insculpta</i>	Acocks
POACEAE	<i>Brachiaria arrecta</i>	PRECIS
POACEAE	<i>Brachiaria humidicola</i>	PRECIS
POACEAE	<i>Brachiaria serrata</i>	Acocks
POACEAE	<i>Brachypodium flexum</i>	Acocks
POACEAE	<i>Briza maxima</i>	PRECIS
POACEAE	<i>Bromus catharticus</i>	PRECIS (KZN)
POACEAE	<i>Bromus natalensis</i>	PRECIS
POACEAE	<i>Bromus sp.</i>	PRECIS
POACEAE	<i>Chloris gayana</i>	Acocks
POACEAE	<i>Chloris virgata</i>	PRECIS
POACEAE	<i>Cymbopogon caesius</i>	Acocks
POACEAE	<i>Cymbopogon marginatus</i>	Acocks
POACEAE	<i>Cymbopogon nardus</i>	PRECIS
POACEAE	<i>Cynodon dactylon</i>	PRECIS
POACEAE	<i>Cynodon hirsutus</i>	PRECIS
POACEAE	<i>Dactylis glomerata</i>	PRECIS (KZN)
POACEAE	<i>Danthonia sp.</i>	PRECIS (KZN)
POACEAE	<i>Digitaria ciliaris</i>	PRECIS
POACEAE	<i>Digitaria diagonalis var. diagonalis</i>	PRECIS
POACEAE	<i>Digitaria natalensis</i>	Acocks
POACEAE	<i>Digitaria sanguinalis</i>	Acocks
POACEAE	<i>Digitaria setifolia</i>	PRECIS
POACEAE	<i>Digitaria ternata</i>	Acocks
POACEAE	<i>Digitaria tricholaenoides</i>	Acocks
POACEAE	<i>Diheteropogon filifolius</i>	Acocks
POACEAE	<i>Echinochloa colona</i>	PRECIS
POACEAE	<i>Echinochloa crus-galli</i>	PRECIS
POACEAE	<i>Echinochloa sp.</i>	PRECIS
POACEAE	<i>Ehrharta erecta var. erecta</i>	Acocks
POACEAE	<i>Ehrharta erecta var. natalensis</i>	PRECIS
POACEAE	<i>Eleusine coracana subsp. africana</i>	PRECIS
POACEAE	<i>Eleusine coracana subsp. coracana</i>	PRECIS (KZN)
POACEAE	<i>Elionurus muticus</i>	PRECIS
POACEAE	<i>Eragrostis capensis*</i>	Acocks
POACEAE	<i>Eragrostis chloromelas</i>	PRECIS
POACEAE	<i>Eragrostis curvula*</i>	Acocks
POACEAE	<i>Eragrostis heteromera</i>	PRECIS
POACEAE	<i>Eragrostis inamoena*</i>	PRECIS
POACEAE	<i>Eragrostis patentipilosa</i>	PRECIS
POACEAE	<i>Eragrostis plana</i>	Acocks
POACEAE	<i>Eragrostis planiculmis</i>	Acocks
POACEAE	<i>Eragrostis pseudosclerantha</i>	PRECIS (KZN)
POACEAE	<i>Eragrostis racemosa*</i>	Acocks
POACEAE	<i>Eragrostis tincta</i>	PRECIS (KZN)
POACEAE	<i>Eriochrysis pallida</i>	Acocks
POACEAE	<i>Eulalia villosa</i>	Acocks
POACEAE	<i>Festuca africana</i>	PRECIS
POACEAE	<i>Festuca caprina</i>	PRECIS
POACEAE	<i>Festuca costata</i>	PRECIS (KZN)
POACEAE	<i>Festuca scabra</i>	PRECIS
POACEAE	<i>Festuca sp.</i>	PRECIS
POACEAE	<i>Harpochloa falx*</i>	PRECIS (KZN)
POACEAE	<i>Helictotrichon turgidulum</i>	PRECIS
POACEAE	<i>Hemarthria altissima</i>	Acocks
POACEAE	<i>Heteropogon contortus*</i>	Acocks
POACEAE	<i>Hyparrhenia anamesa</i>	PRECIS
POACEAE	<i>Hyparrhenia cymbaria</i>	Acocks
POACEAE	<i>Hyparrhenia dregeana</i>	PRECIS

