DETECTING ENVIRONMENTAL CHANGE AND ANTHROPOGENIC ACTIVITIES ON THE LAIKIPIA PLATEAU, KENYA

By

Muiruri V. M.

Earth Science Department

Palynology Section

National Museums of Kenya

P.O Box 40658 00100

Nairobi, Kenya.

Thesis submitted for the Degree of Masters (MSc)
At the University of the Free State
Department of Plant Sciences
Bloemfontein, South Africa

Supervisor: Robert Marchant (Dr.)
: Louis Scott (Prof.)
: Paul Lane (Dr.)

February 2008

Table of content

PART ONE

CHAPTER ONE: RESEARCH PHILOSOPHY, CONTEXT AND THESIS OUTLINE

1.1 Structure of the thesis

This thesis is arranged into three parts. Part One comprises five chapters detailing the introduction and background to the thesis and the study area. Part Two contains three chapters detailing the methods and results. The discussion and conclusions chapters form Part Three. The first chapter in Part One presents the structure of the thesis, project background, the aim and objectives of the research, guiding research questions of the thesis. The second chapter describes the present-day environmental and climatic setting of the Laikipia Plateau of East Africa in terms of geology, topography, drainage, climate and flora. Chapter Three describes the ecology and management of the study area. Chapter Four presents sources of evidence used to reconstruct past environmental conditions and socio-cultural changes of the Laikipia Plateau over the late Holocene. Chapter Five describes the past and present day environments of archaeological sites on Laikipia Plateau.

Part Two is arranged into three chapters detailing the laboratory-based methods used to reconstruct past ecosystem shifts. The procedures for sediment analysis, including radiocarbon dating of sediments, are also described. The third part contains two chapters comprising the discussion of the results and the thesis conclusions.

1.2 Aim, concepts and context of the research

Lake, swamp and bog sediments trap evidence from the surrounding environments for paleoenvironmental reconstruction (Lamb *et al*., 2003; Mworia-Maitima, 1997; Darbyshire *et al*., 2003). In addition to pollen, other proxies such as charcoal (Long *et al*., 1998; Gasse, 2002), grass cuticles (Mworia-Maitima, 1997; Wooller *et al*., 2000) and diatoms have proven to be very useful tools for paleoenvironmental reconstruction.

The use of a multiproxy approach enables paleoecologists to be more accurate in reconstructing the paleoenvironment (Boyd and Hall, 1998) because different proxy record represent different components of the environment.

In this particular study, pollen, fern-spore, fungal spore and charcoal analyses have been applied to a series of radiocarbon dated sediment sequences to describe ecosystem changes that have taken place on the Laikipia Plateau in Rift Valley Province, Kenya over the late Holocene. Relatively few palaeocological reords have been generated from this area. The justification of choosing this particular area is because there is reasonably a well resolved archaeological record that can be compared with palaeoenvironmental data. Hence, the stratigraphic records were taken from locations in the general vicinity of archaeological sites; thus providing an environmental backdrop to the archaeological record from the area. This proximity is vital to avoid pitfalls associated with research that correlates archaeological and palaeoecological results across different environmental settings (Marchant, 1997). The research focuses on the interactions between 'human' and natural factors in the ecosystem, and in particular the impact of climate, agriculture and subsistence pastoralism on the local environment. In addition to detailing the environmental backdrop to the *in situ* archaeology, results from this research will provide an insight on the pre-disturbance environment that will be relevant to current debates on land-use and resource management of Laikipia Plateau.

Despite considerable and growing interests on the inter-relationship between human impacts and environmental change, equifinality makes palaeoenvironmental signals difficult to separate (Taylor *et al.*, 2005). Climate change events (for example a shift to a drier climate) may produce the same signals, such as an increase in grasses, as a shift to increased pastoral activity. However, by applying a multi-proxy approach, and combining archaeological and palaeoecological investigation from the same locational context, it is possible to separate out these impacts, and indicate what impact cultures imparted on their environment, and how these impacts changed during periods of agricultural development (Robertshaw *et al*., 2004).

Accumulated sediments contain plant microfossils that reveal environmental change and human impacts on vegetation, such as pastoral development, control of livestock diseases through burning, and the use of fire that would result in a change of the flora and fauna characteristic of catchments (Cole *et al*., 2003). Studies of past human-environment inter-relationships often begin as discipline-specific attempts to expand the explanatory potential of results, for example, palaeoecologists may reconstruct a sequence of environmental changes and then consult the archaeological evidence for cultural changes that can be “explained” by their data (Marchant, 1997). On the other hand, archaeologists may try to interpret their findings with reference to the literature on climate change. Indeed, such cross-disciplinary research is often carried out in an over-simplistic manner that can lead to a misinterpretation of the results. Thus, to better understand late Holocene environmental history of the Laikipia Plateau it is nessecary to apply a multi-proxy analysis. Indeed, previous research (Leju *et al*., 2005) has demonstrated the importance of past environmental evidence for contextualising archaeological findings. This approach is particularly important when and where there are strong environmental impacts such as those following the introduction of iron working, changes in agriculture, transition to nucleated settlement patterns, the decline of these settlements and the arrival of new populations with different subsistence strategies (Taylor *et al*., 1999; 2000). Thus, there is a pressing need to bridge the divide that exists between palaeoenvironmental and archaeological evidence (Cole *et al*., 2003), this thesis contributes to bridging that gap by using several proxies to detect such trasitions and changes in the ecosystem and environmental histoty of an area. A major aim of the study is to determine the possible role of environmental changes surrounding occupation and settlement on Laikipia Plateau.

The main objective of this thesis is to present the environmental history of Laikipia Plateau Kenya over the Late Holocene against the context of previously researched archaeological sites in what is now an arid to semi arid area associated with significant environmental (including climatic) and socio-economic changes (Sutton, 1993). Notable among recent changes are a transition to drier, possibly more seasonal, climatic conditions (Robertshaw & Taylor, 2000; Taylor *et al*., 2000) and the introduction of pastoralism in the region from around 4000 yr BP (Sutton, 1993). Recently there have been significant changes in land use, substantial increases in population and the introduction of an agricultural economy to a formerly pastoralist system. Much of these changes in settlement and economic activities have been associated with the colonial legacy established from 1895 up to independence in 1963. Postcolonial changes in land use have also been dramatic with a re-organisation of land ownership that has also created a new state of social and land conflict.

The second obective of this thesis is to use the available evidence to examine the extent to which the changes in settlement and related environmental impact, evolved in the wider region on Laikipia Plateau. According to the archaeological record, hunter-gatherer populations exclusively occupied the area until around 4000 years ago when evidence for the presence of domestic stock and associated pastoralist material culture appears (Lane, in press). The archaeological evidence suggests that pastoralist activity intensified over the next three millennia, but there were periodic declines in pastoralist activity that may have been brought about by a shift in settlement possibly caused by environmental changes, similar but not identical to trends observed elsewhere in the region such as near the site of Munsa in Uganda (Robertshaw, 1997). Environmental drivers of change in occupational phases may have been caused by environmental degradation, arising from the over-exploitation of natural resources locally, and climate change, notably the repeated incidence of prolonged droughts (Robertshaw & Taylor, 2000).

1.3 Guiding research questions

- ❖ How has vegetation in Laikipia Plateau changed over the Late Holocene? According to White, (1983), *Acacia* bush land may be associated with degradation of Afromontane vegetation due to frequent burning, over-grazing and the activities of charcoal production, a phenomenon that this study intends to test.
- ❖ To what extent are environmental changes, including climatic variations, likely to have influenced changes in settlement and socio-economic conditions on Laikipia Plateau?
- ❖ Is it possible to identify and date significant changes of food production on Laikipia Plateau based on sedimentary evidence, and can these changes be related to processes, such as climate variation and the spread of food technologies?

CHAPTER TWO: ENVIRONMENTAL SETTING OF LAIKIPIA PLATEAU

This chapter describes the geography, physiography and climatical setting of the Laikipia Plateau and reviews the environment and present vegetation ecology of the study area.

2.1 Geographical and climatic setting

2.1.1 Physiography

The research focuses on the Laikipia Plateau which is located between 0º17S - 0º45N and 36º15E - 37º20E in the northern part of the central highlands of Kenya in Rift Valley Province, and covers an area of c. 9, 723 sq.km (Fig 1.a and b). It exhibits considerable variation in relief, with altitude ranging between 1,500 m.s.l. in the area surrounding the Ewaso Ngiro River, to over 2,600 m.s.l. in the Marmanet uplands (Fig 1.c). Mt. Kenya and the Nyandarua (formerly Aberdare) Range in the south and the Great Rift to the west, border Laikipia Plateau; to the north and east, it merges gradually into low-lying plains.

Fig 1a: Location, main geographical and topographical features of East Africa and in more detail for the Laikipia District (Afri cover ILRI-UNEP 2000).

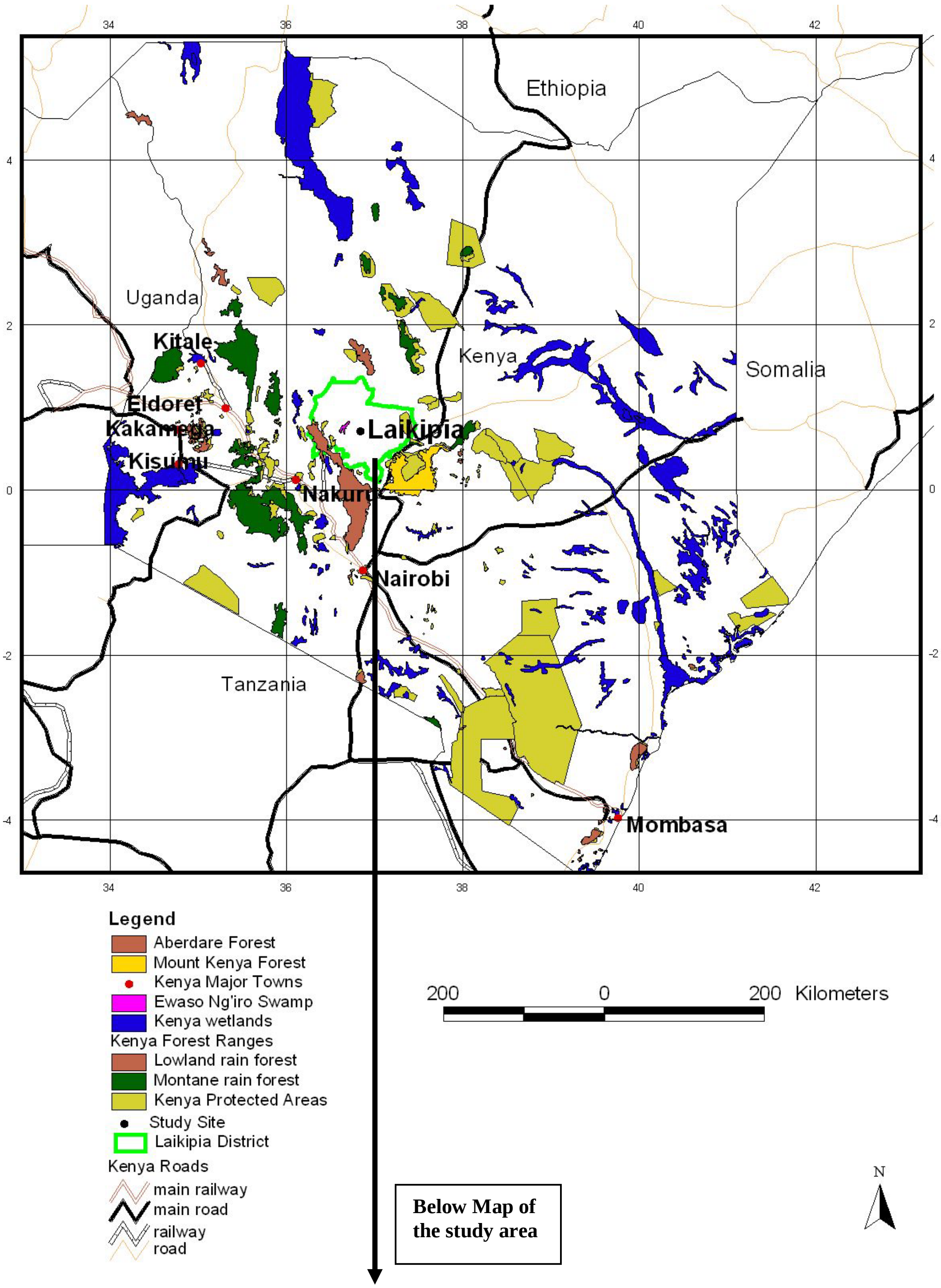
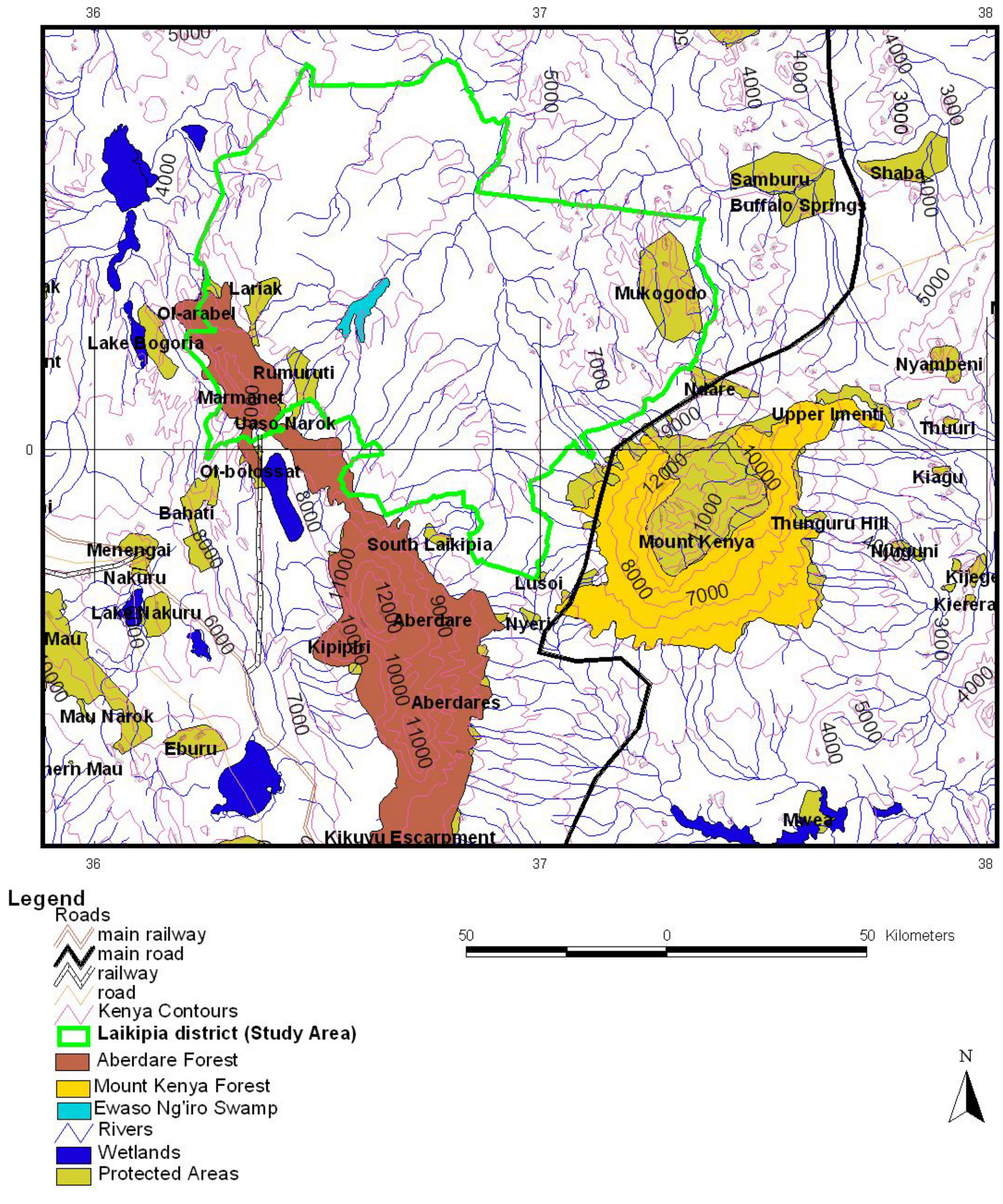


Fig 1b: Detailed map of the study area



Laikipia Plateau can be divided into four main regions based on its physiographic features that describe the landscape of the area (Fig 1.c).

i) The South Western Plains dominate much of the southern and central part of the district.

ii) The Western Highlands comprise those elevated landmasses of the Marmanet Ridge and Aberdares.

iii) The South Eastern Highlands comprise Mt. Kenya and its foothills.

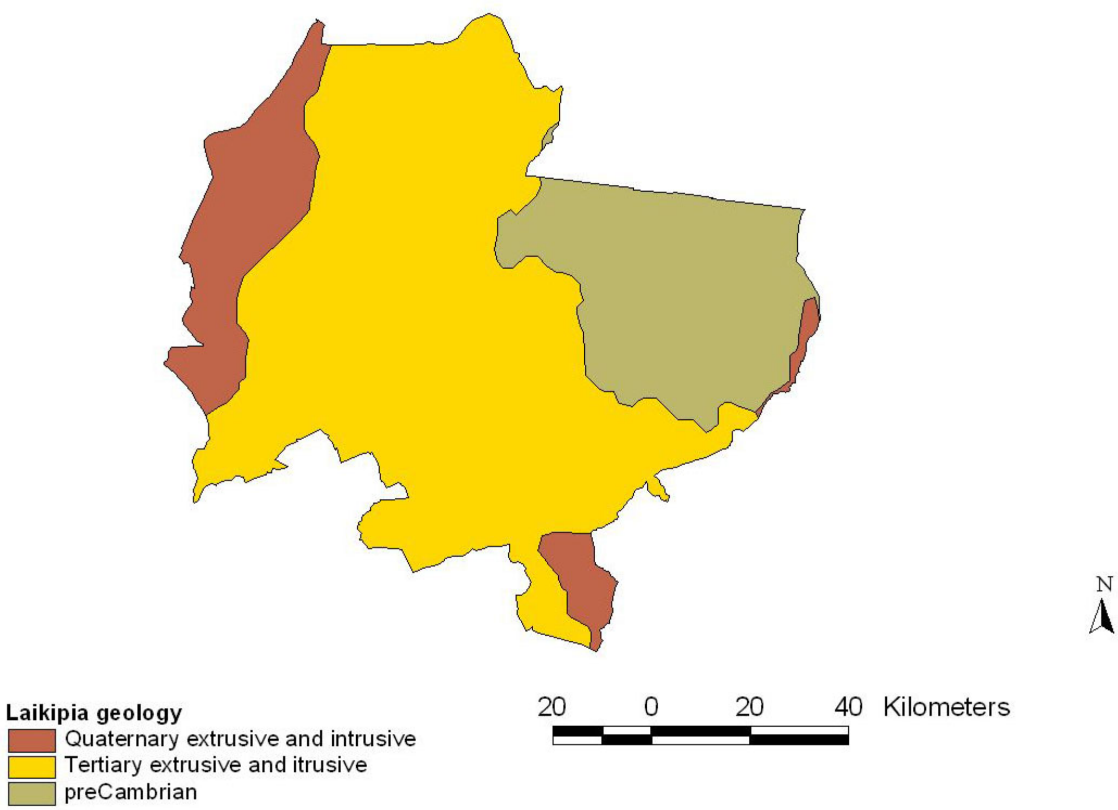
iv) The Eastern Uplands comprise the Lolldaiga Hills and Mukogodo Mountains that border Isiolo district.

Fig 1c: Physiographic features on the area and location of the coring sites and spatial relationship to archaeological excavations on Laikipia Plateau (Landsat Images 1980) Google Earth.

2.1.2 Geology

There are three main geological formations on Laikipia Plateau; Tertiary volcanic rocks consisting of nearly horizontal layers of Phonolitic lava of Miocene age (Rumuruti Phonololites) in the west, and basement rock (granites and gneisses) of the Pre-cambrian complex in the east (Fig 2).

Fig 2: Basic geology of Laikipia Plateau (**Afri cover ILRI-UNEP 2000)**



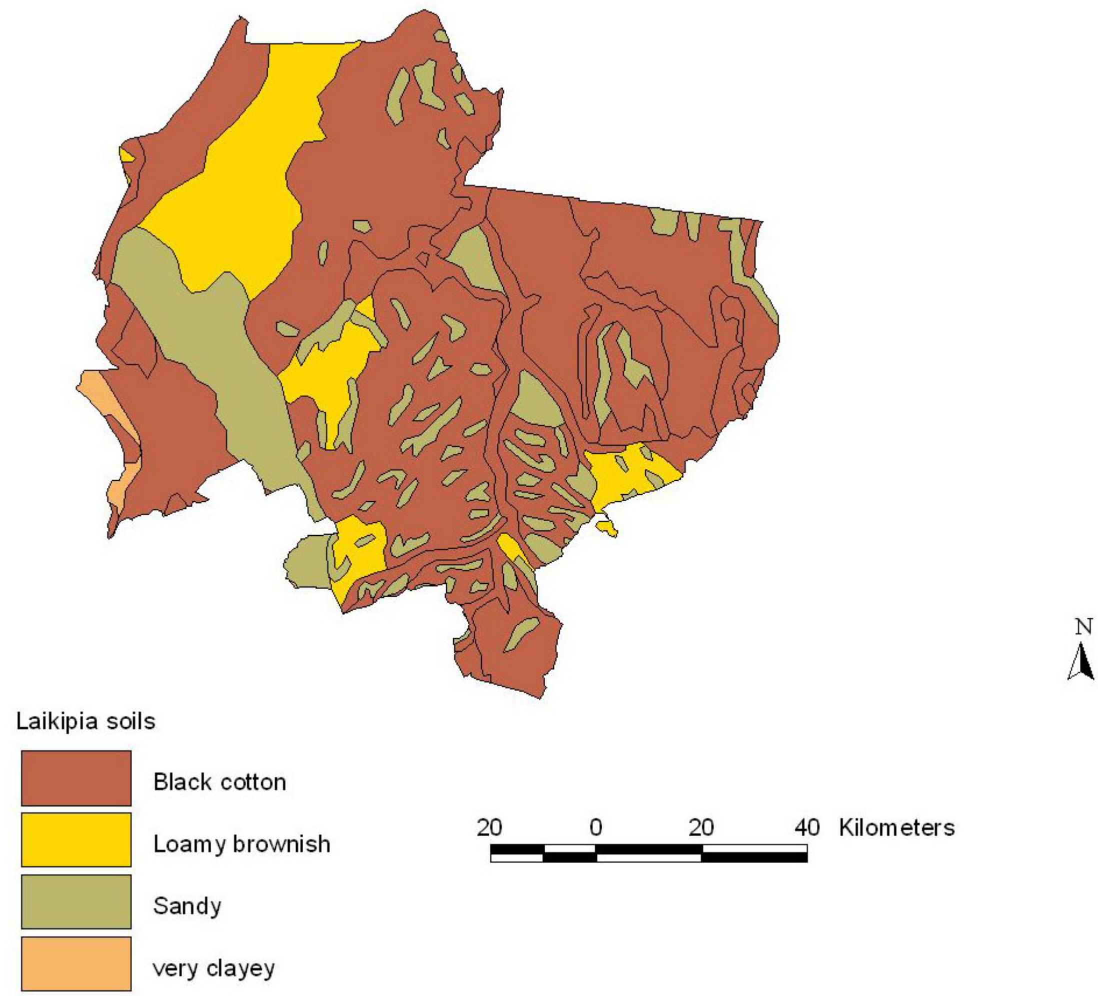
Phonolitic lava, resting on the basement complex, and originating from the fissures on the Laikipia Plateau escarpment, forms the high plateau, which inclines gently eastwards from a general elevation of approximately 2100-2200m at the escarpment to approximately 1800m at the eastern edge of the phonolite plateau.

The zone forms an undulating terrain mainly under 1500m, with some low peaks running in a north-south direction reaching 2300-2400m in the eastern part of Laikipia Plateau (Lolldaiga Range). Thus, a basin exists in the central part of Laikipia Plateau through which the upper course of the Ewaso Nyiro flows. The phonolite escarpment is eroding irregularly westwards forming several step-like surfaces, forming a wide ridge where the lower reaches of the Ewaso Narok now flows. The basement complex is thus uncovered by erosion but only small hills and low ridges are seen above the colluvial debris resulting from the erosion and covering most of the slopes (Lind and Morrison 1974).

2.1.3 Soils

The Laikipia Plateau is characterised by a very poor drainage with the compact, soil types commonly called "black cotton soils" (Lind and Morrison, 1974). Below the escarpment, the basement complex is comprised of brownish and reddish loamy sandy soil types. Although these soils are infertile and strongly leached, on slopes with moderate rainfall, the lateral seepage of water keeps the top soil rich enough in plant nutrients to support relatively dense bush vegetation (Siiriäinen, 1984). There also some parts characterized by hard compact clayey soils (Fig 3).

Fig 3: Soil types of Laikipia Plateau **(Afri cover ILRI-UNEP 2000)**



The southern and southeastern parts are characterised by less agriculturally productive clay soils, and are mainly used for ranching. The northern and northeast region is generally dry with poor sandy soils with some pockets of clay. Within the Laikipia Plateau, depressions are characterized by dark grey to black 'vertisols' and 'planosol' soils, which are unsuitable for crop production (Government of Kenya, 1994). Towards the south and southwest of Laikipia Plateau, red-brown soils are fertile and good for crop production.

Black cotton soils and greying clay volcanic loams dominate the western plains and northern parts of the Aberdare range (Ngobit plains) that occur mainly in the area between Rumuruti and Nanyuki, with patches in Nyahururu, Ol Arabel and the Marmanet uplands.

The southeastern highlands have red volcanic loam soils that are suitable for coffee and support other agricultural activities; however, this is only a small percentage of the whole district.

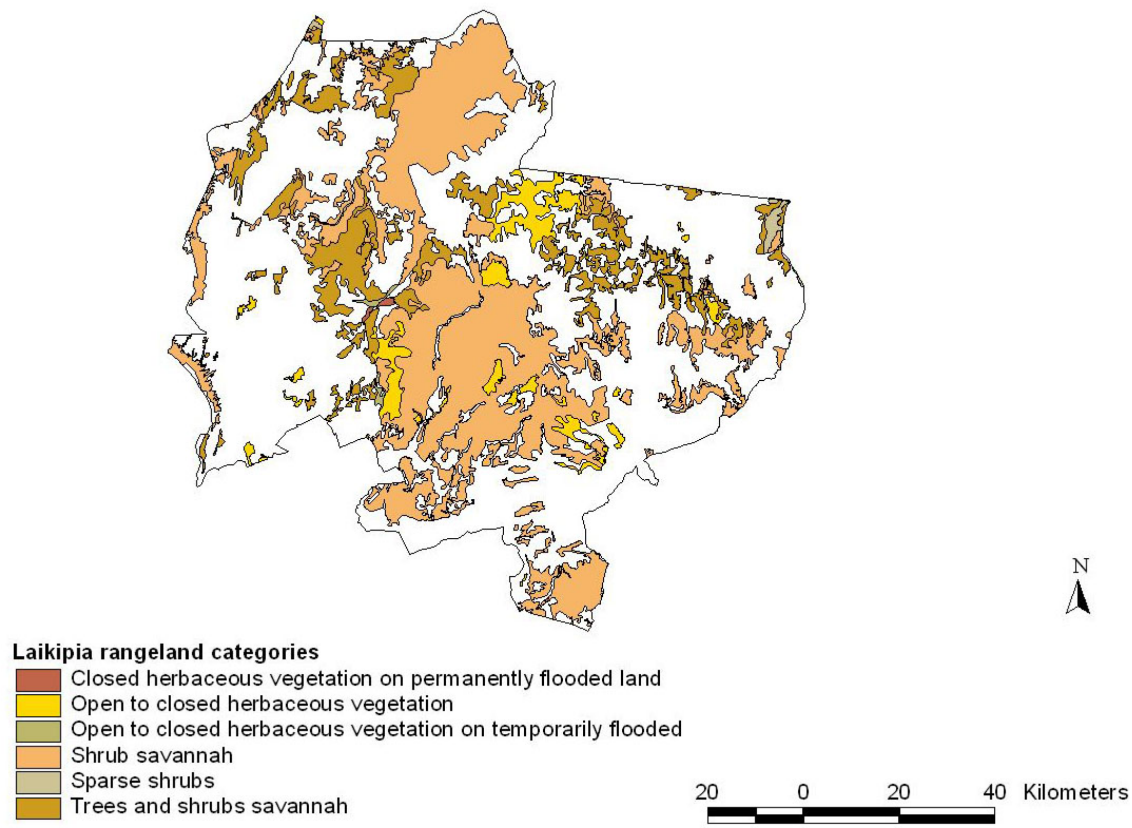
2.1.4 Hydrology

Water from the district drains northwards through the Ewaso Nyiro river with perennial tributaries such as the Sirimon, Oltalele, Liki and the Timau joining to form the Nanyuki River, all originating from Mt. Kenya. The Pesi Mutara, Engare Nyiro, Enkare Narok, Ngobit tributaries, emanating from the Aberdare range, drain into the Ewaso Nyiro river further north. Lake Bogoria and Baringo border Laikipia Plateau on the west while Mt. Kenya and the Aberdares form the southern boundary. Most settled areas have limited water for livestock and the rivers are heavily utilized for irrigation of horticultural crops. Surface water is otherwise limited with a few dams on the ranches that last throughout the year, except in drought years. Movement of wildlife during the dry season is largely dictated by the availability of water.

2.1.5 Vegetation ecology

Laikipia Plateau belongs to semiarid and arid eco-climatic zones which are considered good rangelands (Fig 4) under conditions of moderately high rainfall (Lind and Morrison, 1974). The natural vegetation is an expression of environmental conditions: on the central plateau, dry savannah is dominated by *Acacia* and *Themeda* species that give way to thorn savannah towards the north with *Acacia drepanolobium*, *A. tortilis* and *Croton dichogamus* becoming the common tree species.

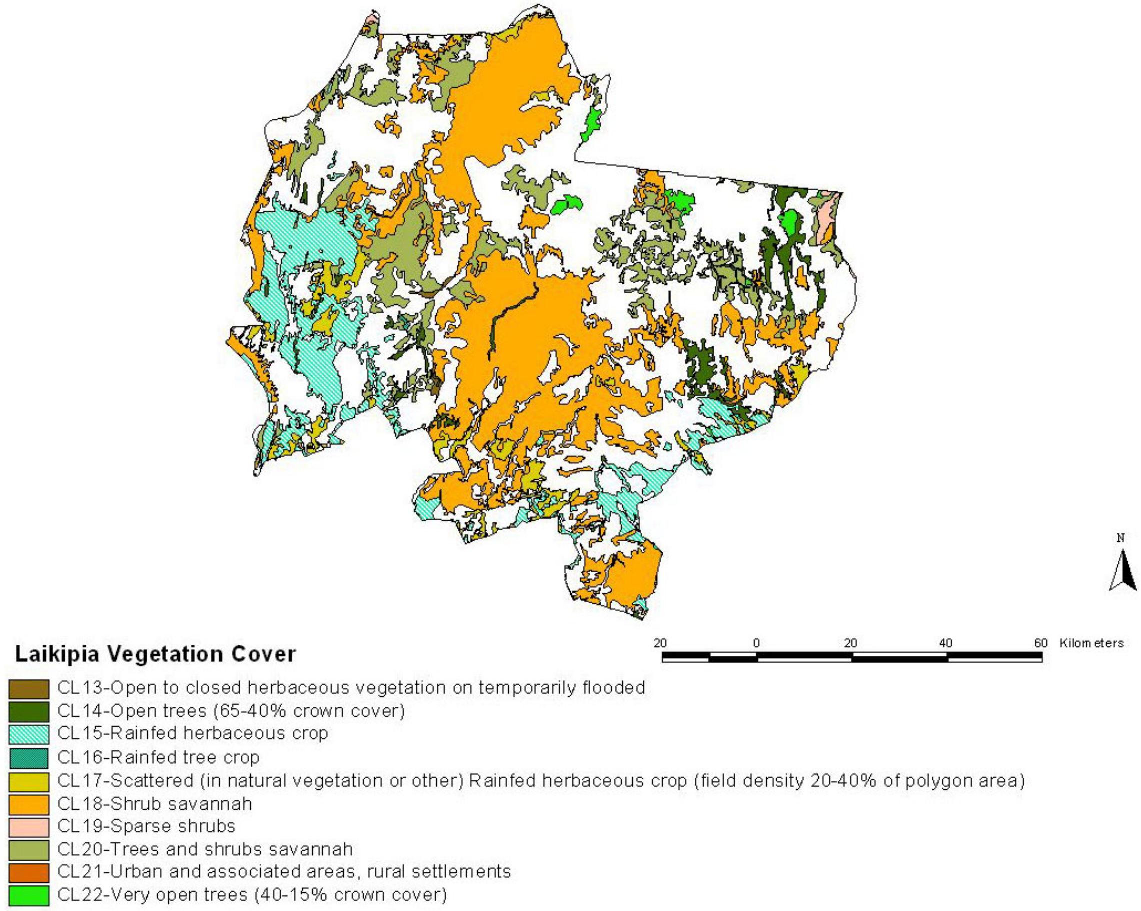
Fig 4: Types of range lands on Laikipia **(Afri cover ILRI-UNEP 2000)**



The soil supports sparse open grassland vegetation with scattered *Acacia* bushes. In much of Laikipia Plateau, probably because of rather heavy grazing by both wild and domestic animals, the undergrowth is very sparse. Bush, consisting mainly of thorned *Acacia* spp. and *Themeda triandra* grass, in parts is almost impenetrable. Without grazing and clearing by people through fire, large areas would revert to bush thicket. According to Lind and Morrison (1974), much of the grassland in Eastern Africa is maintained in that condition by regular burning and the grazing of wild or domestic animals such as in the case of southern and central Laikipia Plateau.

Laikipia Plateau is divided into the following vegetation types as shown in Fig 5.

Fig 5: Vegetation types of Laikipia Plateau **(Afri cover ILRI-UNEP 2000)**



i) Leafy bush land and thicket consisting of shrub thickets of *Carissa edulis* and *Themeda triandra* found in the north western and eastern part of the district (Fig 5, CL 13).

ii) Degenerate dry upland forest of *Euclea divinorum Juniperus procera.* (Fig 5, CL 14)

iii) Riverine upland forest: consisting of tree vegetation occurring along riverbanks and they are evergreen forest communities (Taiti 1992). *Ficus sycamore, Olea europaea* and *Podocarpus millianjus* dominate the area.

This type of vegetation is found mainly in Rumuruti forest, Mukogodo forest, and on the Lariak, Marmanet and Lolldaiga hills. (Fig 5, CL 16)

iv) *Acacia drepanolobium* bush land dominates most of the district growing on the vertisols in flat areas that are poorly drained interspersed by *Themeda* and *Pennisetum mezianum* grasses. These areas form good habitat for giraffes, elephants and impalas (Fig 5, CL 18).

v) Leafy bush lands found on Laikipia ranches in the west are dominated by *Tarchonanthus* and *Rhus natalensis* bushes (Fig 5, CL 19).

vi) *Acacia seyal* bushlands comprising of *Acacia seyal* and *Themeda triandra* grasslands dominate the central parts of the district in areas around Rumuruti.

Dwarf grass bush and patches of grassland dominated by *Aristida spp*, *Pennisetum mezianum* and *Themeda triadra* (Fig 5, CL 20) cover the rest of the district.

Vegetation at Marura comprises low, open, grazed, species-rich grassland grading into *Acacia*, *Euclea divinorum* bush land; the commonest grasses are *Cynodon dactylon* and *Pennisetum stramineum. Euclea divinorum* is a common regenerating tree species, while Ewaso Narok is an area of bushy grassland composed of *Acacia drepanolobium, Acacia seyal, Aristida spp, Croton dichogumus, Pennisetum mezianum*, *Solanum sp* and *Themeda triandra*.

2.2 Climate

2.2.1 Climate of East Africa

Subtropical high-pressure areas situated about 20-30^o north and south of the equator are important controls on the climate of tropical Africa. These subtropical high-pressure cells tend to move north during the northern summer and south during the southern summer. The northeast trade winds, which flow out from the North African and Arabian high-pressure cells, are very dry and often laden with dust. South-east trades, coming off the Indian Ocean, constitute the dominant air-stream over East Africa in July, but, although deep, because the air-stream is divergent their passage does not result in a July rainfall peak over most of the region.

As well as the trade winds, the western part of East Africa is also under the influence of moist westerlies coming across the Congo basin, originating in the South Atlantic. Rainfall data from East Africa indicate that most rain occurring during the passage of the inter-tropical convergence zone (ITCZ). The ITCZ is the ill-defined low-pressure zone where the north-east and south-east trades converge and is characterized by convectional rainfall. The ITCZ migrates north and south with the sun, and there is a tendency for there to be two well marked wet seasons near the equator, but only one further to the north or to the south.

Climate variations related to latitude, distance from the coast and topography are complex (Kenyworthy, 1966). The association of rainfall maxima with highland areas invariably results in great variations in precipitation related to aspect and altitude. On Mt Kenya, for instance, highest rainfall probably occurs at an altitude of 2500-3000m, much less rain is received in the north than the southwest, the latter facing the local direction of the south-east trades. Lake Victoria, and to a lesser extent other large lakes, modify regional climatic patterns (Kenyworthy, 1966). The heavy rain on the western and northern margins of Lake Victoria is associated mainly with the presence of the large water body and, in the case of Lake Malawi, the funnelling of air northwards along the lake.

Potential evapotranspiration is defined as the quantity of water that would be evaporated from a vegetated surface if water input were maintained at such a rate as to always meet plant needs. The difference between potential and actual evapotranspiration determines water deficit or surplus. It is estimated that only approximately 3 % of the land surface of East Africa regularly receives annual rainfall in excess of potential evapotranspiration (Morgan, 1973). Extensive areas are subject to severe water deficit and have little potential value for agriculture (Table 1). Kenya, with its vast semi-arid north-east territory, including areas like Laikipia Plateau, the arable lands are over utilized because of surplus rainfall in some years while the more arid areas are only suitable for pastoralism because of the low annual rainfall.

2.2.2 Climate of Kenya

The temperature in Kenya shows the characteristic pattern of inner tropical regions with large diurnal temperature oscillations, (Troll, 1959) but small amplitude of annual variation. Because of Kenya's equatorial position, the daylight period is nearly constant all year round. The areas east of the Rift Valley are characterized by two rainy seasons following the equinoxes. The "long rains" last from March to June and are followed by the short dry season from July to September, while the so-called "short rains" last from October to November and are followed by the long dry season from December to February (Sansom, 1954; Criffiths, 1958, 1972 Asani & Kinuthia, 1979; Brown, 1986). This pattern follows the seasonal migration of the ITCZ and the trade wind systems. High solitary mountains like Mount Kenya usually modify the wind system, which shows four main currents (Findlater, 1968).

- The SE monsoon from June to October to the end of April, carrying dry masses from Egypt and the Sudan.
- The SE monsoon from June to October carrying moist air from the Indian Ocean.
- The SW monsoon, mainly active in western Kenya, from June to October, is dependent on the strength of the South Atlantic anticyclone and the seasonal position of the equatorial low-pressure zone.
- "Easterly disturbances" occurring frequently during the equinoctial transitions (Coetzee, 1967) and during the short dry season at the coast (Gichuiya, 1974).

2.2.3 Climate of Mt Kenya and Laikipia

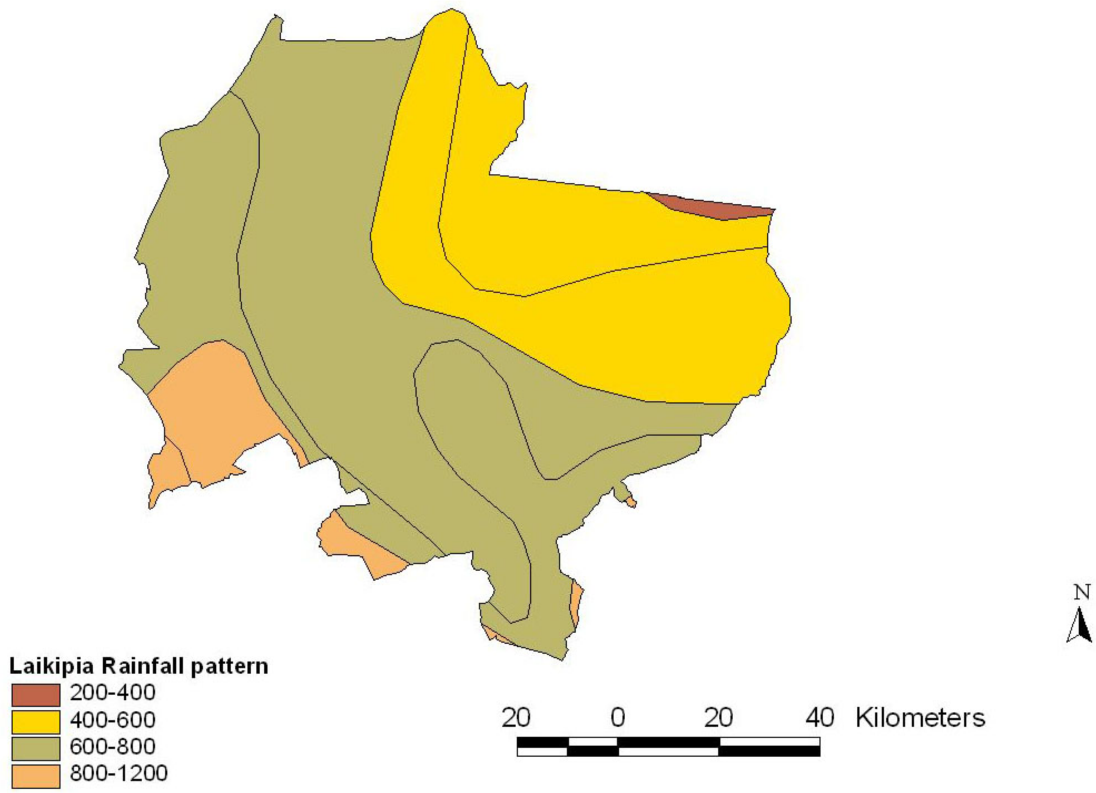
The Mount Kenya region is included in the general circulation patterns described above. Troll and Pfaffen (1964) excluded the climate of tropical high mountains from their climatic definitions (using the seasonal value of temperature, precipitation and illumination for the classification) and termed it "*Gebirgstklima* (mountain climates)". Combining thermic and hygric parameters, Lower (1975) described the tropical high mountains as true tropics and the Mount Kenya area as "*feuchte Kalthropen*" (moist cold tropics).

According to Jatzold (1977, 1981), the Mount Kenya temperature regimes range from "tropically moderately cool" to "tropically very cold", with a mainly humic hygric regime. Hedberg (1964a & 1964b), used the term "afroalpine climate" for the climate above 3500-4100, which he described as "winter every night, summer every day". However, the climate of Laikipia Plateau is influenced by the rain shadow of Mt. Kenya and the high altitude of the plateau as stated above (2.6.1 and 2.6.2).

2.2.3. i. Rainfall

The Laikipia Plateau is situated close to the rainiest areas in East Africa, the Nyandarua Range and Mt. Kenya where annual precipitation reaches approximately 2000 mm yr^{-1}. However, the rainfall gradient from surrounding elevated high-rainfall areas to the north is strong, where the southern and western parts of the Laikipia Plateau receive only 500-700 mm yr^{-1} and the central and northern part 300-500 mm yr^{-1}. Rains fall mainly in two seasons, 80% of the total annual rainfall account from March to May (the long rains) and October-November (the short rains). In most of Laikipia Plateau, rains are unpredictable and drought years are frequent (Hackman, 1988). Rainfall is highest on the slopes of Mt. Kenya in the eastern highlands and on the slopes of Aberdares in west Laikipia Plateau, receiving 800-900mm yr^{-1}. Most of the area receives 500-700mm yr^{-1} (Fig 6).

Fig 6: Rainfall pattern in Laikipia Plateau (Afri cover ILRI-UNEP 2000)



2.2.3. ii. Temperature

The mean annual temperature lies between 16°C and 24°C decreasing in value with increasing altitude (Siiriäinen, 1984). There are very strong diurnal temperature oscillations, warm temperature and cold. Temperature regimes range from "tropically moderately cool" to "tropically very cold", with a mainly humic hygric regime.

CHAPTER THREE: ECOLOGY AND MANAGEMENT OF THE AREA

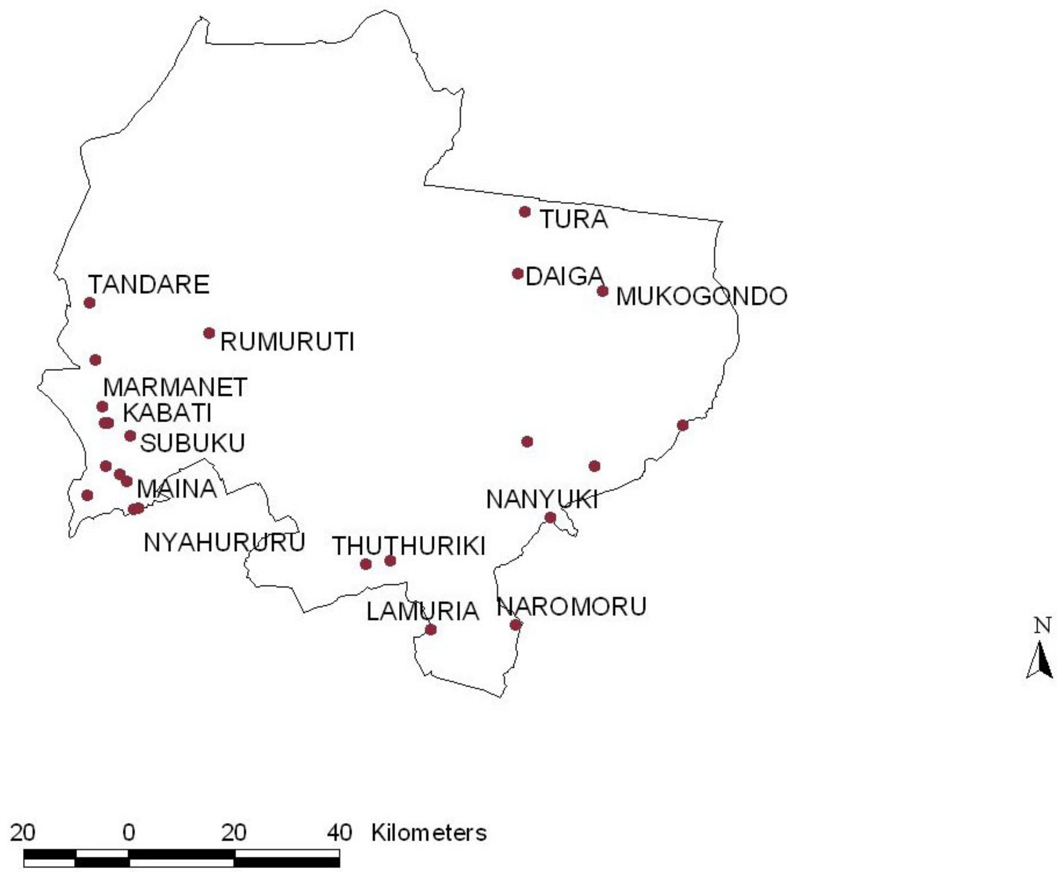
This chapter describes the land transformation and land-use systems, ecology, biodiversity, and conservation / current management of the Laikipia Plateau.