Family	Scientific Name	CollectionCode
POACEAE	<i>Hyparrhenia hirta</i>	Acocks
POACEAE	<i>Hyparrhenia pilgeriana</i>	PRECIS
POACEAE	<i>Hyparrhenia schimperi</i>	PRECIS
POACEAE	<i>Hyparrhenia sp.</i>	PRECIS
POACEAE	<i>Hyparrhenia tamba</i>	PRECIS
POACEAE	<i>Hyperthelia dissoluta</i>	PRECIS
POACEAE	<i>Imperata cylindrica</i>	Acocks
POACEAE	<i>Ischaemum fasciculatum</i>	PRECIS
POACEAE	<i>Koeleria capensis</i>	PRECIS
POACEAE	<i>Leersia hexandra</i>	Acocks
POACEAE	<i>Lolium multiflorum</i>	PRECIS (KZN)
POACEAE	<i>Loudetia densispica</i>	PRECIS (KZN)
POACEAE	<i>Loudetia simplex</i>	Acocks
POACEAE	<i>Melinis minutiflora</i>	PRECIS
POACEAE	<i>Melinis nerviglumis*</i>	PRECIS
POACEAE	<i>Melinis repens subsp. repens</i>	Acocks
POACEAE	<i>Merxmuellera stricta</i>	PRECIS
POACEAE	<i>Microchloa caffra</i>	Acocks
POACEAE	<i>Microlaena stipoides</i>	PRECIS
POACEAE	<i>Microstegium nudum</i>	PRECIS
POACEAE	<i>Miscanthus capensis</i>	Acocks
POACEAE	<i>Monocymbium cerasiiforme*</i>	Acocks
POACEAE	<i>Oplismenus hirtellus</i>	Acocks
POACEAE	<i>Panicum aequinerve</i>	Acocks
POACEAE	<i>Panicum deustum</i>	PRECIS
POACEAE	<i>Panicum dregeanum</i>	Acocks
POACEAE	<i>Panicum ecklonii</i>	PRECIS
POACEAE	<i>Panicum hymeniochilum</i>	PRECIS
POACEAE	<i>Panicum maximum</i>	Acocks
POACEAE	<i>Panicum natalense</i>	Acocks
POACEAE	<i>Panicum schinzii</i>	PRECIS
POACEAE	<i>Panicum sp.</i>	PRECIS
POACEAE	<i>Panicum subalbidum</i>	PRECIS
POACEAE	<i>Paspalum dilatatum</i>	Acocks
POACEAE	<i>Paspalum notatum</i>	Acocks
POACEAE	<i>Paspalum scrobiculatum</i>	Acocks
POACEAE	<i>Paspalum urvillei</i>	Acocks
POACEAE	<i>Pennisetum sphacelatum</i>	PRECIS
POACEAE	<i>Pennisetum thunbergii*</i>	PRECIS
POACEAE	<i>Pennisetum unisetum</i>	Acocks
POACEAE	<i>Pentaschistis*</i>	Anel Geer
POACEAE	<i>Pentaschistis natalensis</i>	PRECIS (KZN)
POACEAE	<i>Phragmites australis</i>	Acocks
POACEAE	<i>Poa annua</i>	PRECIS
POACEAE	<i>Poa binata</i>	PRECIS
POACEAE	<i>Poa sp.</i>	PRECIS
POACEAE	<i>Prosphytochloa prehensilis</i>	Acocks
POACEAE	<i>Rendlia altera</i>	PRECIS
POACEAE	<i>Saccharum munroanum</i>	PRECIS
POACEAE	<i>Schizachyrium sanguineum</i>	PRECIS
POACEAE	<i>Setaria megaphylla</i>	Acocks
POACEAE	<i>Setaria nigrirostris</i>	PRECIS
POACEAE	<i>Setaria pallide-fusca</i>	PRECIS (KZN)
POACEAE	<i>Setaria pumila</i>	PRECIS
POACEAE	<i>Setaria sp.</i>	PRECIS
POACEAE	<i>Setaria sphacelata var. sericea</i>	Acocks
POACEAE	<i>Setaria sphacelata var. sphacelata</i>	Gardens (KBG)
POACEAE	<i>Sporobolus africanus*</i>	Acocks
POACEAE	<i>Sporobolus centrifugus*</i>	PRECIS
POACEAE	<i>Sporobolus festivus</i>	PRECIS (KZN)
POACEAE	<i>Sporobolus fimbriatus</i>	PRECIS