3.1 Land tenure and settlement

Laikipia Plateau is largely open savannah grassland home to abundant and varied species of wildlife. Traditionally, the Laikipia Plateau was home to pastoralist Maasai (mostly belonging to the Purko section). The Maasai were moved to Narok and Kajiado by colonial administration following the signing of an agreement (still highly disputed) in 1911 between their spiritual leader Laibon Lenana and the colonial authorities. This agreement paved the way for white settlers to occupy much of the Laikipia Plateau. During the early colonial era, the district was divided into large-scale ranches and settled by white farmers. Farms ranged from 20,000-100,000 hectares. After independence, many but not all of these European settlers gradually withdrew from these ranches and sold them to private individuals and land buying companies who later subdivided them into small farms. Fifty-five percent of Laikipia Plateau is still devoted to large-scale commercial ranching, 28% is used for small scale farming, 8% is covered by group ranches communally owned by the Mukogodo Maasai for grazing and 9% is covered by forests, urban areas and swamps (Government of Kenya, 1994). Of the small-scale farms, about 20% were occupied under government settlement schemes while 20% were bought by land buying companies. People from the neighbouring Nyeri district bought most of the small-scale farms. Due to the semi-arid conditions, some of the land settlement has been very slow.

The settlement pattern in the Laikipia Plateau as indicated in Fig 7 shows it is concentrated in areas where moderate rainfall is experienced.

Fig 7: Settlements pattern on Laikipia Plateau (Afri cover ILRI-UNEP 2000)

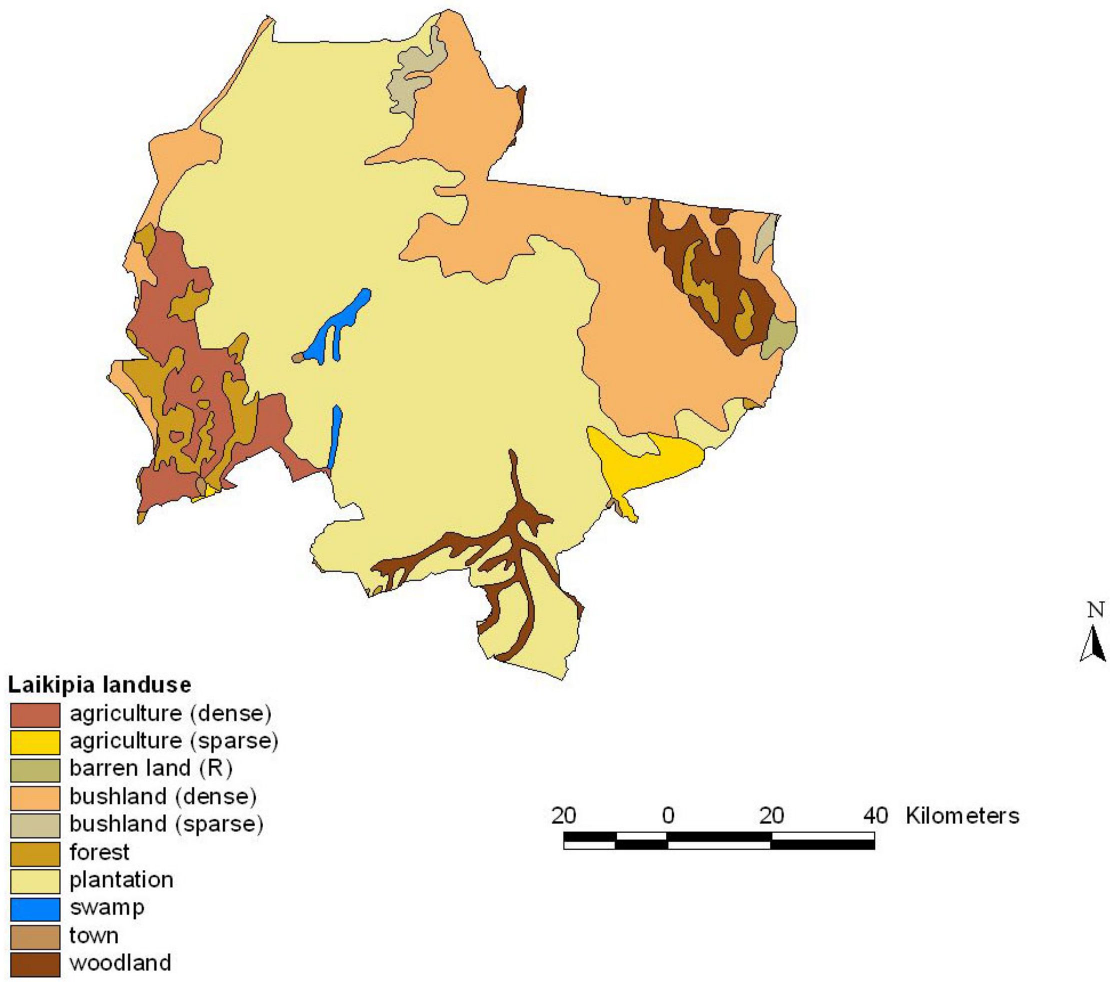


3.2 Land use transformation

Before 1970, extensive land use comprising mainly ranching and community grazing by a pastoral community dominated the entire district (Taiti, 1992a). However, the advent of independence saw increased freedom of movement, property ownership and population increase which was accompanied by land transformation into small scale plots of 2-10 ha (Thenya, 1998). Most of these immigrants came from the neighbouring and agriculturally high-potential districts like Meru, Nyandarua, Nakuru, Embu, Nyeri and Kiambu (Thenya, 1998). The western parts of Laikipia Plateau around Rumuruti forest and Ol Ngarua division in particular are areas of high potential agriculture (Fig 8).

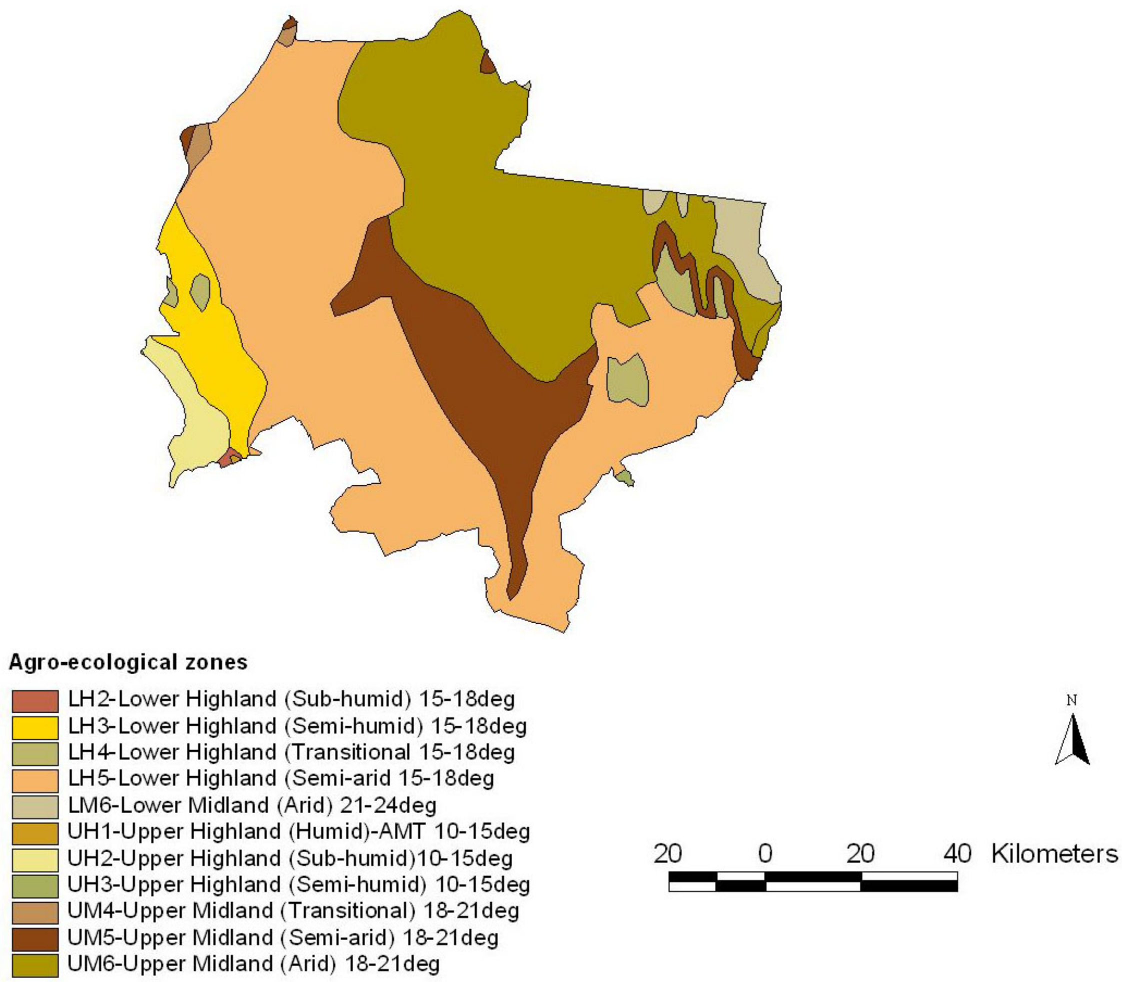
The rest of the Laikipia Plateau is unsuitable for arable agriculture. The Laikipia Plateau is primarily a ranching area with lower and mid- altitude areas being suitable for livestock (see Table 1 below).

Fig 8: Landuse on Laikipia (Afri cover ILRI-UNEP 2000)



The Laikipia Plateau spans across Agro-Ecological Zone (AEZ) II, IV, V and VI. Most of the Laikipia Plateau is in zones IV and V, which are suitable for ranching (Fig 9). The AEZ are presented in Table 1 below.

Fig 9: Agro-ecological zones of Laikipia Plateau (Kenya a-e zones 1998)



However, some of this has been transformed into arable land in uneconomical farm units. Pastoralism is practiced in the north-eastern area by Mukogodo Maasai. Due to the pressure of land in the neighbouring districts like Nyeri, land-buying companies bought land and later subdivided it into parcels ranging from one to five acres. People from neighbouring districts have been trying to practice arable farming, particularly growing maize and beans, with little success.

Results of a study undertaken in Sirima, Tigithi, Mutara, Salama and Olmorani location have shown persistent crop failures for as many as five successive years (Government of Kenya, 1994). This has led to some of the people becoming discouraged and abandoning the farms to seek employment in Nairobi, Nyeri, Nanyuki and Nakuru. Those who have persevered still rely on their original home districts for food while others rely on famine relief. Livestock keeping was successful in the 1970s and 1980s but during the 1990s increasing cattle rustling between Maasai and these other communities has discouraged most settlers.

Former hunter-gatherers have slowly been changing to agro-pastoralist activity. While this change sounds positive in terms of the region’s food sufficiency and security, it also exerts great pressure on the few water resources available and contributes to reductions in macrophyte and riparian vegetation cover through harvesting for use as building materials, hence destroying natural habitats in the process. This also interferes with important dry season grazing zones and puts subsistence farmers into direct conflict with wildlife and pastoralists who have to use the wetland as grazing land. Due to the increased irrigation, the water available from the wetlands and rivers is not adequate to meet demand, hence the increasing conflicts between farmers for water. The local administration has to intervene on frequent occasions to solve water-related conflicts.

3.3 Agro-Ecological zones

The Agro-Ecological zones and sustainability of the Laikipia Plateau is clearly defined below as the areas that are of high to low potential in reference to the climatic variability.

Table 1: Agro-Ecological Characteristics of the district (Laikipia Research Programme, 2002)

Zone (rainfall in mm)	**Characteristics**	**Hectares**	**%**	**Suitability**
II. (900-1200)	High potential sub humid climate	61,855	5	Wheat, dairy farming, maize, potatoes
1V. (600-800)	Arable land semi-humid and semi arid	376,604	28	Potatoes, maize, beans, dairy farming
V. (500-700)	Ranching and arid climate	661,479	49	Ranching and wildlife
V1. (400-500)	Pastoral and arid climate	242,310	18	Pastoralism and wildlife

Arable agriculture is suitable in zone II (Table 1) that comprises of 5% of the total area, and zone IV, found in western Laikipia in Rumuruti and Ngarua Divisions. However, arable agriculture is also practiced in zone V (Table 1 & Fig 8) in Rumuruti, Lamuria and central divisions, where erratic rainfall and shallow soils are a limiting factor (Kiteme *et al.*, 1998). Such areas do not produce high yields, as the average productivity of maize is five to eight bags per acre in a good year as opposed to 15 to 25 bags in zone II and IV. These areas also have high human-wildlife conflicts arising from crop damage and raiding.

About 30-40% of the farms in this area are settled in, leaving large areas as bush habitat for buffaloes and elephants. In such areas, farmers loose between 25-50% of the annual crop to elephants, buffaloes, zebra, eland and baboons (Kiteme *et al*., 1998).

Studies by the Laikipia Research Programme show that in Agro-Ecological Zone V an average family of eight would need about 3.1 acres to sustain themselves. However, in most of this zone, the families' plots average less than 3.1 acres, and are insufficient to sustain the people living on them.

3.4 Livestock production

Livestock ranching is practiced in about 70% of the total area. Pastoralists and large- and small-scale farmers across the district keep cattle, goats, sheep, donkeys and camels. Ranches such as Ol Pejeta keep about 8000 cattle and 2000 goats while most medium ranches keep an average of 3000 cattle with 800 sheep or goats. Most ranchers do not maximize the use of their land due to wildlife grazing; a ranch like Segera, for instance, has only 2500 cattle while it has the capacity of 5000 cattle without wildlife. Livestock predation by lions, leopards and hyenas is prevalent, mostly in central and Mukogodo divisions. Borana Ranch loses about 100 cattle worth about KShs.1.27million per year to leopards and lions. Ol Pejeta Ranch in 1994/95 lost 162 cattle to lions, leopards and hyenas estimated to cost over KShs 2million. There has been a marked change in attitude toward predators in the last decade or so – while some ranchers still see predators as a threat, the majority now see them as an economic asset, fueling the rise in high-end tourism across Laikipia Plateau. This change in attitude has been driven in part by the Laikipia Wildlife Forum. Laikipia Plateau used to produce 80-85% of the country's beef export, but this has since fallen to about 45% due to falling beef prices and changes in land use with a shift toward wildlife management rather than ranching.

3.5 Wildlife conservation and management

Laikipia Plateau harbours a wide diversity of large mammal species ranging from elephants, rhinos, buffaloes, lions, leopards, cheetahs, hyenas, to plains game species such as zebra, elands, oryx, kudu, hartebeest, waterbuck, Grant's and

Thompson’s gazelles, impala and giraffes. Five rhino sanctuaries exist on private land, hosting about half the population of black and white rhinos in the country. About 3000 elephants migrate between Samburu and Laikipia. Through the pilot cropping programme started by Kenya Wildlife Services, land owners are allowed to derive direct benefits from sale of game meat and skins. Other ranches have tended to reduce the number of livestock on their ranches to pave the way for wildlife as a land use activity (Government of Kenya, 1994).

CHAPTER FOUR: THE PAST ENVIRONMENTAL CONDITIONS OF THE LAIKIPIA PLATEAU OVER THE LATE HOLOCENE

This chapter reviews current literature concerning various sources of evidence used in the reconstruction of the past environments derived from sedimentary archive and documentary sources. Within this chapter, the environmental, cultural and socio-economic changes that have occurred during the Late Holocene on the Laikipia Plateau are discussed.

4.1 Sources of evidence from sediment for environmental changes in Kenya and East Africa

4.1.1 Pollen and other micro-fossils

In East Africa environmental reconstructions have been focused on swamp-and lake-sediment records (e.g. Livingstone, 1967; Morrison, 1968; Kendall, 1969; Morrison & Hamilton, 1974; 1982; Hamilton *et al*., 1986; Haberyan & Hecky, 1987; Taylor, 1988; 1990; 1993; Vincens, 1989; Casanova & Hillaire-Marcel, 1992; Marchant, 1997; Marchant *et al*., 1997; Marchant & Taylor, 1998; Taylor *et al*., 1999; Bonnefille & Chalie, 2000; Vincens *et al*., 2003; Alin, & Cohen, 2003).

Sediment-based material contains a range of proxies of past environmental conditions, including microfossils, among which pollen and spores are the most useful (Lowe & Walker, 1997). Pollen analysis has been a vital tool used in the reconstruction of Quaternary environments in East Africa (e.g. Livingstone, 1967; Kendall, 1969; Hamilton, 1982; Hamilton *et al*., 1986; Taylor, 1988; Marchant, 1997; Ssemmanda & Vincens, 2002; Ssemmanda *et al*., in press). Pollen preserved in the sediments provides a record indicating the surrounding ecosystems of past vegetation and within the catchment, this is usually regarded as a good indicator of the general environment of an area. Pollen is often present in a sediment sequence, allowing the reconstruction of vegetation change over time.

A number of environmental factors influence interpretation of pollen data; for example, pollen production, preservation and dispersal often tend to affect the representation of each pollen taxon in an assemblage (Birks & Birks, 1980; Feagri & Inversen, 1989; Lowe & Walker, 1997; Hamilton, 1976; 1982; Marchant, 1997; Bonnefille & Lezine, 2000). Some plants, for example, produce numerous pollen grains and spores, while others hardly produce any.

The interpretation of the above has seen two components: reconstruction of vegetation from the pollen record, and reconstruction of environment from the reconstructed vegetation. Other useful microfossils include charcoal, fungal spores and phytoliths. The chemical composition, including isotopic content, of sediments can also be used to reconstruct past environmental conditions. The use of pollen data in conjunction with other proxies, such as diatoms, isotopes and charcoal records, together with improved dating control (Alin *et al*., 2003; Russell *et al*., 2003; Stager *et al*., 1997, 2003; Thevenon *et al*., 2003), has led to an improved understanding of long-term environmental changes elucidating relatively recent environmental histories.

Additional proxies, such as the use of remains of fungal spores to enhance palaeoenvironmental studies (e.g. van Geel, 1978; 1986; 2001; van Geel *et al*., 1982, 1983; Davis, 1987; Innes & Black, 2003) have had limited application in equatorial Africa, where the initial attempts to analyse fungal spores in lake sediments was conducted by Wolf (1966). The parent taxa of some fungal spores can be associated with relatively precise ecological conditions. Some fungal species, and the presence of their spores are indicative of the levels of moisture, while others indicate the influence of human activities, such as burning, deforestation, animal keeping (herbivore dung) and eutrophication (van Geel, *et al*. 1982-83; van Geel, 1986; Davis, 1987; van Geel, 1986; van Geel, 2001). For example, fungal spores of the dung fungi *Sporormiella* and *Cercopora* are reported to be associated with the dung of herbivores, as well as decaying wood (Ahmed & Cain, 1972; van Geel, 1986; Davis, 1987; Innes & Black, 2003).

Spores of the fungus *Neurospora* indicate the occurrence locally of burning, while those of *Chaetomium* are associated with human settlements (van Geel, 1978; van Geel, 2001).

4.1.2 Fire history as a source of evidence for environmental changes

There are a number of methods used to infer information about past burning regimes. These include examining all components of a fire regime; in the form of charcoal preserved in sediments; using palynology and dendrochronology; (Clark and Robinson, 1992; Pyne *et al.,* 1996). For the Quaternary, fire history may be reconstructed from the fire scars on living and dead trees, from charcoal in terrestrial soil profiles, and from charcoal which has accumulated in lake sediments and in bogs (Clark and Robinson, 1992). The most useful evidence of past fire regimes comes from both macroscopic and microscopic charcoal preserved in the stratigraphic record of terrestrial soils and of lake and wetland sediments, as these can provide a measure of fire frequency and intensity within the catchment (Pyne *et al*., 1996).

4.1.3 Documentary records

Long-term records of water level fluctuations have provided a useful means of reconstructing the climatic history of the Eastern Highlands and Rift Valley in East Africa (Flohn, 1987; Nicholson, 1996; 1998; Conway, 2002). These records are available from the Nile River and from several of the Rift Valley lakes, including Victoria, Naivasha, Tanganyika, and Turkana. The Nile River provides the longest record of reliable measurements, covering more than the last 1000 years (Nicholson, 1996, 1998). The River Nile receives its water from two major sources, the White Nile, which drains most of its water from Lake Victoria, and the Blue Nile, which drains water from the Ethiopian highlands. The maximum flood levels are reported to be indicators of precipitation in the Ethiopian highlands, while the minimum levels, which relate to the early part of the Northern Hemisphere summer, are thought to reflect, to a degree, equatorial rainfall (Herrings, 1979; Nicholson, 1996).

The annual water levels in Lake Turkana have been recorded for several decades and correspond to reduced amount of rainfall in the catchments areas of Lake Victoria; this evidence is also registered in water levels from Lake Naivasha (Verschuren *et al*., 2000).

Evidence for drought induced famine, political unrest, and large-scale migration of indigenous inhabitants are believed to have occurred, on the basis of oral traditions, from around 1390-1420 AD (the Wamara famine), 1560-1625 AD (the Nyarubanga famine), and 1760-1840 AD (the Lapanarat-Mahlatule famine) in the area of modern day Malawi.. These famines have been found to correlate with the reconstructed sequence of Lake Naivasha low stands (Verschuren *et al*., 2000) and probably correlate well with reconstructed Nile River summer minimum levels. The Nile levels at the period from 1390 to 1420 AD and 1560 to 1625 AD were low, suggesting a continuous period of low precipitation, with the most extreme conditions occurring in the later part of the 1500 AD and early 1600 AD (Herring, 1979).

This homogeneity suggests that there must have been widespread water connections during relatively recent times across the whole region from the Senegal to Lake Turkana. Increased aridity and the loss of water bodies from some of these lakes have produced some evidence of environmental change.

4.2 A summary of sediment records from mid-to late-Holocene environmental history for the Laikipia Plateau based on published evidence

The climate history of the region from around 6000 yr BP to the present is registered in the sediment cores described by Taylor *et al*., (2005). The available data suggests that environmental conditions at Loitigon in Laikipia before 2300 BP were a response to higher levels of effective precipitation and lower levels of human activity than today. Sedimentary records from this flood plain on Laikipia Plateau suggest a period of relatively drier climatic conditions between around 6000-2300 yr BP.

The pollen record from Loitigon (Taylor *et al*., 2005), indicates a marked change in vegetation composition and distribution during mid to late Holocene from around 6000 yr BP to present. Afromontane forest vegetation experienced a marked transition from moist montane forest vegetation to a drier type of forest vegetation, in which *Podocarpus* was a common component from about 6600-2300 yr BP. Between this same period at around 3500 yr BP, areas around Lake Victoria (Kendall, 1969; Ssemmanda & Vincens, 2002) experienced a decrease in evergreen forest replaced by semi-deciduous forest. This was followed by a progressive decline of semi-deciduous forest replaced by grass dominated vegetation cover after around 2000 yr BP to present.

All pollen records from the region indicate the presence of more open forest vegetation after around 2000 yr BP, and this has been attributed to human-induced forest disturbance (Kendall, 1969; Ssemmanda & Vincens, 2002). Evidence for forest clearance is recorded for the Central Rift Valley at around 2200 and 800 yr BP (Taylor, 1990; 1993). These phases of forest clearance were thought to relate to technological innovation among the developing communities in the region (Taylor, 1990). Clearances of forest on the Laikipia Plateau appear, from the sediment records, to have been associated with fire (Taylor *et al* 2005). Similarly, but subsequently, a phase of increased forest clearance was also associated with a marked increase in the amount of charcoal in sediments from Loitigon dated about 1760 yr BP (Taylor *et al* 2005). Disturbances of forest on the Laikipia Plateau during the late Holocene, associated as they often are with indications of increased burning, presumably represent the impacts of early farmers or herders in the region. The introduction of agriculture to the wider region is commonly associated with Bantu-speaking people who are reported to have spread throughout much of central African after about 3000 yr BP (Schoenbrun, 1998).

Lamb *et al*., 2003 suggested that during the past 1100 yrs, lake level fluctuation reflects rainfall variability over the Rift Valley as well as surrounding highlands within the Naivasha catchment. The correlation between lake level and vegetation change indicates a direct vegetation response to climatic variation, with forest expansion to lower elevations during wet intervals, and contraction during droughts. Some of the evidence of climatic conditions, for instance in the form of records of past water levels in Lake Naivasha basins i.e the highest rainfall inferred from this basin over the past millennium was contemporaneous with the ‘Maunder Minimum’ of solar radition (Verschuren *et al*., 2000). Hence, variation in solar activity may have contributed to the changes in the palaeoclimate of East Africa as described above. Water levels in Lake Naivasha are reported to have dropped to relatively low levels between about 3340 and 2000 yr BP (Verschuren *et al*., 2000).

CHAPTER FIVE: ARCHAEOLOGICAL AND HISTORICAL EVIDENCE FOR HUMAN IMPACT ON ENVIRONMENT

This chapter describes the history of pastoralism and the cultural changes over the last 4-5000 years on the Laikipia Plateau evident from published archaeological records. It also describes the range of evidence e.g. faunal remains, botanical remains, artefacts, settlement types, and traces of agriculture that archaeologists typically rely on to construct settlement and land use histories.

5.1 Pastoralism Development in East Africa

In East Africa, the transformation from hunting and gathering to herding and agriculture has often been associated with the arrival of people from elsewhere introducing the local population to livestock and crops (e.g. Clark, 1976). While population migration undoubtedly played a part, archaeologists now give equal weight to the possibility that changes in subsistence strategies took place because of indigenous adaptations. The oldest known bones of domestic animals in E. Africa have been discovered in sites containing Nderit pottery and a Later Stone Age stone-tool technology, which is recorded from the Northern Rift Valley, especially around Lake Turkana, and in parts of the Central Rift (Gifford-Gonzalez, 2005; Onyango Abuja, 1977; Phillipson, 1977). The cattle herders were certainly in northern East Africa by around 4500 years ago (Barthelme, 1985). By around 4000-3400 BP pastoralists were present in different parts of highland central, southern and western Kenya, (Karega-Mũnene, 2002; Marshall, 2000; Marshall and Hildebrand, 2002); by around 3800 BP they were also present in the Tsavo region of southeastern Kenya (Wright, 2005, 2007); and had reached the Serengeti Plain by the second millennium BP. It is thus likely that their arrival is part of the general southward movement of pastoralists across Africa induced by aridity after around 4500 BP.

Finds include stone pestles and mortars, pottery, baskets and beads of semi-precious stones; some artefacts (Oliver and Fagan, 1975); indicate links with the north or northeast. There is no direct evidence of cultivation but the stone-bowls associated with this Pastoral Neolithic culture could have been used for the preparation of food from a cultivated grain (Clark, 1976).

There is some evidence that pottery and perhaps cereal cultivation and cattle keeping were present in the Lake Victoria region for a brief period before the introduction of iron-working (Oliver and Fagan, 1975). However, there is little doubt that major expansion, if not perhaps the introduction, of cultivation in East Africa was a consequence of the spread of Bantu-speaking people into and within the region during the period about 600 B.C - 400 A.D. (Phillipson, 1975, 1977; Kusimba and Kusimba, 2005). These people also introduced iron-working as well as the pottery types known as Urewe, Kwale and Lelusu ware (Phillipson, 1977).

The introduction of domesticated animals and of cultivation resulted in a revolution in the relationship between humans and the environment. Cattle were introduced into the arid Egyptian Sahara at 8500-9000 BP as a risk-reduction strategy to cope with climatic instability and then spread to the central Sahara by 6500 BP. In Fekri Hassan's scenario, caprines were introduced by 7500-7000 BP from Southwest Asia (Gifford-Gonzalez, 2005). Pastoralists first appeared in the Sahara shortly after 7000 BP, driving herds of cattle and goats or sheep. The pastoral way of life spread rapidly across much of the Sahara down to 10^{o} N and from the longitude of Timbuktu to Khat on the Nile. The Saharan Neolithic persisted until shortly after 4500 BP, when increased aridity resulted in most of the area becoming unsuitable for habitation by pastoralists (Smith, 1980). In East Africa, the late Pleistocene and early Holocene (about 12,500-7,000 BP) were considerably wetter than today (rainfall in south-central Kenya, for instance, was perhaps as much as 35% higher than today), as indicated by the widespread evidence for higher lake levels across the Rift Valley lakes (Butzer *et al.*, 1972; Hamilton, 1982; Isaac *et al.,* 1972). Although there was a drier phase centred around 10,000 BP, lake levels at Lake Turkana were still around 80m higher than they are today (Butzer *et al.*, 1972).

As lake levels fell, LSA hunter-gatherer groups began to focus activities around the lake and on the exploitation of fish and other lacustrine resources, possibly becoming more sedentary in the process (Barthelme, 1985). Between around 5500 and 3000 BP, the Central Rift lakes (Naivasha, Nakuru, and Elmenteita) possibly dried out altogether (Richardson, 1972). While this increased aridity may have made the area less attractive for settlement, climate and vegetation changes during the Holocene in East Africa may have actually facilitated pastoral immigration through the narrow Central Rift Valley of Kenya. This was the main avenue of entry from Lake Turkana to the plains of southern Kenya and Northern Tanzania (Ambrose, 1984, 1998). Prior to the mid-sixth millennium BP, this corridor would have been blocked by the distribution of tsetse fly, which causes sleeping sickness. With the onset of drier conditions after the end of the early Holocene wet phase, the tsetse belt may have shrunk, allowing the southward movement of people and livestock (Ambrose, 1998; Ambrose and Sikes, 1991; Gifford-Gonzalez, 2000).

5.2 History and Archaeology of East Africa for the last 4-5000 yr BP

In Eastern Africa, the earliest archaeological evidence of cattle, goat and sheep occurs on sites dated to between 5500-4000 yr BP found around Lake Turkana basin (Barthelme, 1985; Marshall *et al*., 1984). The domestic stock remains are typically found in association with fish and reptile remains, grinding stones, ceramics and bone harpoons (Barthelme, 1985; Phillipson, 1977; Robbins, 1980). Some of the sites around Lake Turkana are associated with Nderit and Ileret styles of pottery, which have also been recovered from the Jaragole Pillar Tomb site (Koch, 1994; Nelson, 1993). Excavations here yielded cremated human remains, large, broken Nderit pots, fired clay models of domestic cattle and wild animals, and shell beads and lithics from distant sources. The pastoral people around Lake Turkana were involved in seasonal activities which were similar but not alike to those of the "Late Neolithic" of Nabta Playa (Wendorf and Schild, 1998), and with other pastoral groups in Sudan of slightly more recent date. Similar pottery styles (especially Nderit ware) are also found in the southern central part of Kenya and Northern Tanzania.

The sites with Nderit ceramics tend to be dominated with wild fauna, such as at the Enkapune ya Muto rockshelter in central Kenya where Nderit ceramics associated with an Eburran Phase 5 LSA stone tool technology were found, dated to around 4860 ± 70 BP (Ambrose, 1998). Nderit ceramics have also been recovered at sites around Lukenya Hill in Southern Kenya, and on the Serengeti plains in Tanzania – in this latter case associated with a local and long-lived lithic tradition, as at Nasera rockshelter (Bower, 1991; Mehlman, 1977, 1989).

Around 3000 yr BP a major change occurred across much of East Africa, when there was a marked shift toward specialized pastoralism (Ambrose, 1984; Bower, 1991; Marshall, 2000). This is indicated by the change in the nature of the faunal assemblages recovered from archaeological sites. In particular, especially in the Serengeti-Mara region, there is an almost complete absence of wild fauna represented in these assemblages, and a marked increase in reliance on the intensive use of domesticated cattle, sheep, goats and even donkey (Robertshaw, 1988; Gifford-Gonzalez, 1998; Marshall, 2000). The faunal assemblages from most of the sites in open environments tend to be dominated by cattle rather than sheep or goat (Gifford-Gonzalez, 1998). The beginning of specialized pastoralism in East Africa coincides well with the onset of the modern bimodal rainfall regime, and as proposed by Marshall (1990) this may have permitted a more productive pastoral cycle.

Where there is evidence for the shift to specialized pastoralism, there is also a general increase in settlement size, and evidence from sites such as Ngamuriak just east of Lemek, suggests the presence of large, complex settlements and substantial shelter construction (Robertshaw, 1990). The larger sites were typically located on gentle slopes in areas of open vegetation in locations similar to those zones favoured by contemporary pastoralists, (Ambrose, 1984; Bower, 1991; Robertshaw, 1988, 1990; Western and Dunne, 1979). This period also witnessed increasing diversity of ceramic styles (the main ones being Elmenteitan and the various Savanna Pastoral Neolithic (SPN) wares) and it is possible that this diversity may relate to the formation of distinct cultural identities.

It has been suggested that those sites associated with SPN pottery, which tend to occur in more wooded zones may have been those of local foragers, who acquired ceramics from their pastoralist neighbours and perhaps were also in the process of adopting pastoralism (Gifford-Gonzalez, 2005). It is not clear whether any of these groups practised some form of cultivation. The presence of small portable grindstones on both Elmenteitan and SPN sites suggest that seeds, such as those of the various domesticated Sahelian crops like millet and sorghum, may have been ground, but by themselves do not provide proof of cultivation (Mashall, 1998).

From around 1900 BP to 1300 yr BP, at least in the Central Rift and adjacent areas, there appears to have been a further shift, with a return to more highly mobile settlement strategies and an increased importance of foraged wild resources, even among groups of previously specialized pastoralists (Bower, 1991). By around 1300 yr BP, many of these groups had adopted iron smelting technologies, and were using iron tools, although the use of stone tools alongside iron seems to have continued for several hundred years.

5.3 Pastoralism in Laikipia Plateau at around 4000 yr BP

Compared with some other areas of East Africa, the Laikipia Plateau has not been subjected to intensive archaeological research until quite recently (see Lane, 2005; Causey and Lane, 2005). As a result, the known archaeological traces associated with the transition to pastoralism on Laikipia Plateau are very patchy. Site types include a mix of rock shelters, and open sites with surface scatters of flaked stone, pottery, iron slag and iron smelting furnaces. Much of the rock art on Laikipia Plateau is also probably associated with pastoralist groups. The following is a brief reconstruction of the transition from hunting and gathering to food production on Laikipia Plateau.

Before 5000 years, only hunter-gatherers were present on Laikipia Plateau. Excavations at a limited number of other rock shelters on the Plateau by Jacobs (1972) and Siiriäinen (1977; 1984) suggest the first appearance of domestic stock on Laikipia Plateau occurred around between 4000-3000 yr BP.

As at other early Pastoral Neolithic sites in the Central Rift and around Lake Turkana, the faunal assemblages from these sites contain a mix of wild and domestic taxa (Siiriäinen, 1984:88), suggesting a continuing reliance on wild animals. Recent excavations at Ol Ngoroi rock shelter on Lolldaiga Hills Ranch, undertaken as part of a British Institute in Eastern Africa (BIEA) research project during 2002-6, support this view. Specifically, excavations revealed the presence of domestic livestock remains associated with wild fauna, a microlithic stone-tool assemblage on obsidian, and *in situ* hearth deposits. A charcoal sample from the lowest of these hearths, of which there were seven in all, produced an AMS radiocarbon date of 4090±40 BP (Cal. 4800-4520 yr BP, 1 sigma range) (Beta-189983). Although sheep/goat bones were present, the bulk of the identifiable elements in the faunal assemblage are of wild fauna, and the range of the taxa reflects the structure of the habitats proximal to the site today, with hyraxes and small bovids predominating (Mutundu, 2005).

These pastoralist societies, and the nature and pattern of human land use and subsistence, changed over time. Although the sequence is still not fully understood, previous research by Siiriäinen (1977; 1984) and more recent surveys (see below) suggest that following the first appearance of domestic stock on Laikipia Plateau around 4000 yr BP, pastoralist activity expanded across the Laikipia Plateau. This is indicated by the presence of Pastoral Neolithic pottery associated with the Elementeitan and Akira traditions. This activity may have been at a relatively low intensity. For example, recent surveys undertaken as part of a British Institute in Eastern Africa (BIEA) research project between 2001-6 on Lolldaiga Hills, Mugie, and Borana Ranches, supplemented by information collected during rock art surveys on Mpala, Jessels, and Chololo Ranches, have located over 250 previously unrecorded sites (Lane in press; Lane and Causey 2005; Smith *et al*. 2004). Of these, only c. 5% have been attributed (on stylistic grounds) to the Pastoral Neolithic phase.

Many more sites (29% of the total sample) appear to date to the Pastoral Iron Age (ca 800-1750 AD), based on the presence at these sites of a new style of pottery known as Kisima Ware (see Lane, in press). This probably reflects a steady increase in human activity and presence on Laikipia Plateau during the second millennium AD, although it is also possible that a proportion of the older sites have yet to be detected because they lie buried beneath colluvial and alluvial sediment that has accumulated along valley floors over the millennia (see also Pearl and Dickson, 2004). Interestingly, Siiriäinen concluded from his excavations that there was considerable typological continuity in the stone-tool assemblages from different levels at the sites he excavated, from around 3000 yr BP to the 12th century AD, and perhaps even the 15th century. This suggests that there was some continuity also in the populations on Laikipia Plateau over this time period. One possibility is that the rock-shelters he excavated were occupied by hunter-gather populations who gradually acquired livestock.

The recent transition in Laikipia Plateau from hunter-gatherer subsistence to pastoralism among Mukogodo provides a good analogy, as can be seen through changes in the faunal assemblages at Shulumai rock shelter (Mutundu, 1999). The Mukogodo people are among those who inhabit the Mukogodo Hills today. They live as semi-sedentary people whose subsistence centres on goats, sheep and cattle raising, supplementing this with honey obtained from bee keeping. Previously, the Mukogodo spoke Yaaku and lived by foraging in the rich tropical-dry uplands forest and trading animal skins, giraffe tails and elephant or rhinoceros tusks to surrounding people in exchange for grain and livestock (Cronk, 1989). The Mukogodo lived in remote caves and rock shelters in Mukogodo forest as a defensive measure against the regular raids made on them by the surrounding Maasai, Samburu and Meru who regarded them as cattle thieves. A number of scholars (Ehret, 1974; Cronk, 1989, 2002; Cronk and Dickson, 2001) suggest that the Mukogodo and other ‘Dorobo’ hunters represent the final phases of a very successful, prehistoric foraging adaptation to the East African highland forests.

5.4 Pastoral Iron Age Sites on Laikipia Plateau

The adoption of iron manufacturing technologies among pastoralist communities of the Central Rift took place around 1200-1100 yr BP (Collett and Robertshaw, 1983:71; Sutton, 1993a: 113; Ambrose, 1998). This change in productive activity could have altered settlement patterns and the environment of the area, and archaeologists refer to the period following the introduction of iron smelting among pastoralists as the Pastoral Iron Age (PIA). One of the earliest dated pastoralist sites with evidence of iron working is Deloraine, near Rongai to the north-west of Lake Nakuru. This site contains abundant remains of cattle and cereals as well as iron implements. On Laikipia Plateau, there is evidence, in the form of scatters of iron slag and tuyeres, and the remains of furnace bases, that pastoralist groups adopted iron smelting. A few of these sites have been excavated near the site of Mili Sita, on Lolldaiga Hills ranch. Radiocarbon dates from these excavated furnaces cluster around 1650-1890 AD (Iles, 2006). It is likely that iron smelting was introduced onto the Laikipia Plateau somewhat earlier, however, but that these early PIA sites have yet to be investigated.

Two large, open-air pastoralist settlements containing PIA pottery known as 'Kisima Ware' (which has been tentatively associated with the Laikipia Plateau), have been investigated on Laikipia Plateau. Of the two, the Maasai Plains site on Mugie is the older, which based on available radiocarbon dates was occupied around 1400-1480 AD. The site is situated in a glade, or area of open grassland surrounded by woody vegetation (in this case mixed acacia scrub), about 1.5 km to the west of Loitigon vlei, which has been sampled for pollen and other environmental remains (Taylor *et al*., 2005). It consists of three concentric and roughly circular arrangements of low ash-mounds between c. 0.35-1.0 m high, covering an area approximately 750 m in diameter. Two of the mounds have been examined by excavation, and indicate that they consist of interleaved layers of ashy soil, containing pottery and bone fragments, and occasional lithic artifacts. Traces of burnt dung, charcoal and other organic materials also occur.

The mounds may represent rubbish dumps associated with a former pastoralist settlement (Lane, in press).

The other site, Mili Sita, is located on a low ridge in the Lolldaiga Hills, and like the Maasai Plains site appears to have been used as an area of pastoralist settlement. On either side of the ridge, gentle to moderate slopes run roughly east and west to alluvial valley floors. At the centre is a large, grass-covered area with several discrete concentrations of archaeological material, including later variants of Kisima Ware similar but not identical to that from the Maasai Plains site. Some of scatters appear to represent the remains of rubbish dumps, while others have been shown by excavation to mark the site of former dwellings or stock enclosures. About 300m north-east of this area on the upper slopes of the ridge, is a heavily eroded area virtually bare of grass cover and with only a sparse covering of low acacia thorn trees. Scattered across this area are numerous distinct scatters of iron slag mixed with tuyere fragments and the remains of several smelting furnaces, some of which have been excavated (see above). On the basis of the available radiocarbon dates, the site appears to have been occupied around 1640-1730 AD which, on the basis of available oral histories of the region, would suggest an association with the Laikipiak Maasai (Lane, in press).

5.4.1 Oral traditions

Jacobs (1972b) described briefly some oral traditions, which he collected amongst the Maasai in the Narok District in SW Kenya, which have some relevance to the ethnohistory of Laikipia Plateau. According to these traditions, people called Iltatua were expelled from Laikipia Plateau by elements of the Laikipiak Maasai some time before 1400 AD. The Iltatua people were described by the Maasai as fierce people who were cattle keepers, buried their dead in stone cairns but they did not make iron, though they had trading contacts with the Somali, Rendille and Borana from whom they acquired iron weapons. It is also suggested they might have even originated from these tribes.

The Iltatua are believed to have moved further south to the Narok district, and then spread slowly up into the Loita highlands and along the Nguruman escarpment, eventually crossing the eastern part of Serengeti plains in northern Tanzania and then moving up into the Ngorongoro highlands of Tanzania (Jacob 1972b). Feierman (1974) reports a very clear tradition told by Mbugu (Vama'a or Ma'a) who live among the Shambaa in the Usambara Mountains in northeastern Tanzania that they (Mbugu) originally came from a place called 'Lukipya' - i.e. Laikipia Plateau, and they were driven away by Maasai. According to Feierman, the Mbugu speak a Cushitic language related to the Mukogodo (Yaaku). The Mbugu language is a Southern Cushitic language (Ehret, 1974), which according to Ehret probably derives from the extension of Southern Cushitic speakers into the Pare Mountains and to Usambara area some three hundred or so years ago. Thus, as argued by Siiriäinen, (1984: 92-3), "we have two cases where Laikipia Plateau is mentioned in oral traditions which refer to southwards migrations of peoples from that area, and in one case these peoples, on the basis of their recent representatives, can be firmly identified as a southern Cushitic-speaking population."

5.5 Evidence from cultural and archaeological changes in Kenya and East Africa

Information from other discipline, such as archaeology (Reid, 1990; 1993; Robertshaw, 1997; Schmidt, 1997), historical linguistics, oral traditions (Sutton, 1993) provide interesting additional and complementary information about the environmental history of the study area, with potentially new perspectives given the possible close associations between environmental and human histories in this region (Robertshaw & Taylor, 2000; Taylor *et al*., 2000).

In archaeological records, the Pastoral Neolithic (PN) contains well-defined developmental stages. This allows the transition to a food producing society to be reconstructed. Starting in northern Africa (Ethiopia and Sudan) at about 5500-4500 yr BP, the PN spreads southward (Bower and Lubell, 1988). The rate and direction of this spread are partly determined by mid- to late Holocene shrinkage of the Rift Valley lakes (Butzer *et al*., 1972). This exposed large areas of previously inundated grazing land.

It is suggested there was a major rise in livestock levels about 3000 yr BP (Bower, 1988), probably as a result of a transition to a more intensive and established pastoral system. The real extent of the PN is unknown; linguistic work by Schoenburn (1993) suggests the presence of southern Cushitic cattle-herders in Rwanda and northern Tanzania from about 3000 yr BP Dated remains of goat and sheep teeth in Rwanda suggest mixed pastoralism had become established between 2500 and 2000 yr BP Thus by about 2500 yr BP pastoralists were widely spread throughout East and central Africa (Sutton, 1998).

As with the hunter-gatherer populations, due to low population densities, impact on vegetation composition and distribution would have been localized and relatively negligible at the start of the period. As populations became increasingly settled, and the number of people seeking an agricultural base grew, impact on vegetation would have been increasingly noticeable, although the impacts of pastoralist must also be considered in any event, due to technological innovation and change of environment, some cultures were either displaced or assimilated.

PART TWO

CHAPTER SIX: METHODS USED

This chapter describes the field sites and the collection of the core material for two sites i.e. Ewaso Narok and Marura (Fig 10). The laboratory-based procedures used in the preparation of sediment samples and analyses of inorganic and organic matter, including plant microfossil (charcoal, pollen and spores) content are also described.

Also included is a description of the criteria used in the identification of the pollen and spores. The procedures used in clustering and zoning sediment based data are also presented. As for Marura, pollen and spore are calculated separately based on their sum while in Ewaso Narok, pollen and spores are calculated together.

6.1 Field Work

Sediment cores were collected from Ewaso Narok and Marura swamps during fieldwork in June 2005 and September 2006 respectively. Both sites are located on the Laikipia Plateau, which rises to 1800m in the north and 2100m in the south. Marura swamp (Fig 10 and Plate 1) is located along Mutara River on the eastern side of Nanyuki District at an altitude of 1800m, and 0° 21' 59.10" N 36° 43'19.55" E, adjacent to Ol'Pejeta ranch. The core was collected at the centre of the swamp seven metres from the edge. The swamp is about 2 km long though it fluctuates during the dry seasons.