Family	Scientific Name	CollectionCode
POACEAE	<i>Sporobolus pyramidalis</i> *	PRECIS
POACEAE	<i>Sporobolus stapfianus</i>	PRECIS
POACEAE	<i>Stiburus alopecuroides</i> *	PRECIS
POACEAE	<i>Stipa dregeana</i> var. <i>dregeana</i>	Acocks
POACEAE	<i>Themeda triandra</i> *	PRECIS
POACEAE	<i>Trachypogon spicatus</i> *	PRECIS
POACEAE	<i>Trichopteryx dregeana</i>	Acocks
POACEAE	<i>Tristachya leucothrix</i> *	PRECIS
POACEAE	<i>Vulpia myuros</i>	PRECIS
PODOCARPACEAE	<i>Podocarpus falcatus</i>	Acocks
PODOCARPACEAE	<i>Podocarpus henkelii</i>	Acocks
PODOCARPACEAE	<i>Podocarpus latifolius</i>	Acocks
PODOSTEMACEAE	<i>Sphaerostylis</i> sp.	PRECIS
POLYGALACEAE	<i>Muraltia lancifolia</i>	PRECIS (KZN)
POLYGALACEAE	<i>Muraltia saxicola</i>	PRECIS
POLYGALACEAE	<i>Polygala gerrardii</i>	PRECIS
POLYGALACEAE	<i>Polygala gracilentia</i> *	PRECIS
POLYGALACEAE	<i>Polygala gymnoclada</i>	PRECIS
POLYGALACEAE	<i>Polygala hispida</i>	PRECIS
POLYGALACEAE	<i>Polygala hottentotta</i> *	PRECIS
POLYGALACEAE	<i>Polygala leendertziae</i>	PRECIS
POLYGALACEAE	<i>Polygala macowaniana</i>	PRECIS
POLYGALACEAE	<i>Polygala ohlendorffiana</i>	Acocks
POLYGALACEAE	<i>Polygala refracta</i>	PRECIS
POLYGALACEAE	<i>Polygala serpentaria</i>	PRECIS
POLYGALACEAE	<i>Polygala sphenoptera</i> var. <i>sphenoptera</i>	PRECIS (KZN)
POLYGALACEAE	<i>Polygala virgata</i> var. <i>decora</i>	Acocks
POLYGONACEAE	<i>Oxygonum dregeanum</i> subsp. <i>lanceolatum</i>	PRECIS
POLYGONACEAE	<i>Persicaria attenuata</i> subsp. <i>africana</i>	PRECIS
POLYGONACEAE	<i>Persicaria decipiens</i>	PRECIS
POLYGONACEAE	<i>Persicaria hydropiper</i>	PRECIS (KZN)
POLYGONACEAE	<i>Persicaria lapathifolia</i>	PRECIS (KZN)
POLYGONACEAE	<i>Persicaria meisneriana</i>	PRECIS
POLYGONACEAE	<i>Persicaria serrulata</i>	PRECIS (KZN)
POLYGONACEAE	<i>Persicaria</i> sp.	PRECIS (KZN)
POLYGONACEAE	<i>Rumex acetosella</i> subsp. <i>angiocarpus</i>	PRECIS
POLYGONACEAE	<i>Rumex bequaertii</i>	PRECIS
POLYGONACEAE	<i>Rumex sagittatus</i>	Acocks
POLYGONACEAE	<i>Rumex woodii</i>	Acocks
POLYPODIACEAE	<i>Lepisorus schraderi</i>	PRECIS
POLYPODIACEAE	<i>Loxogramme abyssinica</i>	PRECIS
POLYPODIACEAE	<i>Pleopeltis macrocarpa</i>	PRECIS
POLYPODIACEAE	<i>Pleopeltis polypodioides</i> subsp. <i>ecklonii</i>	PRECIS
POLYPODIACEAE	<i>Polypodium polypodioides</i> subsp. <i>ecklonii</i>	Acocks
POLYPODIACEAE	X <i>Pleopodium simianum</i>	PRECIS
POLYTRICHACEAE	<i>Atrichum androgynum</i>	PRECIS
POLYTRICHACEAE	<i>Pogonatum capense</i>	PRECIS
POLYTRICHACEAE	<i>Polytrichum commune</i>	PRECIS
PORELLACEAE	<i>Porella capensis</i>	PRECIS
POTAMOGETONACEAE	<i>Potamogeton crispus</i>	PRECIS
POTAMOGETONACEAE	<i>Potamogeton nodosus</i>	PRECIS
POTAMOGETONACEAE	<i>Potamogeton octandrus</i>	PRECIS
POTAMOGETONACEAE	<i>Potamogeton pectinatus</i>	PRECIS
POTAMOGETONACEAE	<i>Potamogeton pusillus</i>	PRECIS
POTAMOGETONACEAE	<i>Potamogeton schweinfurthii</i>	PRECIS (KZN)
POTAMOGETONACEAE	<i>Potamogeton trichoides</i>	PRECIS
POTTIACEAE	<i>Bryoerythrophyllum campylocarpum</i>	PRECIS
POTTIACEAE	<i>Hyophila involuta</i>	PRECIS
POTTIACEAE	<i>Hypodontium dregei</i>	PRECIS
POTTIACEAE	<i>Leptodontium longicaule</i>	PRECIS
POTTIACEAE	<i>Leptodontium viticulosoides</i>	PRECIS