Fig 10: Coring sites, Marura (plate 1) and Ewaso Narok (plate 2) (Afri cover ILRI-UNEP 2000)

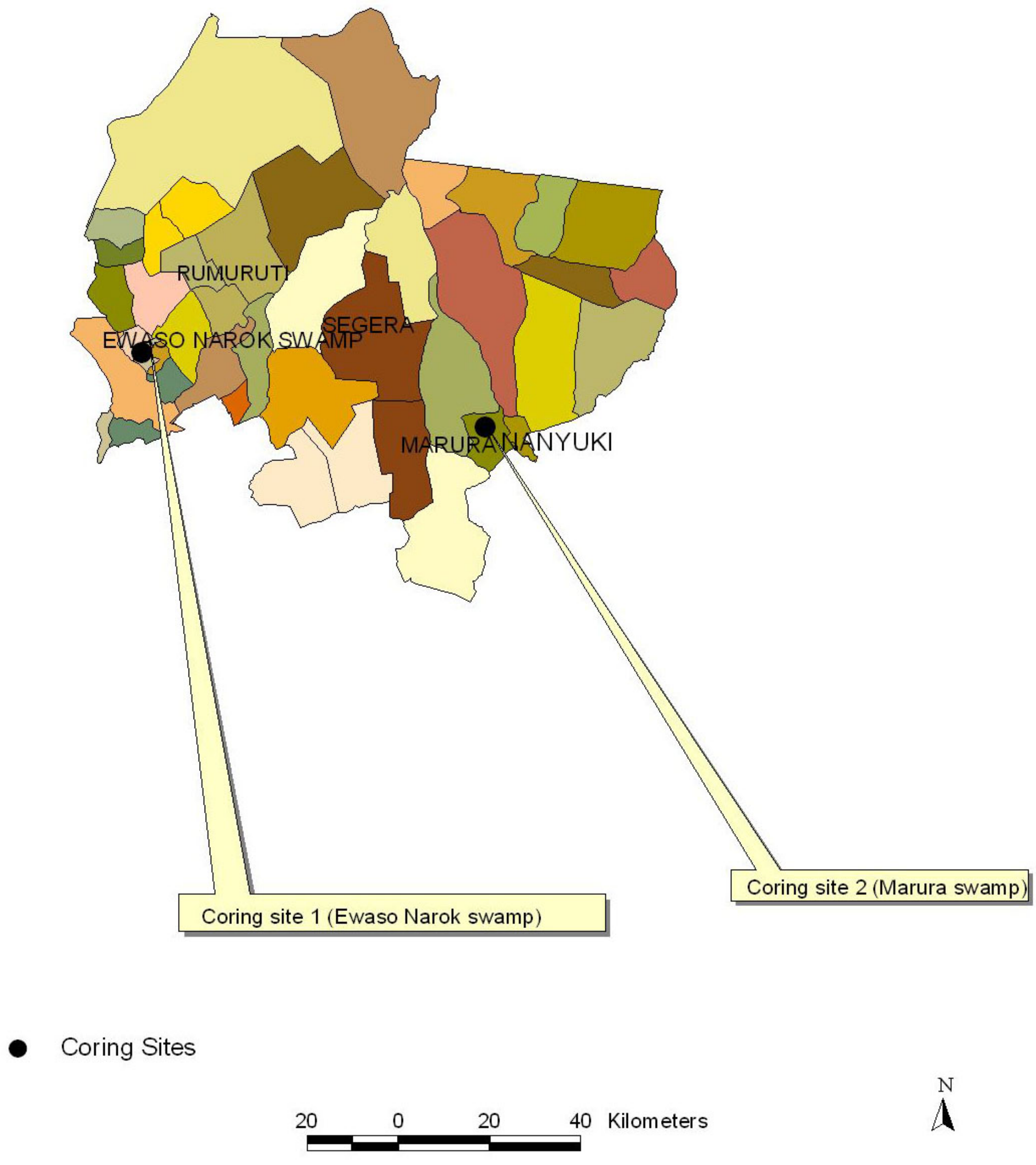


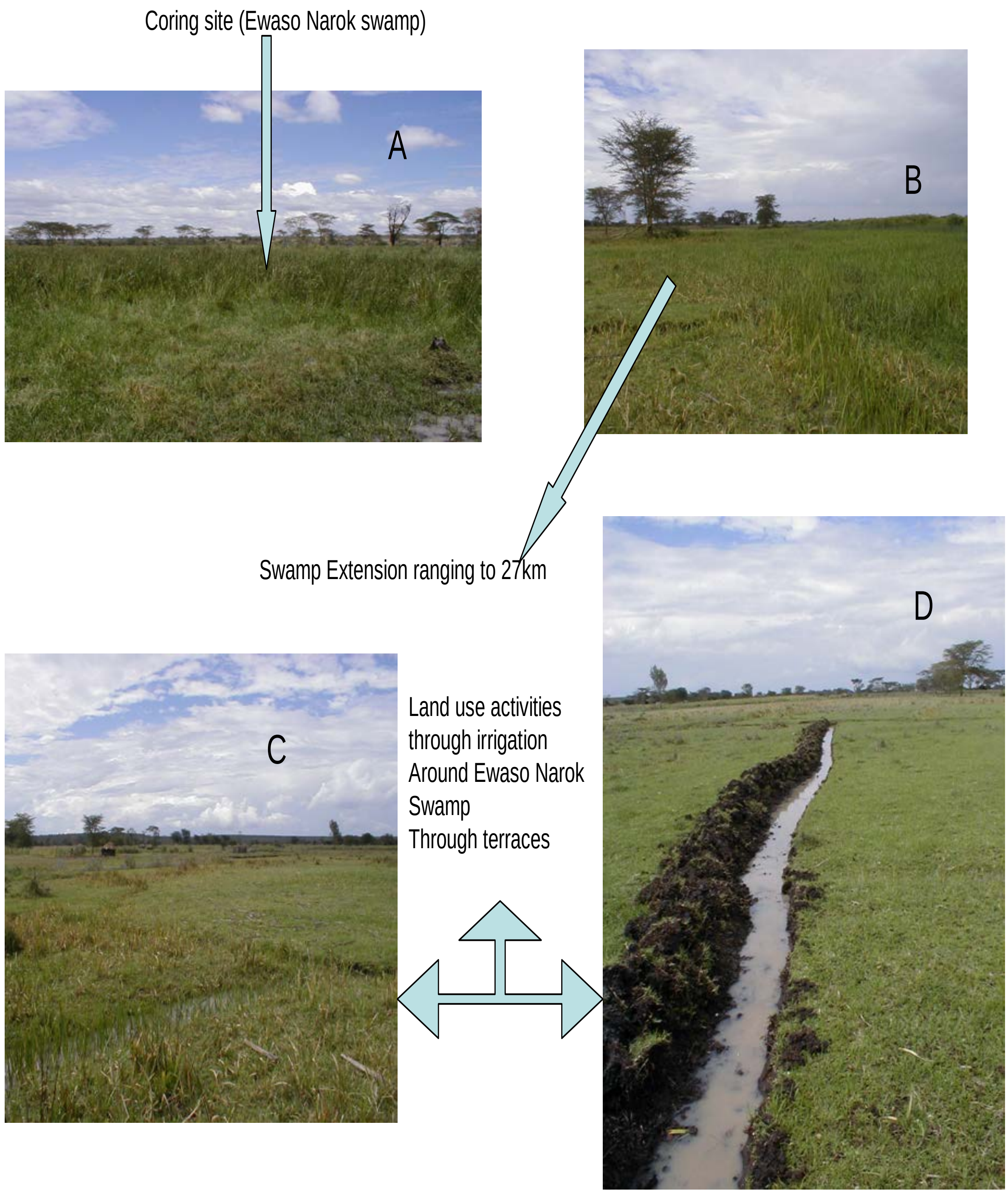
Plate 1. Showing the nature of vegetation around the coring site (Marura)

The vegetation surrounding the site (see section 2.4) includes *Acacia drepanolobium*, Asteraceae, Brassicaceae, *Casuarina*, *Cyperus*, *Euclea divinorium*, *Eucalyptus*, *Gravellea* and *Zea Mays*. Marura swamp is surrounded by settlements and cultivation though irrigation takes place. It is one of the wetlands that serve the communities and their animals where they border the site after the Ol'Pejeta ranch was fenced to prevent further encroachment. Perishable food like cabbages are grown for sale during the drought season through irrigation, and as a source of local income. Thus, Marura swamp helps buffer the negative effects that can arise from a failure of the short rains, which happens quite often.

The second core was collected 20m from the northern edge of the swamp at Ewaso Narok (Fig 10, Plate 2). Ewaso Narok swamp is located in Rumuruti Division, between latitudes 0° 15', and 0° 17' N and between 36° 34' and 36° 41' E along the Eng’are Narok River. The swamp is set in a semi-arid grassland plateau with frequent drought and unreliable rainfall (Government of Kenya, 1994), which causes the swamp area to fluctuate between 14 and 20 km^2 between dry and wet seasons each year. It is a riverine wetland dominated by *Cyperus papyrus* within a semi-arid area and forms a biogeographical island with ecological and socio-economic importance. It is also an area of bushy grassland composed of *Acacia drepanolobium, Acacia seyal, Themeda triandra, Pennisetum mezianum* and *Aristida spp*. *Croton dichogumus, Solanum sp*. The area is characterised by low rainfall as described in Chapter 2.

Before the 1970s, the dominant land use was large-scale ranching and nomadic pastoralism. Slowly it has been transformed into high-density small-scale farming. This has brought about a strong trend for settlements to concentrate along riverine and wetland areas due to their suitability and easy availability of water for cultivation through irrigation (Plate 2).

Plate 2. Showing the nature of the land and landuse activities around the coring site. (Ewaso Narok Swamp)



6.2 Coring

The coring was carried out using a 5cm diameter Russian corer. The recovered cores were described in the field and transferred into 50cm plastic pipes sectioned in half, wrapped using aluminium foil, and transported to the Palynology Department at the National Museums of Kenya and later to the University of York for cold room storage. Cores were sub-sampled at 2.5cm (Ewaso Narok) and 5cm (Marura) intervals and processed for pollen, spore and charcoal analysis using the standard pollen concentration.

6.3 Preparation of fossil pollen and spores

The preparation of sediments for microfossil pollen and spores was based on modified standard procedures published in Faegri & Iversen (1989), Moore *et al*., (1991) and Van Geel & Anderson (1988). The modification comprised use of chemical treatment involving KOH, acetolysis mixture (Erdtman, 1960), and HF to remove humic acids, cellulose and silica (Faegri and Iversen, 1964). The pollen was mounted in glycerine jelly. A total of 500 grains were counted for each sample wherever possible, i.e. Marura. The Ewaso Narok core was very poor in pollen count in some of the levels.

6.3.1 Pollen identification and counting

The prepared samples were mounted on microscope slides under glycerol and pollen and spores were counted under x400 magnification; detailed features were examined under x1000 magnification. Identification was based on comparisons with a collection of prepared slides of East African modern pollen reference collection of over 6000 slides at the Department of Palynology, NMK for comparison, which was supplemented with a range of publications (Hamilton, 1976, 1982; Taylor, 1988; Marchant, 1997) and digital photographs of pollen types. Identification of pollen grains was made to the lowest possible taxonomic level, although some pollen types could only be identified to family level. The nomenclature used followed that of Benninghoff & Kapp (1962). At least 500 pollen grains were counted from each slide, except in a few samples where preservation was poor.

According to other pollen investigations conducted in the region (Hamilton, 1972; Taylor, 1988; Marchant, 1997), 500 pollen grains have been found to be appropriate for pollen analysis. Generally, samples rich in clay and sand particles had very few or no pollen grains, resulting in gaps in the pollen record as in the case of Ewaso Narok core.

6.4 Presentation of results

The data were plotted using Tiliagraph Version 2.0.b.S (Grimm, 1995). The boundaries of pollen assemblage zones were defined using a stratigraphically constrained clustering procedure (CONISS; Grimm, 1987); (Fig 15) and the Edwards and Cavalli-Sforza chord distances used as a dissimilarity measure. DCA ordination clustering has also been applied to identify pollen zones using the CANOCO programme (Fig 17). These zones are entirely based on pollen assemblages**.** For the charcoal analysis, the point count method (Clark, 1984) was used to calculate charcoal influx in the sediment.

CHAPTER SEVEN: RESULTS OF SEDIMENT STRATIGRAPHY AND RADIOCARBON DATING

This chapter presents the results of the analyses of sediment stratigraphy and radiocarbon dating of the two sediment cores for Marura and Ewaso Narok. The chapter also contains determinations of the autochthonous and allochthonous sediments.

7.1 Sediment stratigraphy for Marura core

The stratigraphic zonation for Marura core is based on description of sediment type (Fig 11). The bottom part of the core (250-400cm) is composed of hard compact clay with a depth of 150cm. Very soft clay with a depth of 75cm with fibrous roots and frequent laminations describes the second part of the core (175-250cm). The following part has a depth of 81cm (94-175cm) composed of dark clay with fibrous roots and brown, frequent laminations. The uppermost part comprises decomposed clay with organic matter with a depth of 78cm (16-94cm). This varied considerably in composition particularly in the degree of decomposition of the herbaceous peat. Toward the top part, there is sand with brown laminations. The top of the core contains decomposed herbaceous peat forming a very short zone from 0-16cm.

Fig 11: Lithology of Marura swamp core

0-10cm		Decomposed peat.
10-16cm		Sandy clay with brown laminations.
16-34cm		Greyish clay with fibrous roots.
34-82cm		Compact greyish clay.
82-94cm		Decomposed clay with organic matter
94-134cm		Dark clay with fibrous roots laminations.
134-175cm		Greyish clay with very dark laminations.
175-250cm		Soft clay.
250-400cm		Hard compact clay.

Olp C1

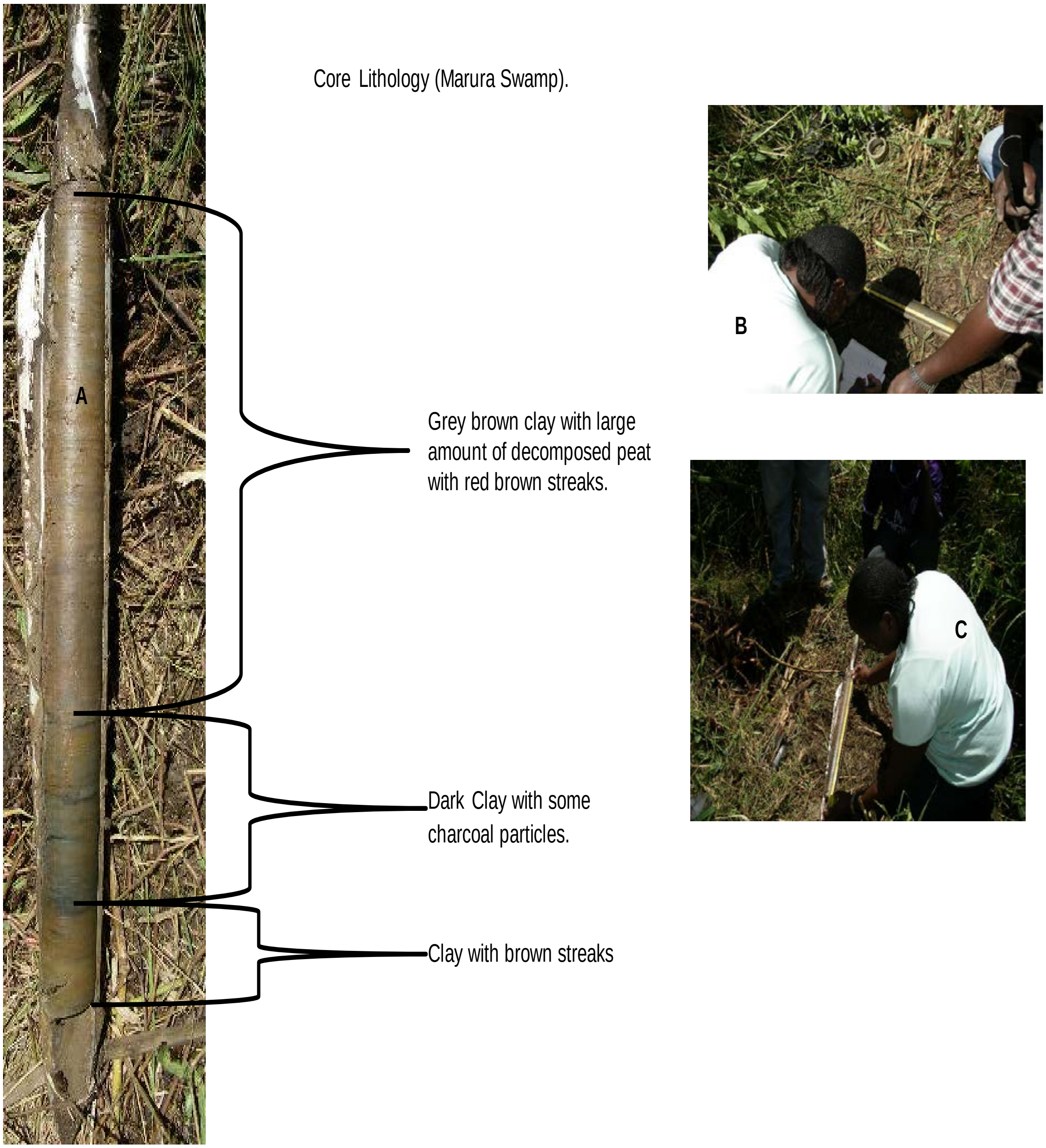
Olp C

Olp B1

Olp B

Olp A

Plate 3. Showing the lithology of Marura core and where the samples for carbondates were extracted.



7.1.1 Results of sediment chronology and Age-depth curve for Marura

The results of the AMS ^{14}C dating of samples from Marura are presented in Table 2. The calibrated dates are presented as 2-sigma calibrated age (AD/BC). Of the three samples dated, two AMS ^{14}C ages are stratigraphically consistent from the basement sample of 2150 ± 40 BP (380cm) to 1870 ± 40 yr BP (100cm).

The date from 190cm yielded a younger date (1720 ± 40yr BP) than that obtained on the sample from 100cm (1870 ± 40 yr BP).

The age-depth curve for the core was based on three AMS ^{14}C dates, 2150±40 BP (Cal. BC 200 to 10), 1720±40 yr BP (AD 230 to 410), and 1870±40 yr BP (Cal. BC 40 to AD 120). The AMS ^{14}C data and the age-depth relationship for Marura (Fig 12) indicate that the core contains a record of past environmental conditions at this site for the last c. 2000 yr. BP.

Fig 12: Marura, Age-depth curve. A linear relationship between age and depth is assumed between contiguous AMS ^{14}C dates

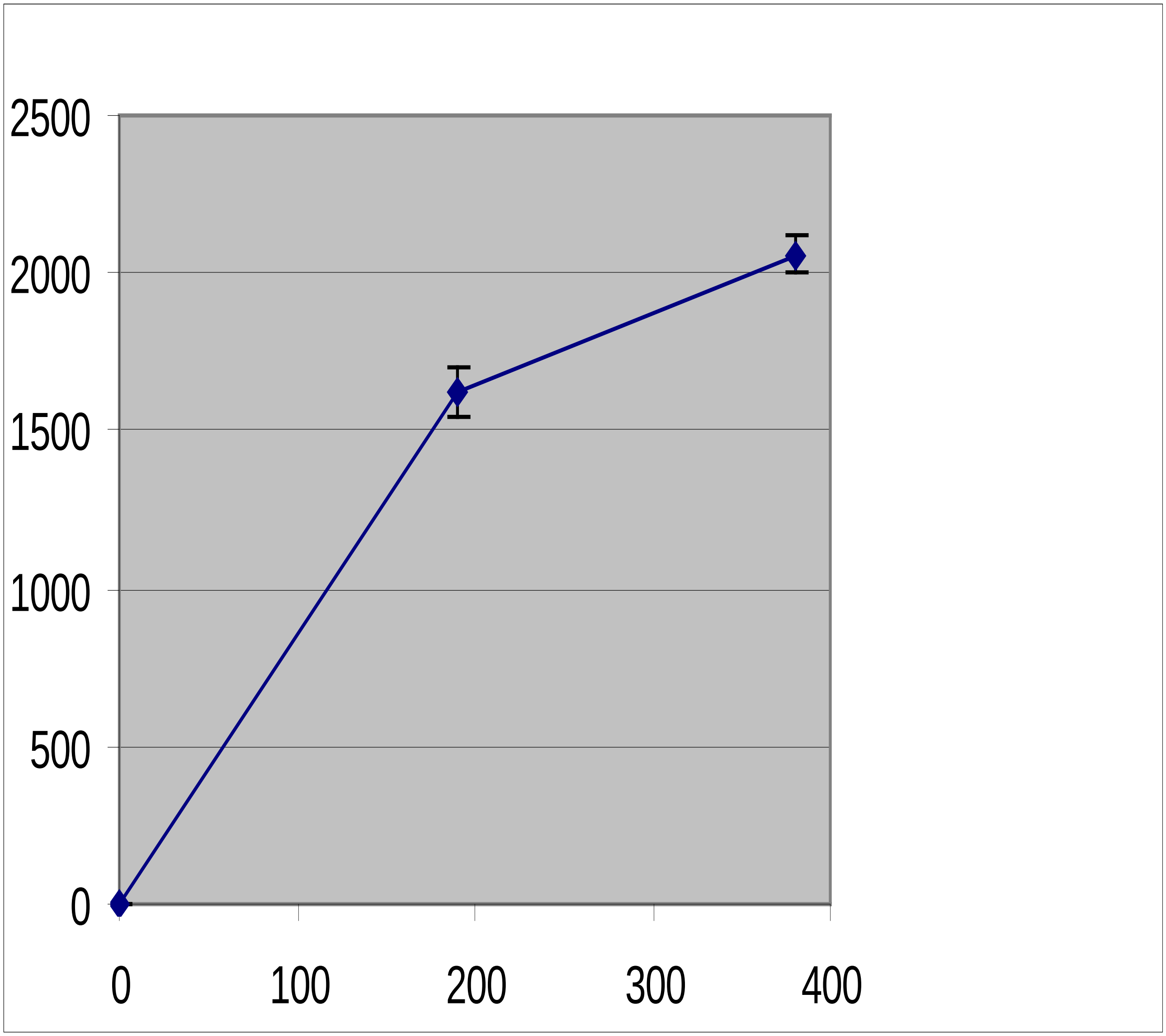


Table 2.

AMS radiocarbon dates and $^{13}C/^{12}C$ ratios ($\delta^{13}C$ ‰) values for Marura, and Ewaso Narok core. The AMS dates were calibrated using Calib 4.4 and calibration curve INTCAL 98 Radiocarbon Age Calibration and presented as 2-sigma calibrated age (BC/AD) at 95% probability

Sediment core	**Laboratory Number**	**Depth (cm)**	**Conventional ^{14}C age (yr BP) ± 1δ**	**Calibrated ^{14}C age (Cal BC/AD) ± 2δ**	**Median Cal. ^{14}C age**	**^{13}C / ^{12}C $\delta^{13}C$(‰) value**	**Material dated**
Ewas 70	Beta-230855	70	109.3 ± 0.4 PmC	-	-	-12.3 ‰	Peat
Ewas 110	Beta-230856	110	1170-960 BP	AD 780-990	1060 AD	-19.8 ‰	Organic sediment
Ewas 145	Beta 230857	145	109.4 ± 0.4 PmC	-	-	-12.2 ‰	Peat
Marura 190	Beta 230859	190	1700-1560 BP	AD 230-410 AD	1620 BP	-19.1 ‰	Organic sediment
Marura 380	Beta 230860	380	2150-1960 BP	2090 BP	2050 BP	-20.7 ‰	Organic sediment

7.2 Sediment stratigraphy for Ewaso Narok

The Ewaso Narok core consists of a sequence of peat, clay and fine/course sand (Fig. 13). To ease interpretation, the sediments have been divided into four stratigraphic zones labelled Rum A, B, C and D from the base of the core towards the top. Stratigraphic zone Rum A forms the base of the core and is composed of compact hard clay with sand particles, it extends from 150-82cm. A clay-rich layer forms stratigraphic zone Rum B, which attains a depth of 37cm extending from 82cm to 45cm. Zone Rum C, which comprises very dark clay, extends just 7cm, between 45-38cm. Stratigraphic zone Rum D is composed of dark clay with organic remains. Zone Rum D varied considerably in composition and thus has been divided into sub zones Rum D1 and D2, (38-27) and (27-0) based on the degree of decomposition of the herbaceous peat.