Family	Scientific Name	CollectionCode
POTTIACEAE	<i>Leptophascum leptophyllum</i>	PRECIS
POTTIACEAE	<i>Syntrichia fragilis</i>	PRECIS
POTTIACEAE	<i>Tortella humilis</i>	PRECIS
POTTIACEAE	<i>Trichostomum brachydontium</i>	PRECIS
PRIMULACEAE	<i>Anagallis huttonii</i>	PRECIS
PROTEACEAE	<i>Leucospermum gerrardii</i>	PRECIS
PROTEACEAE	<i>Protea caffra</i> subsp. <i>caffra</i>	Protea Atlas
PROTEACEAE	<i>Protea dracomontana</i>	Protea Atlas
PROTEACEAE	<i>Protea roupelliae</i>	PRECIS
PROTEACEAE	<i>Protea roupelliae</i> subsp. <i>roupelliae</i>	Protea Atlas
PROTEACEAE	<i>Protea simplex</i> *	Protea Atlas
PROTEACEAE	<i>Protea spp</i> *	Anel Geer
PROTEACEAE	<i>Protea subvestita</i>	PRECIS
PTAEROXYLACEAE	<i>Ptaeroxylon obliquum</i>	Acocks
PTERIDACEAE	<i>Adiantum capillus-veneris</i>	PRECIS
PTERIDACEAE	<i>Adiantum poiretii</i>	PRECIS
PTERIDACEAE	<i>Adiantum raddianum</i>	PRECIS
PTERIDACEAE	<i>Cheilanthes bergiana</i>	PRECIS (KZN)
PTERIDACEAE	<i>Cheilanthes concolor</i>	PRECIS
PTERIDACEAE	<i>Cheilanthes hirta</i>	Acocks
PTERIDACEAE	<i>Cheilanthes quadripinnata</i>	PRECIS
PTERIDACEAE	<i>Cheilanthes viridis</i> var. <i>macrophylla</i>	PRECIS
PTERIDACEAE	<i>Cheilanthes viridis</i> var. <i>viridis</i>	PRECIS
PTERIDACEAE	<i>Doryopteris concolor</i>	PRECIS (KZN)
PTERIDACEAE	<i>Pellaea calomelanos</i> var. <i>calomelanos</i>	PRECIS
PTERIDACEAE	<i>Pityrogramma argentea</i>	PRECIS
PTERIDACEAE	<i>Pteris buchananii</i>	PRECIS
PTERIDACEAE	<i>Pteris catoptera</i> var. <i>catoptera</i>	PRECIS
PTERIDACEAE	<i>Pteris cretica</i>	PRECIS
PTERIDACEAE	<i>Pteris dentata</i>	PRECIS (KZN)
PTEROBRYACEAE	<i>Pterobryopsis hoehnelii</i>	PRECIS
PTYCHOMITRIACEAE	<i>Ptychomitrium crispatum</i>	PRECIS
PTYCHOMITRIACEAE	<i>Ptychomitrium sellowianum</i>	PRECIS
PUTRANJIVACEAE	<i>Drypetes gerrardii</i> var. <i>gerrardii</i>	PRECIS
RACOPILACEAE	<i>Racopilum capense</i>	PRECIS
RADULACEAE	<i>Radula boryana</i>	PRECIS
RADULACEAE	<i>Radula holstiana</i>	PRECIS
RADULACEAE	<i>Radula lindenbergiana</i>	PRECIS
RANUNCULACEAE	<i>Anemone fanninii</i>	PRECIS (KZN)
RANUNCULACEAE	<i>Clematis brachiata</i>	PRECIS
RANUNCULACEAE	<i>Clematis oweniae</i>	PRECIS (KZN)
RANUNCULACEAE	<i>Knowltonia bracteata</i>	PRECIS
RANUNCULACEAE	<i>Ranunculus multifidus</i> *	Acocks
RANUNCULACEAE	<i>Thalictrum rhynchocarpum</i>	PRECIS (KZN)
RANUNCULACEAE	<i>Thalictrum sp.</i>	Gardens (KBG)
RESTIONACEAE	<i>Calopsis paniculata</i> *	Anel Geer
RHAMNACEAE	<i>Phylica paniculata</i>	PRECIS
RHAMNACEAE	<i>Rhamnus prinoides</i>	Acocks
RHAMNACEAE	<i>Scutia myrtina</i>	Acocks
RHAMNACEAE	<i>Ziziphus mucronata</i> subsp. <i>mucronata</i>	Acocks
RHIZOGONIACEAE	<i>Pyrrhobryum spiniforme</i>	PRECIS
RHIZOPHORACEAE	<i>Cassipourea gummiflua</i> var. <i>verticillata</i>	Acocks
RHIZOPHORACEAE	<i>Cassipourea malosana</i>	PRECIS (KZN)
RICCIACEAE	<i>Riccia stricta</i>	PRECIS
ROSACEAE	<i>Agrimonia procera</i> *	PRECIS (KZN)
ROSACEAE	<i>Alchemilla elongata</i> var. <i>elongata</i>	PRECIS
ROSACEAE	<i>Alchemilla incurvata</i>	PRECIS (KZN)
ROSACEAE	<i>Alchemilla kiwuensis</i>	PRECIS
ROSACEAE	<i>Alchemilla sp.</i>	PRECIS (KZN)
ROSACEAE	<i>Alchemilla woodii</i>	PRECIS (KZN)
ROSACEAE	<i>Cliffortia linearifolia</i>	PRECIS