Fig 13: Lithology of Ewaso Narok core

0-10cm		Black sandy clay, fibrous materials	Rum D1, D2
10-27cm		Greyish sandy clay, frequent laminations.	
27-38cm		Red cotton soils with dark laminations	
38-45cm		Black clay.	Rum C
45-82cm		Clay soils with sand gravels	Rum B
82-150cm		Compact hard clay with sand	Rum A

7.2.1 Results of sediment chronology and age-depth curve from Ewaso Narok

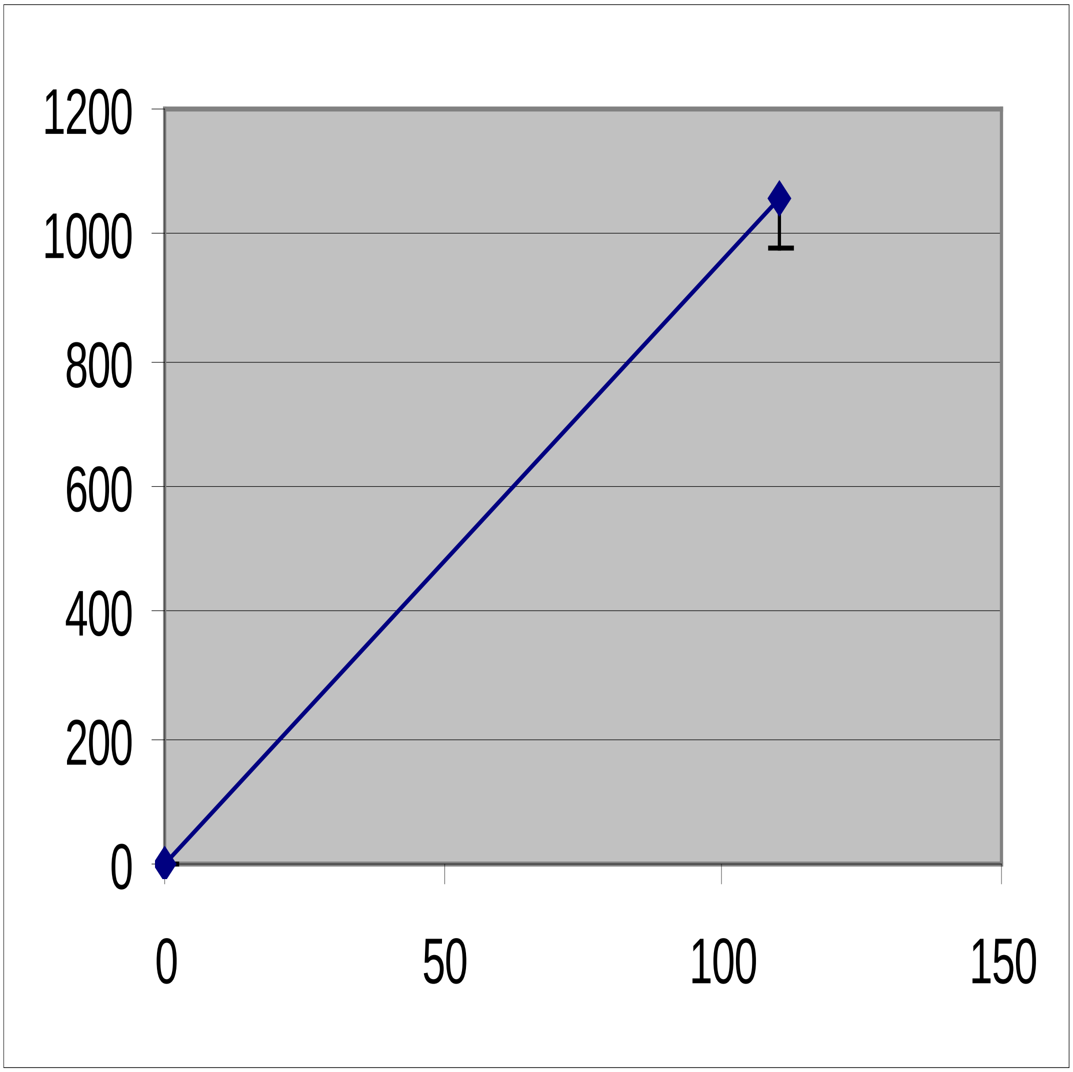
The results of the AMS ^{14}C dating of samples from Ewaso Narok are presented in Table 2. The calibrated dates are reported with units "pMC" ("Percent Modern Carbon") rather than BP, apart from Ewas 110, which dated 1170 ± 40 yrs BP. The results of the two samples Ewas 70 and 145 indicated an age of post 0 BP and have been reported as a percentage of a modern reference standard, indicating that the material was living within the last 50yrs. The results of pMC for Ewas 70 are NA 109.3 ± 0.4 pMC (70cm), while Ewas 145 109.4 ± 0.4 pMC (145cm). Ewas 110 dated 1170 ± 40 yrs BP with 2 sigma calibrated results (95% probability).

The Ewaso Narok Swamp dries up completely when there is very prolonged drought. The dried sediments forms mud cracks that are filled up during the wet seasons. The surface runoff carrying the load and the litter fills up these mud cracks, giving rise to the possibility that modern plant materials will penetrate to lower levels via the mud cracks. As such, the date at 110cm is used with 0cm at the top of the core.

The results of the age-depth curve for Ewaso Narok are presented in Fig. 14. Ewaso 70 did not have a measured radiocarbon age or a ^{13}C / ^{12}C ratio reported. This is because the sample was too small to do a separate ^{13}C /^{12}C ratio and AMS analysis. The only available ^{13}C / ^{12}C ratio available to calculate a conventional radiocarbon age (CRA) was that determined on a small aliquot of graphite. Although this ratio corrects to the appropriate CRA, it is not reported since it includes laboratory chemical and detector induced fractionation.

Ewaso 145cm was also reported with the units "pMC" rather than BP. Results are reported in the pMC format rather than the analyzed modern (AD 1950) reference standard, which is normally used. The Ewas 110 sample was the only one from which a reliable date was reported 1170± 40 yrs BP (110cm).

Fig 14: Ewaso Narok swamp, Age-depth curve. A linear relationship between age and depth is assumed between contiguous AMS ^{14}C dates



CHAPTER EIGHT: RESULTS FROM POLLEN AND SPORE ANALYSIS

This chapter presents the results of microfossil pollen, fungal spore and fern spore for Marura and Ewaso Narok sediment cores. It describes the down-core variations in fossil pollen and fungal assemblages, for both sites and, provides an interpretation of these results.

8.1 Pollen and spores stratigraphy (Marura)

Eighty samples from the Marura Swamp core were analysed for their pollen and spore content. Ninety-three pollen and spore types were recognized to genus and family level. All but 28 samples were rich in well-preserved pollen and spores: for these samples, total count (excluding damaged grains) ranged from 501 to 1246 pollen and spores. By comparison, the recovery of pollen and spores from the sample levels at 25cm, 35cm, 50-60cm, 90-115cm, 125cm, 145-170cm, 180-195cm, 230-255cm and 400cm were poor and only counts of <100 grains per sample were possible.

Core samples were grouped according to their non-local pollen content using stratigraphically constrained techniques of numerical clustering. Pollen types that did not attain levels of greater than 2% in any sample were excluded from the clustering process (following the recommendations of Birks & Gordon 1985). Three pollen zones and sub-zones were recognized within the pollen assemblages of Marura Swamp, which were labelled Olp A, Olp B, and Olp C from the oldest to the youngest. Zones Olp B and Olp C were each subdivided into two sub zones: Olp B1, Olp B2, Olp C1 and Olp C2 Pollen and spores percentage data divided into these three zones are shown in the pollen and spore diagram (Fig 15 and 16). The stratigraphically constrained zonation is also discernible from the DCA ordination bi-plot (Fig 17).

Fig.15 Pollen diagram (Marura) minus spores and other taxas, which just appears once.

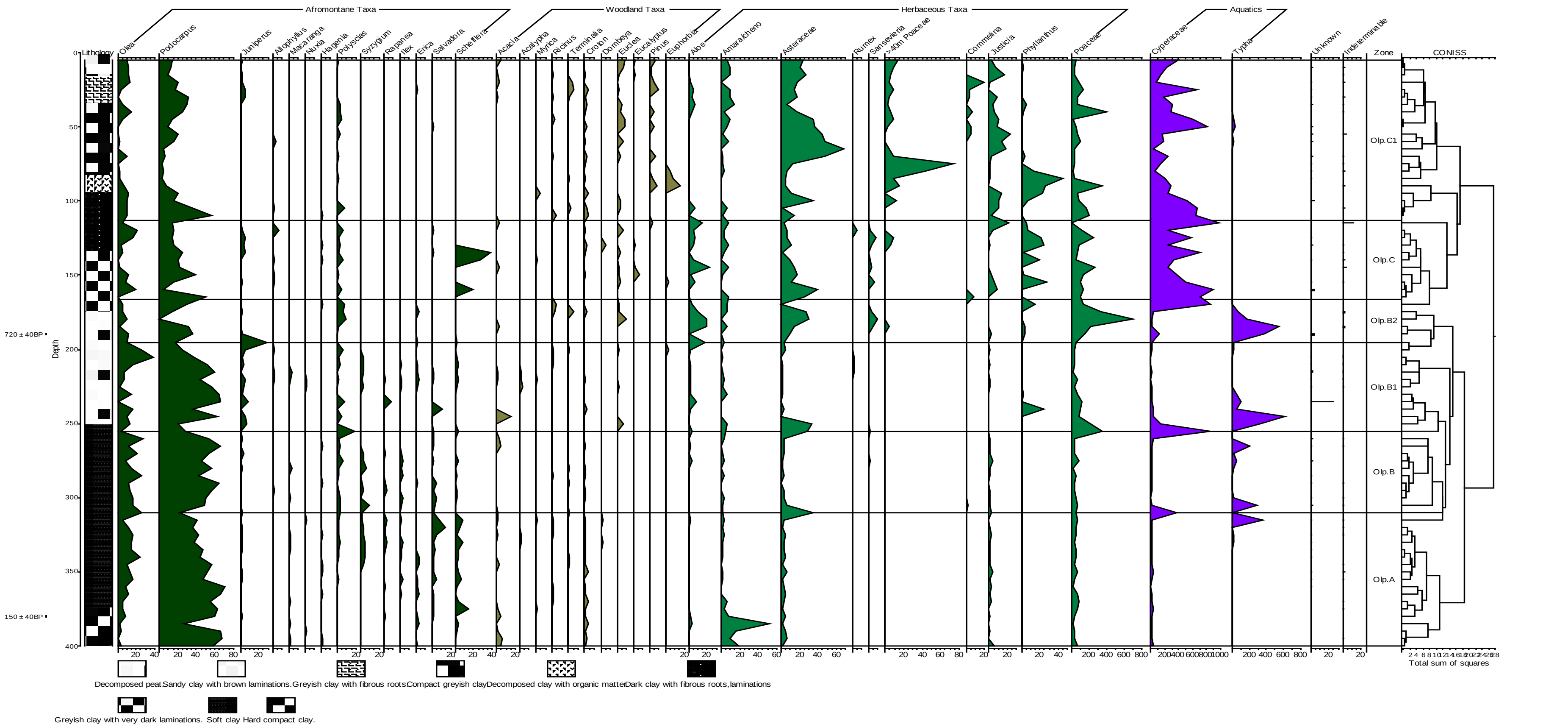
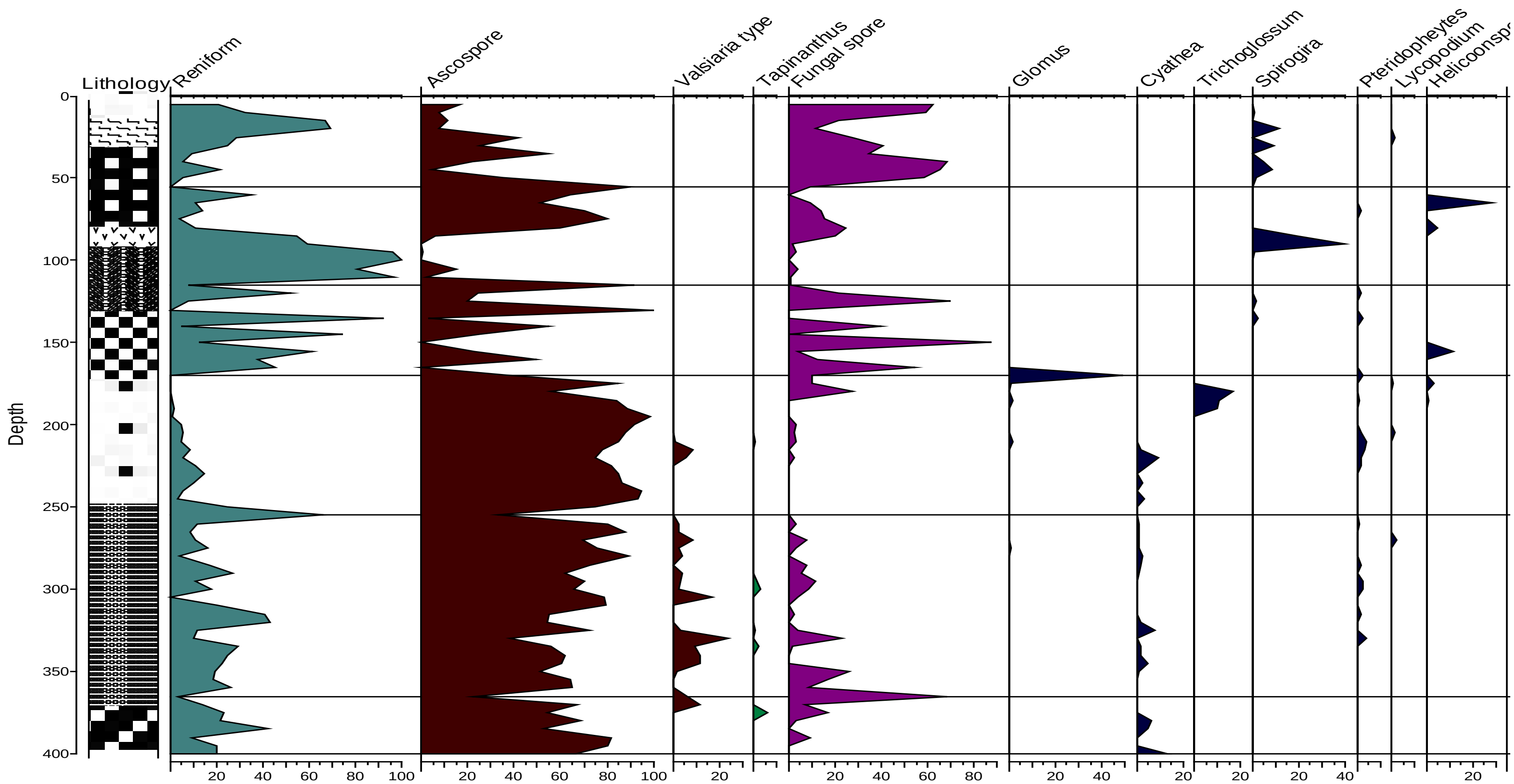


Fig 16: Spore diagram for Marura



Zone Olp A (315-400cm) 2200-1700 yr BP

Pollen zone Olp A extends from the bottom part of the core at 400 cm to 315 cm and includes stratigraphic zone A. This pollen zone is dominated by Afromontane taxa such as *Podocarpus* (25-80%), *Olea* (1-30%), *Juniperus* (0-5%), *Polyscias* (0-5%) *Schefflera* (5-15%), *Rapanea* and *Cyathea* (5-10%).The woodland forest category has relatively low proportion with most taxa accounting for less than 20% apart from *Canthium*, which is well represented with 20%.

Among the herbaceous taxa, Cheno/Ams contributed 60%, while others like Asteraceae and *Justicia* are rare in this zone apart from Poaceae, which recorded more than 10% and others were represented by less than 5%. *Typha* dominates the local pollen and spores, particularly towards the upper boundary of this zone (0-98%), Cyperaceae contributed 50%. The spores are dominated by *Ascospore* (20-80%) and *Reniform* (10-40%), Fungal Type (un-identified) (0-60%), *Tapinanthus* (3%), *Valsaria type* and *Cyathea* ranging from 5% and 20% respectively. The local pollen and spore concentration are generally low at the base of the zone, rising towards the upper boundary of the zone.

Zone Olp B (315-165cm) 1700-850yr BP

Pollen zone Olp B (315-165cm) accommodates the majority of stratigraphic zone Olp B1 and the upper part of B2. This zone represents a period of increase of Afromontane taxa at the expense of woodland taxa. Apart from *Acacia*, which peaks to 20% amongst woodland taxa, other taxa (Capparidaceae, *Canthium*, *Croton Dombeya*, and *Euclea*) range from 0-5% and are evenly distributed. Afromontane taxa are well represented in this zone with some frequent drop and rise of some taxa such as *Juniperus* (1-20%), *Olea* (0-40%) and *Podocarpus* (20-80%) towards the upper part of the boundary of sub-zone OlpB2, Ericaceae (0-10%), *Ilex* (0-10%), *Polyscias* (5-20%), *Rapanea* (0-15%), *Salvadora* (0-15%) and *Syzygium* (0-15%).

Poaceae are the most abundant among the herbaceous taxa in the zone. *Aloe* range (5-20%), Asteraceae (10-40%), *Artemisia* (<5%), Cheno/Ams is evenly distributed (1-10%), *Sansevieria* at 10% toward the end of zone B2. Pollen >40um in the Poaceae family are considered to be cereals. These pollen types start to appear at sub-zone B2 attaining (2%) with *Phyllanthus* and *Stemondia* each ranging from 1-20%.

Local pollen and spores are dominated by *Ascospore* type (90% from 40%), and Reniform (5-60%). *Valsaria* type (0-20%), *Tapinanthus* (0-5%). Fungal type ranges from (1-30%) *Glomus* (0-40%), *Cyathea* (1-15%), *Trichoglossum* (20%), *Spirogyra* (3%), *Lycopodium* and *Helicoon*-spore (fern type) (0-10%) respectively. Local pollen was dominated by *Typha*, which had several peaks ranging from (10-99%). Cyperaceae also has a high percentage (80%) at 52cm level.

Zone Olp C (165-0cm) 850 yr BP - to present

Pollen zone Olp C extends from 165cm to the top of the core and constitutes sub-zone Olp C1. This pollen zone shows a decrease of Afromontane taxa at the expense of woodland and herbaceous taxa and presumably, therefore, reductions in forest cover. There is a proportional decrease of *Podocarpus* from 60% to 5%; a similar trend is followed in sub-zone Olp C1. *Juniperus* (5-0%), *Olea* decreases from (20-1%) and *Polyscias* from (10-0%) towards the upper part of the zone. *Schefflera* reaching a peak of 40%, disappears from the record towards the top of the core, while *Alchornea, Myrica*, Nyctanginaceae, *Ricinus,* Rubiaceae and *Terminalia* are also present but low in percentage; the later attaining 10% in the upper part of the core. *Canthium,* Capparidaceae, *Cleome Commicarpus*, *Croton*, *Euclea, Eucalyptus, Merremia* and *Pinus* all attain less than 10% with *Euphorbia* rising to 20%.

Herbaceous taxa are well represented in this zone when compared with the upper sub-zone C1. Asteraceae are abundantly represented compared with other herbaceous taxa in the zone. It is well distributed in this zone ranging from 10-60%.

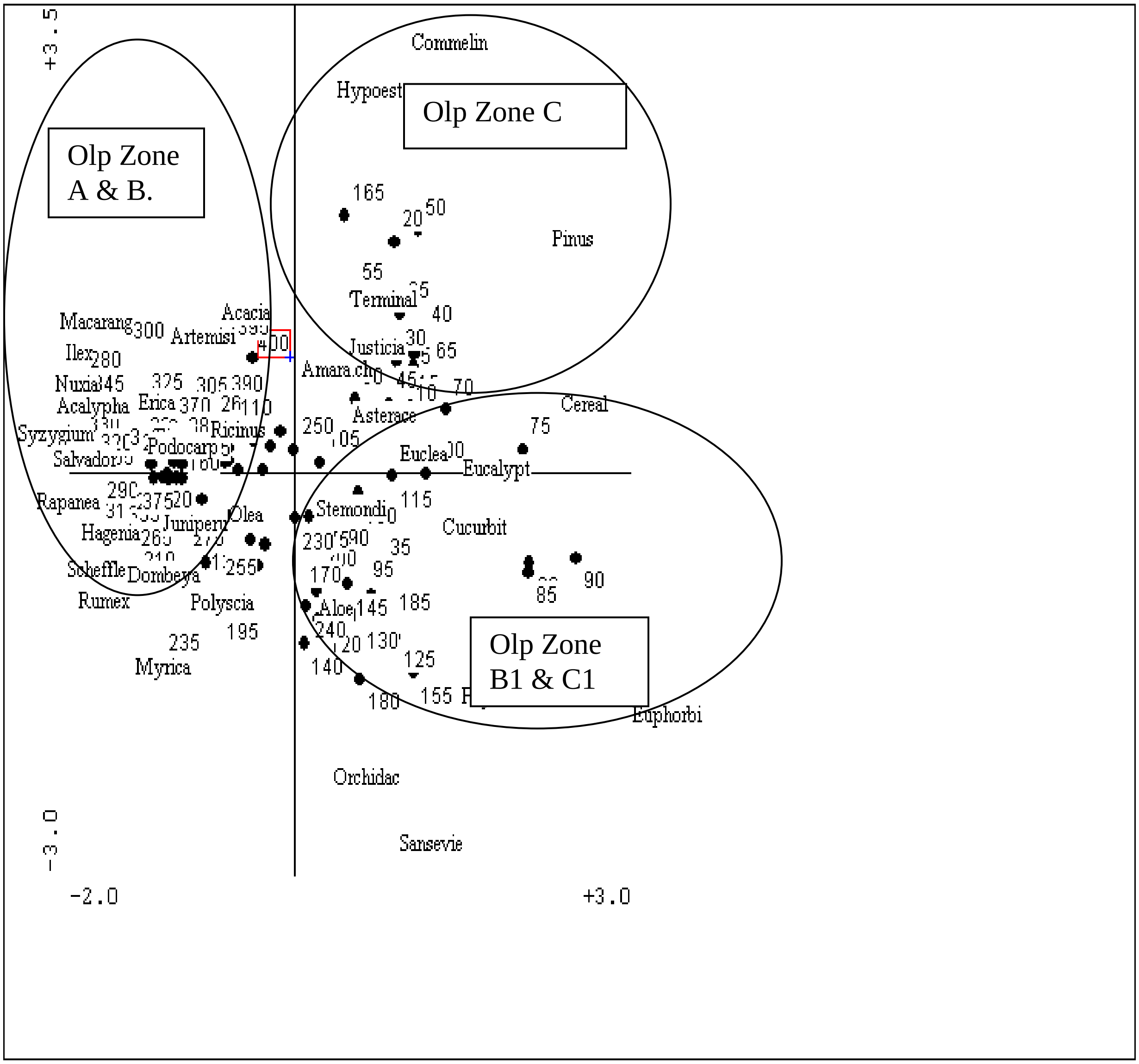
Other taxa represented in this zone are Aloe (0-10%), *Artemisia* (0-3%), Cheno/Ams (10-20%), Cucurbitaceae (0-5%), Orchidaceae (2%) *Rumex* (4%) and *Sansevieria* (1-5%). Others include Cereal-types (10-80%), *Cissampelos* (0-3%), *Commelina* (10-20%), *Hygrophilla* (1-3%), *Hypoestes* (5%), *Justicia* (10-25%), Labiatae (1-20%), *Phyllanthus* (1-45%), *Solanum* and *Stemondia* (2-5%). All these taxa are prominent and are probably components of secondary forest**.** The proportion of *Poaceae* remains relatively high compared to other zones with a percentage increase of 10-60 %. A high proportion of *Cyperaceae* (40-80%) dominates the local pollen and spores while Reniform spores have frequent fluctuation (1-90%).

Ascospores also show frequent changes between 0-90% within the same zone. Fungal spores are also well represented in this zone, ranging from 50-80%. *Spirogyra* only appeared in this zone with a range of 10-40%, with *Pteridophytes* (5%), *Lycopoduim* (3%) and *Helicoon* spores (5-20%) also present.

8.1.1 DCA analysis of Marura Swamp

The results of the DCA (detrended correspondence analysis) ordination of pollen samples from Ol'Pejeta Marura swamp are shown in Fig 17. This shows the three pollen zones described above labelled Olp A, Olp B and Olp C. The samples constituting four sub-zones Olp.B1, Olp.B2 and Olp.C1 are closely located according to DCA axes 1 and 2, by comparison, are more widely dispersed over the plot, suggesting some intra-zone variability and a degree of overlap between the zones. The vegetation gradient on the DCA axis 1 is apparent with pollen from taxa associated with degraded forest and savannah habitats grouped by high positive scores. DCA axis 2 with negative scores of -2.0 comprises Afromontane taxa with neither of the woodland taxa nor herbaceous taxa found in that zone.

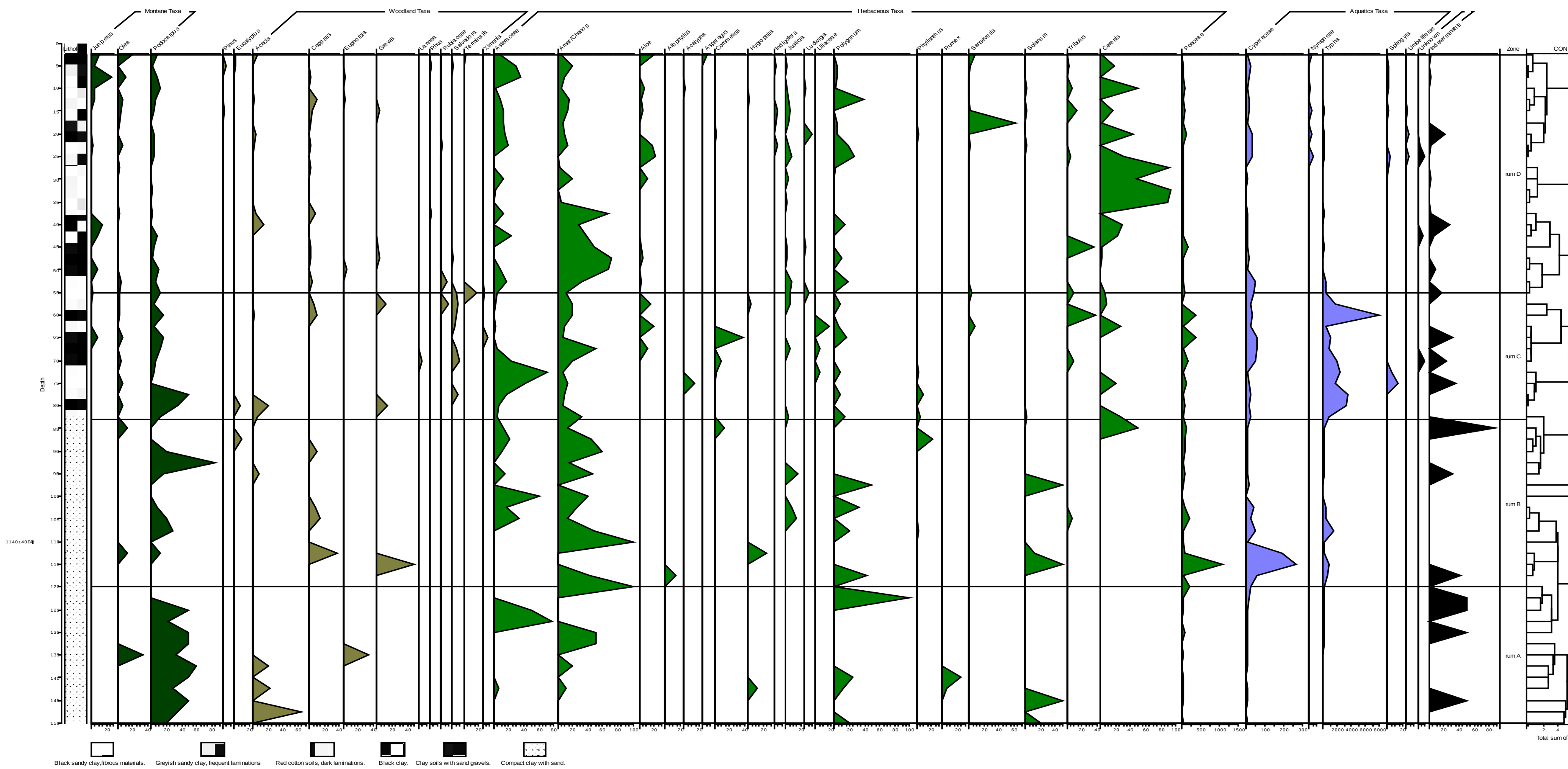
Fig 17: DCA analysis from Marura.



8.2 Pollen and spores stratigraphy from Ewaso Narok Swamp

The interpretation presented below is from the 1.5m core recovered from Ewaso Narok Swamp, Rumuruti. Sixty samples were analyzed at intervals of 2.5cm with 50 fossil pollen taxa, fern spores, fungal spores and *Spirogyra* identified. The pollen diagram (Fig 18) shows four major zones. A gap in the diagram indicates a level of the core with no pollen. These are the levels characterised by a lot of sand and contained little or no microfossils. The levels include 97.5-100cm and 120-150cm. The stratigraphically constrained zonation is also discernible from the DCA ordination bi-plot (Fig 19).

Fig. 18 showing Pollen Diagram (Ewaso Narok)



Zone Rum A (120-150cm) 1140-500 yr BP

The zone contains high percentage of Asteraceae (5-80%) and Cheno/Ams (10-50%). Afromontane tree pollen percentages (*Podocarpus* and *Olea*) are low, particularly above 130cm where *Podocarpus* declines from 20 to 5% and *Olea* reaches 5%. Woodland/bush-land taxa such *Acacia* and *Euphorbia* are recorded at 140cm with a 20% increase together with *Hygrophila* (5%). A percentage decline in other taxa is noted, Poaceae (5% at 135cm) and *Polygonum* (10%). Generally, the preservation was very poor in this zone.

Zone Rum B (83-120cm) 500-200 yr BP

This zone shows decline in *Podocarpus* (20%-5%) and *Olea* (15%). In woodland/bush-land taxa, *Capparis* increases (10-40%) and *Acacia* (5%), *Grewia* (20%) and Asteraceae (20-40%) occur. Cheno/Ams are abundant throughout the zone (40-90%), showing a minor decline at 100cm. *Commelina*, *Hygrophila* and *Justicia* recorded 20% each. *Phyllanthus*, *Solanum* and *Tribulus* recorded <10% each in this zone. Cereals (Poaceae <40um) and exotics such as *Eucalyptus* appear in this zone at 83cm with 60% and 10% respectively. *Poaceae* and aquatics such as *Cyperaceae* and *Polygonum* were abundant throughout the zone but *Polygonum* is less prominent (<2% at 115 and 93cm). *Typha* reaches 99%. Monolete and fungal spores recorded 99% and 10%, respectively.

Zone Rum C (83-55cm) 200-100 yr BP

This zone is richer in pollen than any other zone. Afromontane pollen particularly *Podocarpus* range from (5-20%) and *Olea* (5-10%) with *Juniperus* (1-8%). Woodland/bush-land taxa are common in this zone but lower percentages occur of *Acacia* (19%), *Capparis* (<5%), *Grewia* (8-10%), *Lannea* (5%), cf *Rubiaceae* (5%), *Salvadora* (10%), *Terminalia* (20%) and *Ximenia* (5%). *Asteraceae* is abundant in this zone recording between 10-60%. Other prominent taxa are *Cheno/Ams* (20-50%), *Aloe* (15%), *Commelina* (10-40%), *Hygrophila*, *Justicia*, *Phyllanthus* and *Urticaceae* (<5%), *Tribulus* and cereals (5-40%).

A marked change in abundance of *Typha* and Poaceae occurs only in this zone. *Spirogyra*, monolete, trilete and fungal spores were recorded at 20%, 50%, 20% and 20% respectively.

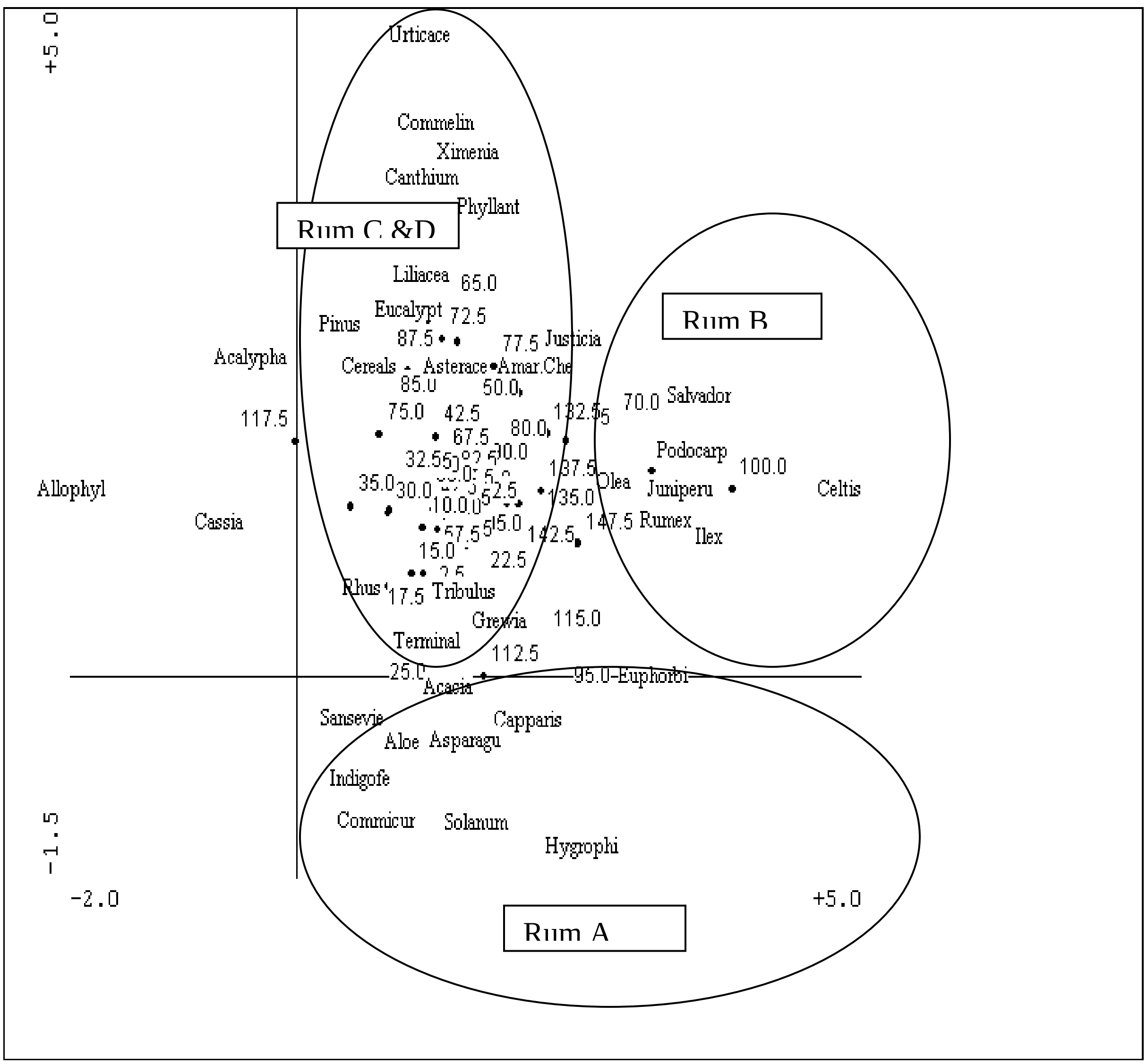
Zone Rum D (55-0 cm) 100 yr BP to present-

In this zone, *Podocarpus* declines throughout (18-3%), there is concurrent decline of *Olea* and *Juniperus.* This zone is also relatively rich in woodland/bush-land taxa compared to other zones. *Acacia*, *Capparis*, *Euphorbia*, *Grewia*, *Rhus*, cf *Rubiaceae, Salvadora, Terminalia* and *Cassia* all recorded between (5-20%). Asteraceae, Cheno/Ams, *Sansevieria* and cereals were abundant in this zone ranging between (20-95%). Other woodland taxa such as *Aloe*, *Asparagus*, *Commelina*, *Indigofera*, *Justicia*, *Kedrostis*, *Ludwigia*, *Phyllanthus, Solanum*, *Tribulus* and Umbelliferae recorded between 2-20%. Exotic taxas such as *Eucalyptus* and *Pinus* were also marked in this zone at <2%. Poaceae and aquatics such as Cyperaceae, *Polygonum* and *Nymphea* are present in this zone. A remarkable change in abundance of the fungal spores in this zone (5-99%) is recorded.

8.2.1 DCA analysis for Ewaso Narok Swamp

The results of the DCA (detrended correspondence analysis) ordination of pollen samples from Ewsao Narok are shown in Fig 19. The DCA axis 1 and 2 is more skewed, with zone Rum A-D receiving a positive score of +5. The pollen taxa associated with savannah habitats mainly receive high positive scores, which accounts for the more distinct grouping of pollen samples. The vegetation suggested is open disturbed savannah in all zones with the few montane taxa present indicative of a very dry environment.

Fig 19: DCA analysis for Ewaso Narok Swamp.



8.3 Comparison between the two sites

When compared, the two pollen records show some interesting similarities but also noticeable differences. The two pollen records indicate generally forested conditions towards the base of the cores with more dense forest reflected in Marura compared to Ewaso Narok. The composition of the forest at Marura is also notably different with a dominance of montane taxa such as *Olea*, *Podocarpus* and *Schefflera*. Given the nature of the catchments and the occurrence of relatively poorly dispersed pollen from forest taxa, it is likely that these forest taxa were growing relatively close to the coring site within the Marura catchment area. Hence, montane forest, similar to that in the highlands of Kenya today, used to be present in lowlands near both sites. The longer period covered by Marura could explain why the clear signals of forest removal and increase in taxa indicative of disturbance are recorded by the rise in Chenopodiacae and Asteraceae mid way through the sequence, whereas at Ewaso Narok these are omnipresent. The clear signal of human impact on the vegetation is recorded at Ewaso Narok by the dominance of Cereal pollen types whereas these are not common at Marura. However, other disturbance indicators are recorded at Marura indicative of a different type of land-use change – these will be discussed within Chapter 10.

CHAPTER NINE: CHARCOAL ANALYSIS AND RESULTS

Within this chapter the use of charcoal as an indicator of fire history in Marura and Ewaso Narok catchment, and in particular to changes in the fire regimes in the context of changes in environmental conditions, land use and settlement patterns are examined. The point count method (Clark, 1984) is applied to calculate microscopic charcoal influx and cluster of the two sites.

9.1 Charcoal as an indicator of past environmental events

Charcoal is an amorphous inorganic carbon compound, which results from the incomplete combustion of plant tissues (Patterson *et al*., 1987). Fires are an important factor in many of the world's ecosystems, and are particularly important in the seasonally arid areas of Eastern and Southern Africa. A reconstruction of changes in the fire regime of an area provides a useful record of environmental history, and can be related to human settlement patterns and land use changes. Fossil charcoal preserved in sediments is a useful proxy of past burning regimes. The charcoal can thus be used to study former fires, and to identify the influence and patterns of anthropogenic activity on vegetation. However, this is complex, fragmentation of this material takes place due to differential shrinking as dehydration progresses, resulting in the production of charcoal fragments ranging in size from microscopic to several cubic centimetres. The brittle nature of charcoal, however, means that larger fragments can easily be broken into smaller ones (Clark, 1984). According to Pyne *et al.,* (1996: 173), 'a fire regime is intended to characterize the features of historic, natural fires that have been typical for a particular ecosystem or set of ecosystems'. Clark and Robinson (1992) base determination of fire regimes on climate characteristics, atmospheric composition, fuels and cultural activities. Present fire regimes are not natural systems as anthropogenic fire practices have directly or indirectly influenced them. Indeed some fire regimes owe their existence and perpetuation very largely to anthropogenic causes.

Both sites on the Laikipia Plateau are likely to yield useful evidence of recent changes in fire history, as they are low energy sediment sinks with relatively limited catchments areas. The settlement history of Laikipia Plateau and the surrounding areas remains poorly understood, and as traditional agricultural practices along with pastoralists in this region of Africa, have a marked effect on fire patterns (Waller, 1990; Schmidt, 1997). It is hoped that a reconstruction of changes in the burning regime of the area will help to provide a palaeoenvironmental context for this settlement history.

In semi-arid areas of East Africa, fire is widely used for a series of purposes, and it is an important ecological factor on the Laikipia Plateau. Burning generally occurs throughout the dry season from June to November with the availability of dry fuel and high burning efficiency. It favours the increase in soil-surface nutrients and the re-growth of plants at the onset of the rains (Pielou, 1952). However, humans also start bush fires in the early dry season when low-intensity fires are less destructive to the woody plants but damage the grass cover (Trapnell, 1959).

9.2 Methods of charcoal analysis

There are many different methods by which to study fossil charcoal, including chemical assays (Clark, 1984). Quantification of microscopic charcoal on slides prepared for pollen analysis is carried out using the most common methods of the 'pollen-slide', which uses reflected light microscopy on standard compound microscopes (Figueiral and Mosbrugger, 2000). Within this method, there are various ways by which the charcoal can be quantified. Absolute particle counts give the abundance of all charcoal particles regardless of size to provide a measure of the total number encountered on the slide. Size classing involves assigning individual charcoal particles to predetermined size classes, on the bases of surface area of particle length, using an eyepiece grid or graticule (Waddington, 1969). Point counting records the number of hits on charcoal particles according to a standard number of points. This is done on an eyepiece graticule for scans over a set area of the slide.

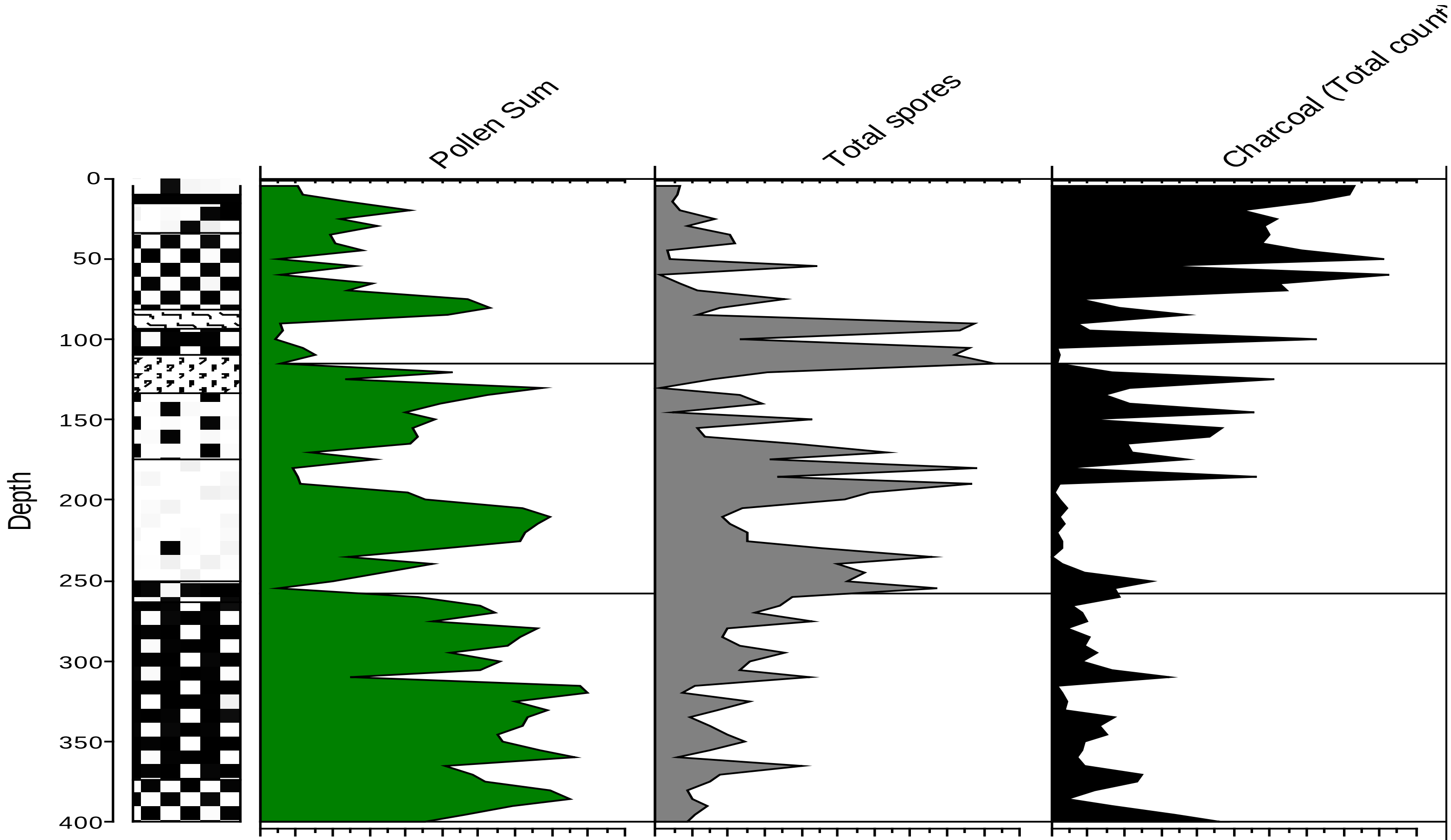
Thus, the charcoal content of a sample is measured on either a five or seven-point scale or percentage basis (Rhodes, 1998). Automated counting of microscopic charcoal particles is a recent development that uses digital image analysis of slides prepared for pollen analysis (Mooney and Black, 2003; Thevenson *et al*., 2003).