Family	Scientific Name	CollectionCode
ROSACEAE	<i>Cliffortia repens</i>	PRECIS (KZN)
ROSACEAE	<i>Cliffortia strobilifera</i>	Acocks
ROSACEAE	<i>Duchesnea indica</i>	PRECIS
ROSACEAE	<i>Leucosidea sericea</i> *	Acocks
ROSACEAE	<i>Prunus africana</i>	PRECIS
ROSACEAE	<i>Rubus apetalus</i> var. <i>apetalus</i>	PRECIS
ROSACEAE	<i>Rubus cuneifolius</i> *	PRECIS
ROSACEAE	<i>Rubus ludwigii</i> subsp. <i>Ludwigii</i> *	PRECIS
ROSACEAE	<i>Rubus ludwigii</i> subsp. <i>spatiosus</i>	PRECIS
ROSACEAE	<i>Rubus phoenicolacius</i>	PRECIS
ROSACEAE	<i>Rubus pinnatus</i>	PRECIS
ROSACEAE	<i>Rubus rigidus</i>	PRECIS
RUBIACEAE	<i>Alberta magna</i>	Acocks
RUBIACEAE	<i>Anthospermum herbaceum</i>	PRECIS
RUBIACEAE	<i>Burchellia bubalina</i>	Acocks
RUBIACEAE	<i>Canthium ciliatum</i>	Acocks
RUBIACEAE	<i>Canthium inerme</i>	Acocks
RUBIACEAE	<i>Canthium kuntzeanum</i>	Acocks
RUBIACEAE	<i>Conostomium natalense</i> var. <i>glabrum</i>	PRECIS
RUBIACEAE	<i>Conostomium natalense</i> var. <i>natalense</i>	Acocks
RUBIACEAE	<i>Galium spurium</i> subsp. <i>africanum</i>	PRECIS
RUBIACEAE	<i>Galium subvillosum</i> var. <i>subvillosum</i>	PRECIS
RUBIACEAE	<i>Galium thunbergianum</i> var. <i>thunbergianum</i>	Acocks
RUBIACEAE	<i>Galopina circaeoides</i>	Acocks
RUBIACEAE	<i>Hyperacanthus amoenus</i>	Acocks
RUBIACEAE	<i>Keetia gueinzii</i>	Acocks
RUBIACEAE	<i>Kohautia amatymbica</i> *	PRECIS (KZN)
RUBIACEAE	<i>Kraussia floribunda</i>	PRECIS
RUBIACEAE	<i>Lagynias lasiantha</i>	PRECIS
RUBIACEAE	<i>Oldenlandia herbacea</i> var. <i>herbacea</i>	PRECIS
RUBIACEAE	<i>Pachystigma latifolium</i>	PRECIS
RUBIACEAE	<i>Pachystigma macrocalyx</i>	PRECIS
RUBIACEAE	<i>Pavetta inandensis</i>	PRECIS
RUBIACEAE	<i>Pavetta kotzei</i>	Acocks
RUBIACEAE	<i>Pavetta lanceolata</i>	Acocks
RUBIACEAE	<i>Pentanisia angustifolia</i> *	PRECIS
RUBIACEAE	<i>Pentanisia prunelloides</i> subsp. <i>latifolia</i>	Acocks
RUBIACEAE	<i>Pentanisia prunelloides</i> subsp. <i>Prunelloides</i> *	PRECIS
RUBIACEAE	<i>Pentanisia</i> sp.	PRECIS
RUBIACEAE	<i>Psyrax obovata</i> subsp. <i>obovata</i>	PRECIS
RUBIACEAE	<i>Pygmaeothamnus chamaedendrum</i> var. <i>setulosus</i>	PRECIS
RUBIACEAE	<i>Richardia brasiliensis</i>	Acocks
RUBIACEAE	<i>Rothmannia capensis</i>	Acocks
RUBIACEAE	<i>Rothmannia globosa</i>	Acocks
RUBIACEAE	<i>Rubia cordifolia</i> subsp. <i>conotricha</i>	Acocks
RUBIACEAE	<i>Spermacoce natalensis</i>	Acocks
RUBIACEAE	<i>Tricalysia lanceolata</i>	Acocks
RUBIACEAE	<i>Vangueria randii</i> subsp. <i>chartacea</i>	PRECIS
RUTACEAE	<i>Calodendrum capense</i>	PRECIS
RUTACEAE	<i>Clausena anisata</i> var. <i>anisata</i>	Acocks
RUTACEAE	<i>Teclea gerrardii</i>	PRECIS (KZN)
RUTACEAE	<i>Teclea natalensis</i>	PRECIS
RUTACEAE	<i>Vepris lanceolata</i>	Acocks
RUTACEAE	<i>Vepris</i> sp.	PRECIS
RUTACEAE	<i>Zanthoxylum davyi</i>	Acocks
SALICACEAE	<i>Dovyalis rhamnoides</i>	PRECIS
SALICACEAE	<i>Dovyalis zeyheri</i>	PRECIS
SALICACEAE	<i>Homalium dentatum</i>	PRECIS
SALICACEAE	<i>Salix babylonica</i> var. <i>babylonica</i>	PRECIS
SALICACEAE	<i>Scolopia mundii</i>	PRECIS
SALICACEAE	<i>Scolopia zeyheri</i>	Acocks

Family	Scientific Name	CollectionCode
SALICACEAE	<i>Trimeria grandifolia</i> subsp. <i>grandifolia</i>	Acocks
SAMYDACEAE	<i>Casearia gladiiformis</i>	PRECIS
SANTALACEAE	<i>Osyridicarpus schimperianus</i>	PRECIS
SANTALACEAE	<i>Thesium costatum</i> var. <i>costatum</i>	Acocks
SANTALACEAE	<i>Thesium costatum</i> var. <i>juniperinum</i>	PRECIS
SANTALACEAE	<i>Thesium pallidum</i>	PRECIS (KZN)
SANTALACEAE	<i>Thesium racemosum</i>	PRECIS
SANTALACEAE	<i>Thesium</i> sp.	PRECIS
SANTALACEAE	<i>Thesium virens</i>	PRECIS
SAPINDACEAE	<i>Allophylus dregeanus</i>	Acocks
SAPINDACEAE	<i>Allophylus melanocarpus</i>	Acocks
SCROPHULARIACEAE	<i>Bowkeria verticillata</i>	PRECIS
SCROPHULARIACEAE	<i>Chaenostoma floribundum</i>	PRECIS
SCROPHULARIACEAE	<i>Diascia cordata</i>	PRECIS
SCROPHULARIACEAE	<i>Diascia purpurea</i>	PRECIS
SCROPHULARIACEAE	<i>Diclis reptans</i> *	Acocks
SCROPHULARIACEAE	<i>Diclis rotundifolia</i>	PRECIS
SCROPHULARIACEAE	<i>Halleria lucida</i>	Acocks
SCROPHULARIACEAE	<i>Hebenstretia comosa</i> *	PRECIS
SCROPHULARIACEAE	<i>Hebenstretia oatesii</i> subsp. <i>oatesii</i>	PRECIS
SCROPHULARIACEAE	<i>Jamesbrittenia breviflora</i>	PRECIS
SCROPHULARIACEAE	<i>Limosella longiflora</i>	PRECIS
SCROPHULARIACEAE	<i>Limosella maior</i>	PRECIS
SCROPHULARIACEAE	<i>Lindernia parviflora</i>	PRECIS
SCROPHULARIACEAE	<i>Manulea florifera</i>	PRECIS (KZN)
SCROPHULARIACEAE	<i>Mimulus gracilis</i>	PRECIS
SCROPHULARIACEAE	<i>Mimulus moschatus</i> var. <i>moschatus</i>	PRECIS
SCROPHULARIACEAE	<i>Nemesia caerulea</i>	PRECIS
SCROPHULARIACEAE	<i>Nemesia denticulata</i> *	PRECIS
SCROPHULARIACEAE	<i>Nemesia silvatica</i>	PRECIS
SCROPHULARIACEAE	<i>Nemesia umbonata</i>	PRECIS (KZN)
SCROPHULARIACEAE	<i>Phygellus aequalis</i> *	PRECIS
SCROPHULARIACEAE	<i>Selago cucullata</i>	PRECIS
SCROPHULARIACEAE	<i>Selago hyssopifolia</i> subsp. <i>retrotricha</i>	PRECIS
SCROPHULARIACEAE	<i>Selago lamprocarpa</i>	PRECIS
SCROPHULARIACEAE	<i>Selago pachypoda</i>	PRECIS
SCROPHULARIACEAE	<i>Selago</i> sp.	PRECIS
SCROPHULARIACEAE	<i>Selago tarachodes</i>	PRECIS
SCROPHULARIACEAE	<i>Sutera floribunda</i> *	PRECIS (KZN)
SCROPHULARIACEAE	<i>Veronica anagallis-aquatica</i>	PRECIS
SCROPHULARIACEAE	<i>Zaluzianskya microsiphon</i> *	PRECIS
SCROPHULARIACEAE	<i>Zaluzianskya natalensis</i>	PRECIS
SCROPHULARIACEAE	<i>Zaluzianskya pulvinata</i>	PRECIS
SELAGINELLACEAE	<i>Selaginella dregei</i>	PRECIS
SELAGINELLACEAE	<i>Selaginella kraussiana</i>	Acocks
SELAGINELLACEAE	<i>Selaginella mittenii</i>	PRECIS
SEMATOPHYLLACEAE	<i>Sematophyllum dregei</i>	PRECIS
SEMATOPHYLLACEAE	<i>Sematophyllum gueinzii</i>	PRECIS
SEMATOPHYLLACEAE	<i>Sematophyllum subpinnatum</i>	PRECIS
SOLANACEAE	<i>Datura stramonium</i>	PRECIS
SOLANACEAE	<i>Physalis peruviana</i>	Acocks
SOLANACEAE	<i>Solanum aculeastrum</i> subsp. <i>aculeastrum</i>	Acocks
SOLANACEAE	<i>Solanum aculeatissimum</i>	Acocks
SOLANACEAE	<i>Solanum auriculatum</i>	PRECIS (KZN)
SOLANACEAE	<i>Solanum didymanthum</i>	PRECIS
SOLANACEAE	<i>Solanum duplosinuatum</i>	PRECIS
SOLANACEAE	<i>Solanum geniculatum</i>	PRECIS
SOLANACEAE	<i>Solanum giganteum</i>	PRECIS
SOLANACEAE	<i>Solanum incanum</i>	PRECIS (KZN)
SOLANACEAE	<i>Solanum linnaeanum</i>	PRECIS
SOLANACEAE	<i>Solanum mauritianum</i>	PRECIS

Family	Scientific Name	CollectionCode
SOLANACEAE	<i>Solanum panduriforme</i>	PRECIS
SOLANACEAE	<i>Solanum pseudocapsicum</i>	PRECIS (KZN)
SOLANACEAE	<i>Solanum sodomaeodes</i>	Acocks
SOLANACEAE	<i>Solanum sp.</i>	PRECIS
SOLANACEAE	<i>Solanum viarum</i>	PRECIS
SPLACHNACEAE	<i>Tayloria isleana</i>	PRECIS
STRIGULACEAE	<i>Strigula maculata</i>	PRECIS
TECTARIACEAE	<i>Ctenitis lanuginosa</i>	PRECIS
THELOTREMATAACEAE	<i>Diploschistes arenarius</i>	PRECIS
THELYPTERIDACEAE	<i>Amauropelta bergiana</i> var. <i>bergiana</i>	Gardens (KBG)
THELYPTERIDACEAE	<i>Christella dentata</i>	PRECIS
THELYPTERIDACEAE	<i>Christella gueinziana</i>	PRECIS
THELYPTERIDACEAE	<i>Stegnogramma pozoi</i>	Gardens (KBG)
THELYPTERIDACEAE	<i>Thelypteris confluens</i>	PRECIS
THUIDIACEAE	<i>Cyrtohypnum versicolor</i>	PRECIS
THUIDIACEAE	<i>Thuidium matarumense</i>	PRECIS
THYMELAEACEAE	<i>Englerodaphne pilosa</i>	Acocks
THYMELAEACEAE	<i>Gnidia kraussiana</i> var. <i>kraussiana</i>	PRECIS (KZN)
THYMELAEACEAE	<i>Gnidia phaeotricha</i>	Acocks
THYMELAEACEAE	<i>Gnidia phaeotricha</i>	PRECIS
THYMELAEACEAE	<i>Gnidia pulchella</i>	PRECIS
THYMELAEACEAE	<i>Gnidia similis</i>	PRECIS
THYMELAEACEAE	<i>Gnidia sp.</i>	PRECIS
THYMELAEACEAE	<i>Passerina montana</i>	PRECIS
THYMELAEACEAE	<i>Peddiea africana</i>	Acocks
TYPHACEAE	<i>Typha capensis</i> *	Anel Geer
UMBELLIFERAE	<i>Peucedanum magalismontanum</i> *	Anel Geer
URTICACEAE	<i>Didymodoxa caffra</i>	Acocks
URTICACEAE	<i>Laportea alatipes</i>	PRECIS (KZN)
URTICACEAE	<i>Laportea peduncularis</i> subsp. <i>peduncularis</i>	PRECIS
VALERIANACEAE	<i>Valeriana capensis</i> var. <i>capensis</i>	PRECIS (KZN)
VELLOZIACEAE	<i>Talbotia elegans</i>	PRECIS
VERBENACEAE	<i>Lantana rugosa</i>	PRECIS
VERBENACEAE	<i>Lippia javanica</i>	PRECIS
VERBENACEAE	<i>Stachytapheta urticifolia</i> *	Anel Geer
VERBENACEAE	<i>Verbena bonariensis</i> *	Acocks
VIOLACEAE	<i>Hybanthus capensis</i>	PRECIS (KZN)
VIOLACEAE	<i>Hybanthus enneaspermus</i> var. <i>enneaspermus</i>	PRECIS
VIOLACEAE	<i>Hybanthus parviflorus</i>	PRECIS
VIOLACEAE	<i>Rinorea angustifolia</i> subsp. <i>angustifolia</i>	Acocks
VIOLACEAE	<i>Rinorea angustifolia</i> subsp. <i>natalensis</i>	Gardens (KBG)
VIOLACEAE	<i>Viola tricolor</i>	PRECIS
VISCACEAE	<i>Viscum triflorum</i> subsp. <i>nervosum</i>	PRECIS
VITACEAE	<i>Cyphostemma hypoleucum</i>	PRECIS (KZN)
VITACEAE	<i>Rhoicissus rhomboidea</i>	Acocks
VITACEAE	<i>Rhoicissus tomentosa</i>	Acocks
VITACEAE	<i>Rhoicissus tridentata</i> subsp. <i>tridentata</i>	PRECIS
WOODSIACEAE	<i>Athyrium scandicinum</i>	PRECIS
WOODSIACEAE	<i>Athyrium schimperii</i>	PRECIS (KZN)
XYRIDACEAE	<i>Xyris capensis</i> *	PRECIS
XYRIDACEAE	<i>Xyris gerrardii</i>	PRECIS
ZAMIACEAE	<i>Encephalartos natalensis</i>	PRECIS

Collection Code

Acocks
Anel Geer
Bolus Herbarium
Gardens (KBG)
MSB
PRECIS
PRECIS (KZN)
Protea Atlas

Collection Information

John Phillip Harison Acocks Field Notes
Anel Geer (University of KwaZulu-Natal)
Bolus Herbarium (University of Cape Town)
Kirstenbosch Botanical Gardens (Cape Town)
Millenium Seedbank (Royal Botanic Gardens and SANBI)
National Herbarium Pretoria Computerised Information System
National Herbarium Pretoria Computerised Information System (KZN)
Protea Atlas (SANBI)

*Noted at Dartmoor Vlei as part of the vegetation analysis and pollen reference collection

APPENDIX Q

Disclaimer

Figure 3.1 Location of Dartmoor Vlei, Mt Gilboa, KwaZulu-Natal in South Africa. Position of sediment cores (DA1; DA2) extracted from Dartmoor Vlei

Figure 5.1 Location of Braun-Blanquet vegetation sampling quadrats in Dartmoor Vlei and immediate surroundings

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Colin Holmes