The majority of charcoal studies over the past six decades have quantified charcoal on pollen slides, primarily because charcoal analysis is often conducted in conjunction with palynological studies, and analysts can quantify the pollen and charcoal simultaneously (Rhodes, 1998). However, the techniques used to concentrate pollen in sediment samples involve severe chemical and physical treatments in order to digest and remove organic and inorganic material from the sediment matrix, and it is possible that this could lead to fragmentation of microscopic charcoal particles (Clark, 1984; Rhodes, 1998). Clark (1984) carried out various tests on the effects of these procedures, and found no significant difference between control samples and those given complete chemical and physical processing. However, it is thought that the particle size distribution may change.

9.3 Charcoal analyses from Marura and Ewaso Narok

This section presents the results of microfossil charcoal analysis for sediment cores from Marura and Ewaso Narok swamps, describing upward-core variations in charcoal concentrations for both sites and where possible provides an interpretation of the results. The zonation of the charcoal results is based on the pollen zones described in Chapter 7 of this thesis in order to link the interpretation with the vegetation changes observed in the summary pollen diagram (Fig 20).

Fig 20: Summary diagram of pollen from Marura i.e. regional taxa against spores and charcoal.


Pollen Sum
Total spores
Charcoal (Total count)
Depth
0
50
100
150
200
250
300
350
400
0 20 40 60 80 100

9.4 Quantification and results of micro charcoal

Microscopic charcoal was counted on slides prepared for pollen analysis. Charcoal is regarded here as black, uniformly opaque, angular particles with a long axis greater than 2.9µm. A total of 30 depths from Ewaso Narok Swamp (Rumuruti) and 80 depths (Marura) were counted, using point counting adapted from Clark (1982) to estimate the area of charcoal on each slide. The theory of point counting was first suggested by Glagoleft (1933), who showed that the probability of any point applied at random on a plane surface intercepting a particular phase (i.e., charcoal) will be the ratio of the area of the phase to the total area of the plane. The technique involved the viewing of samples prepared for pollen analysis on glass slides under a magnification of x400, along transects spaced 2mm apart on the slide. In each field of view, a note was made of the number of points falling on charcoal. The ends of the lines on the eyepiece graticule formed these "points". With rotation of the eye-piece graticule four times around a central point, there were 41 points in each field of view (Table 3 and 4 in Appendix 1). A note was also made of the total number of fields of view; a minimum of 197 fields of view were counted on each slide.

Calculations of the estimated area of charcoal following the statistical method devised by Clark (1982) was applied. The total sample area for a slide was the area of one field of view under x400 magnification multiplied by the total number of field of view.

For the full method and formulae used with charcoal data, see Appendix 1

Formulae used:

1: Calculate the probability (P) of a random point falling on charcoal fragments:

$P = C/N$, where

C = number of points falling on charcoal

N = total number of points applied

2: Calculate the area of charcoal (A) occurring in the fields of view:

$$A = P\ (N_{FW} * A_{FW}),\ \text{where}$$

N_{FW} = number of fields of view

A_{FW} = area of field of view

3: Calculate the standard deviation (S_A) of A

$$S_A = (N_{FW}\ A_{FW}) * \sqrt{\ }\ (P\ (1 - P) / N)$$

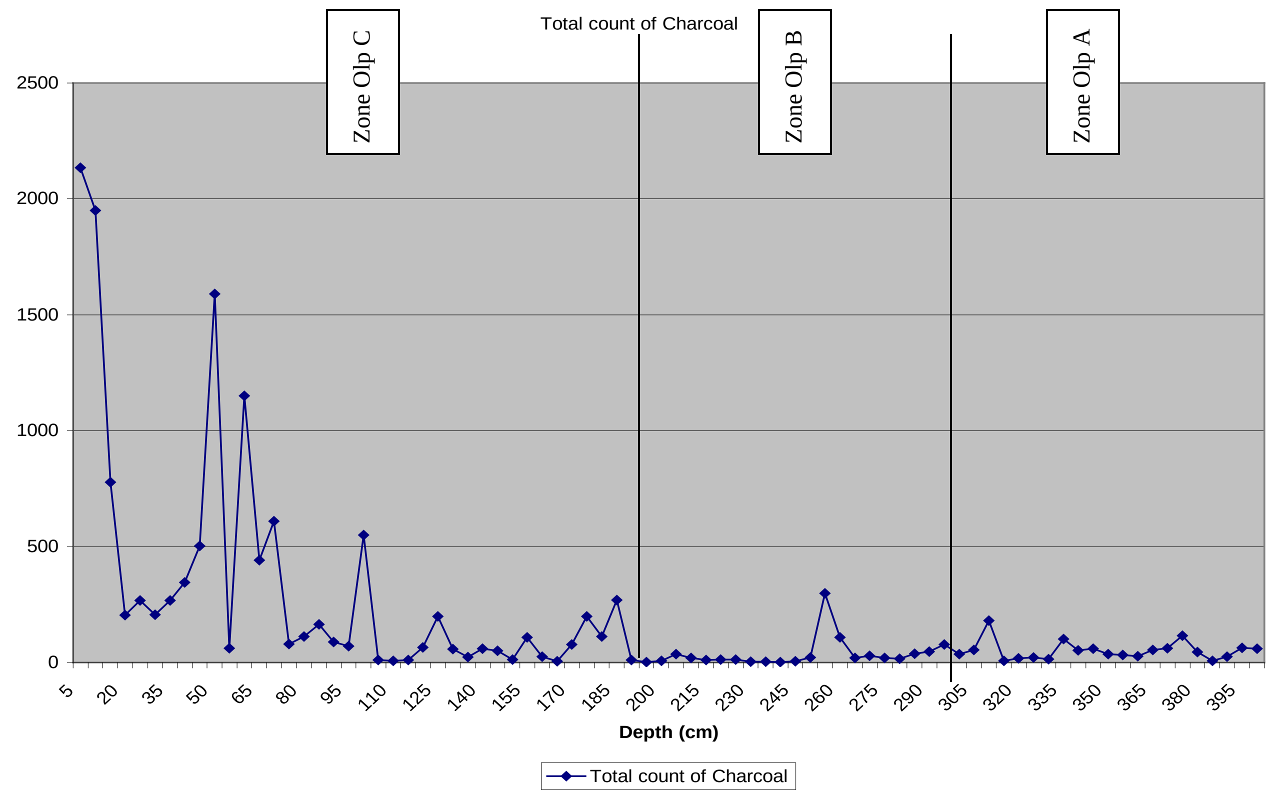
4: Calculate the 95 % confidence limits (cl)

$$cl = (2\ (S_A))$$

Due to lack of exotic grain, stages 5 and 6 were omitted.

Size classing of charcoal fragments was also carried out, following an adaptation of the method devised by Waddington (1969), who placed fragments into size-classes depending on their estimated surface area. For this study, the length of the longest axis was used as the deciding factor. Every fragment of charcoal encountered in transects of fields of view was recorded in one of the three size-classes: 2.9-29 µm, 29-63µm and >63µm (Table 3 and 4 in Appendix 1) to fit the scale on the calibrated graticule. The size limit of the lower and upper size classes were set so as to exclude very small fragments (<2.9 µm) and incorporate the few large particles that had passed through a 150 µm sieve respectively. The number of charcoal particles recorded falling into the size classes outlined were recorded within at least 500 fields of view for each sample.

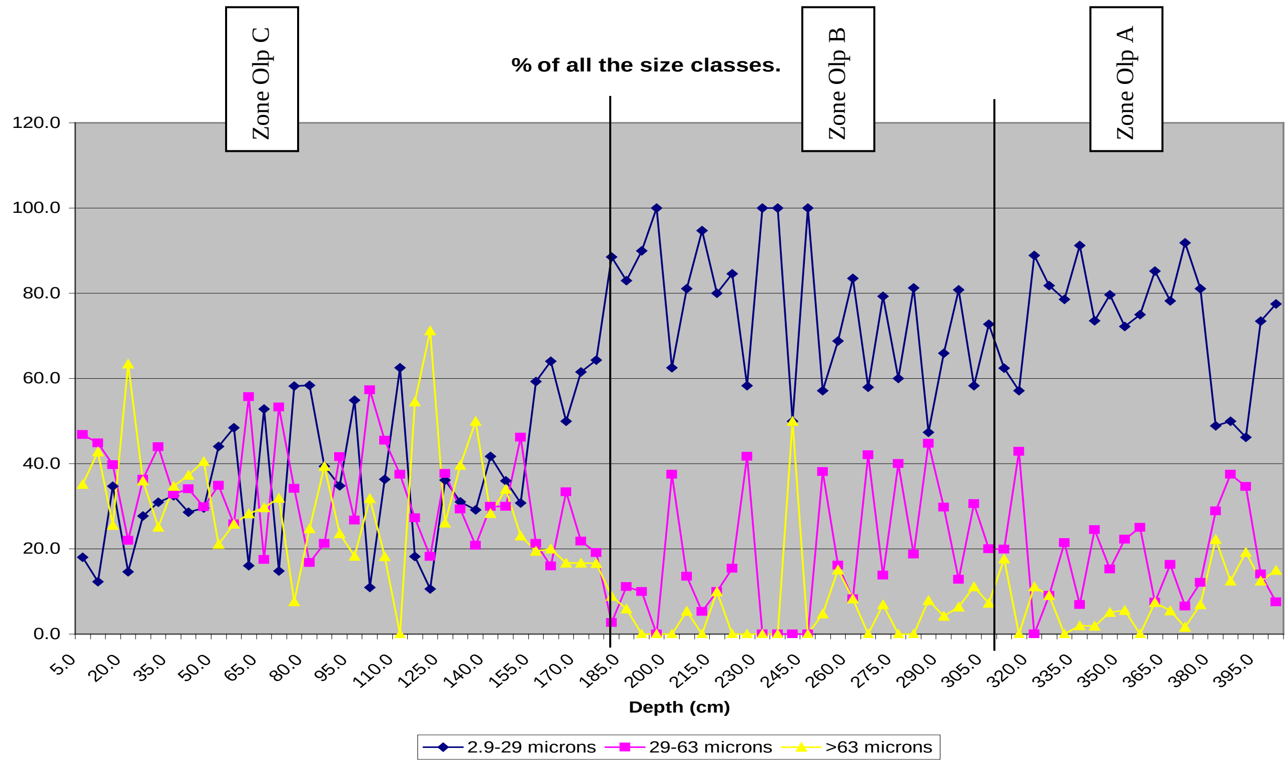
Fig 21: The absolute total count of charcoal (Marura)



9.5 Microscopic charcoal at Marura

All samples contained microscopic charcoal. Results from point counting and size-class counting are displayed in Table 3 and 4 in Appendix 1. Results are expressed in cm^2 of charcoal occurring in each sample of sediment. Fig 21 displays the absolute value of charcoal in all size-class, while Fig 22 represents the overall results for size classing, in absolute numbers of charcoal in size-class (2.9-29µm, 29-63 µm and >63 µm).

Fig 22: The % of all the size classes of Charcoal (Marura)



The size-class data in Fig 22 show a slight decline in the relative proportion of charcoal in the smallest size-class (2.9-29 µm) towards the top of the core, although it remains by far the most significant size-class throughout the entire core. Charcoal in the middle size-class (29-63 µm) experiences a general increased trend at the top of core compared to other size classes. The largest size-class (>63 µm) is characterized by a pattern of extremely low levels at the bottom of the core apart from depths 385, 245, 170, 140, 125, 85, 45, 25 and 10cm which have peaks of 20, 50,19,50, 70, 40, 65 and 43 % respectively.

9.5.1 Upward core variations in charcoal particle size at Marura

The abundance of charcoal particles (Fig 21) is relatively low (<100 particles per particles per pollen slide counted) at the base of Olp zone A of the core, between 400cm and 315cm. The total number of particles increases to >200 particles per slide towards the upper boundary of Olp zone A.

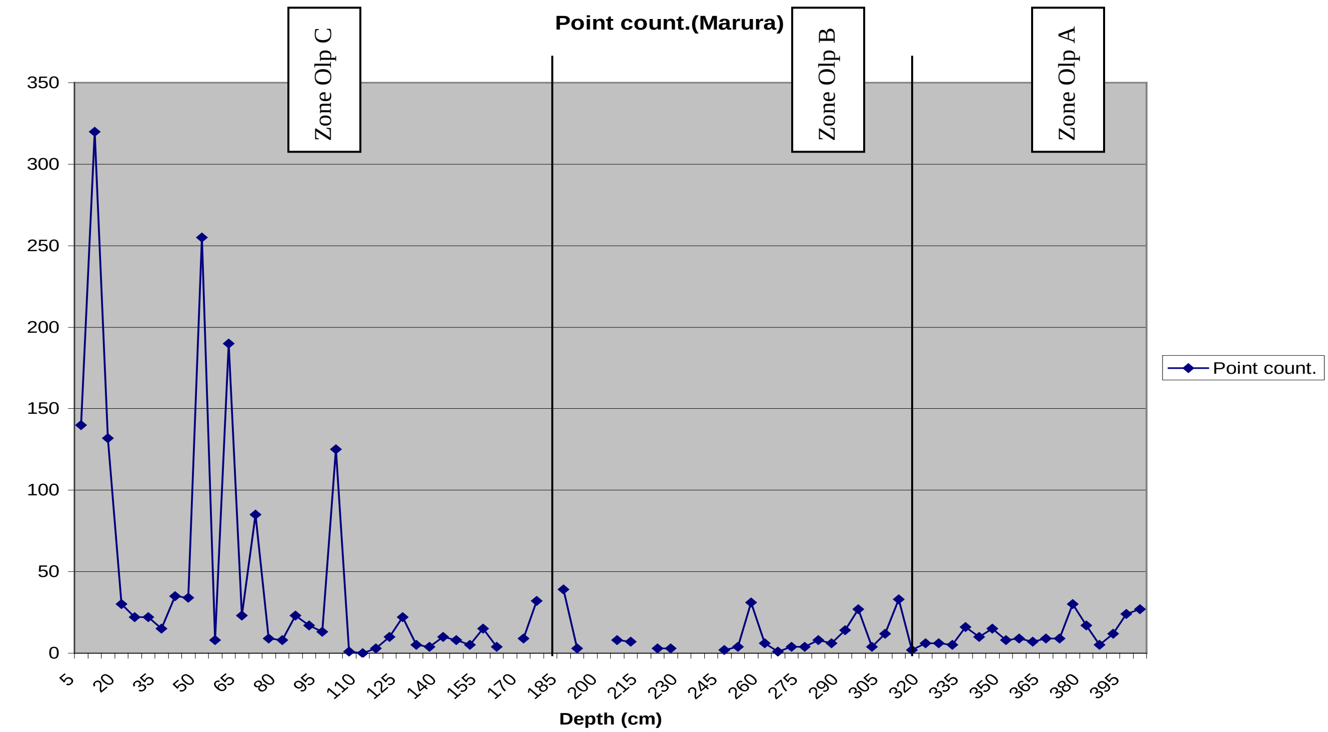
Zone Olp B is marked by a sudden rise in charcoal to 300 particles at 255cm, before dropping to low levels (<100 particles). In zone Olp C, the charcoal particle content marks a sudden rise from the base of the core up to 250 particles and a sudden drop in the same zone, but rises towards the top of the zone to 200 particles. Sub-zone Olp C1 is characterized by a drastic a rise in charcoal to 600 particles. This zone exhibits several more peaks compared to any other zone. At the top of the sub-zone, it rises to 2500 particles, with drops at depths 105cm and 55 cm.

9.5.2 Upward core variation of size classes at Marura

Zone Olp A: 400-315 cm

This zone shows a low level of charcoal, with the lowest recorded value for point-counting, size-classing and absolute total count (Fig 21, Fig 22 and Fig 23). The results from point counting (Fig 23) show decreasing charcoal concentration from 400 cm and a peak at 310 cm. The total number of particles increases to more than 200 particles (Fig 21) towards the upper part of the boundary of this zone. The concentration in charcoal particles in size class 2.9-29 µm is generally high ranging from 50-90% in this zone (Fig 22). Size class 2.9-29 µm is dominant in the two neighbouring zones ranging from 50-99%. The other size class 29-63 µm ranges from 0-40% in this zone. Category >63 µm is very low compared to other size categories, ranging from 1-30 % between 320 and 395cm. The results reflect the low levels of charcoal in this zone (Fig 23).

Fig 23: The point count from Marura



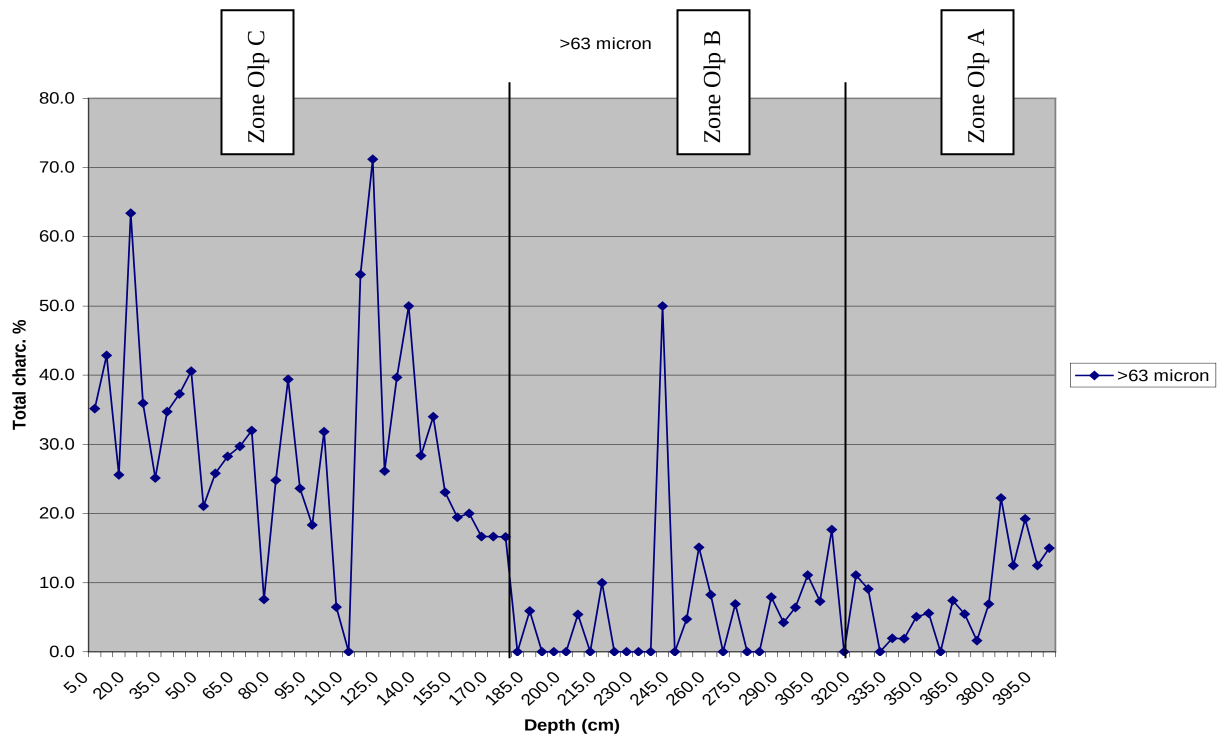
Zone Olp B: 315-165 cm

The size class 2.9-29µm remains relatively high compared to other size classes; ranging from 50-100 %, whereas size class 29-63µm ranges from 1-50 %, and size class >63µm remains relatively very low in the record apart from a sudden peak at 245cm (Fig 22), with 50% declining thereafter in the rest of the zone.

Zone Olp C: 165-0 cm

The uppermost zone shows a rapid increase in charcoal concentration. The size-class results for this zone show some interesting patterns. Overall, there is a higher proportion of charcoal in the largest size (Fig 24)

Fig 24: Total % of >63 microns charcoal (Marura)

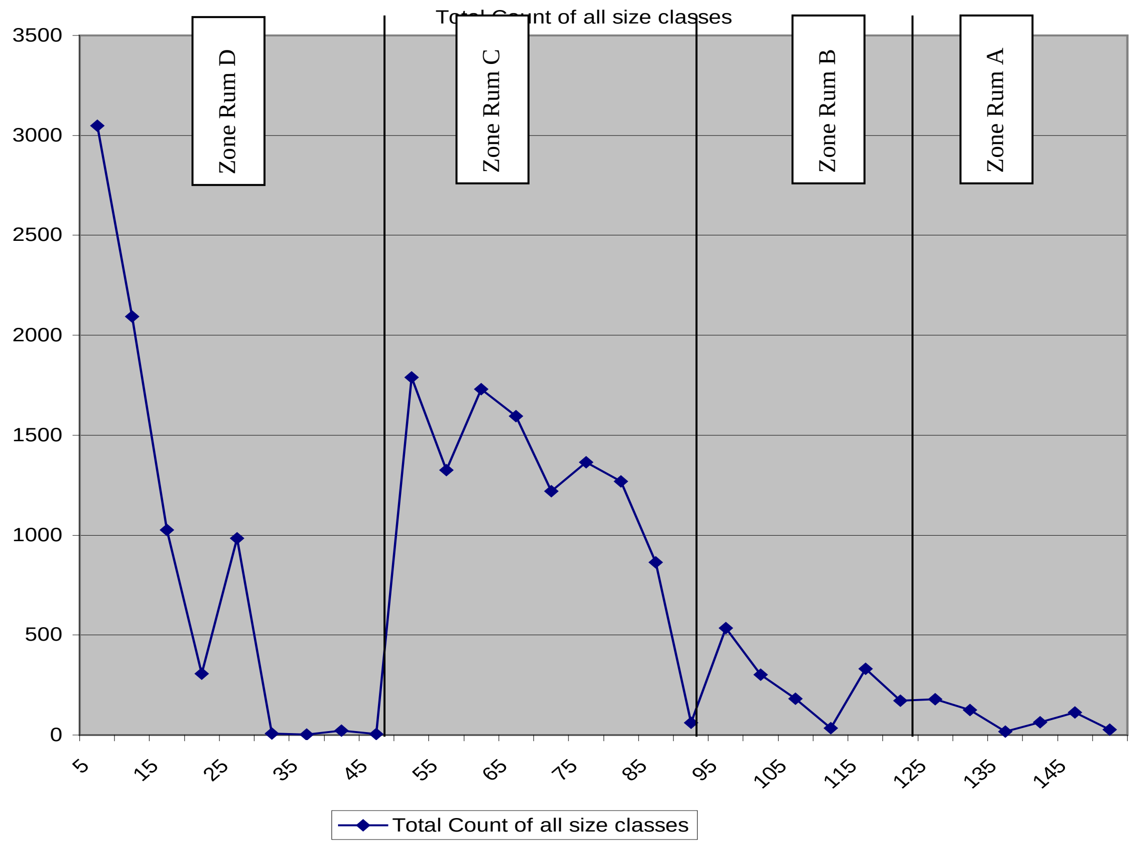


category (>63 µm) ranging from 1-70%, marking the maximum value of charcoal in this category for the entire core (Fig 24). The zone is also characterized by an increase in the absolute charcoal value for both other size-classes (2.9-29 µm, and 29-63 µm) with ranges of 15-59% and 10-65%, respectively. In point counting results (Fig 23), it is apparent that the charcoal peak is more pronounced and concentration is generally very high compared to any other zone in the entire core.

9.6 Upward-core variations in charcoal particle size, Ewaso Narok.

The abundance of charcoal particles at the base (Rum A) of the core (Fig 25) is low, with <100 particles per pollen slide counted between 130 and 150cm but a marked increase to higher levels of 250-500 particles at 125-105cm. The charcoal abundance is generally very low compared to other zones. In zone Rum B, the charcoal abundance is very high ranging from 900-1700 particles between 95 and 55cm. In Zone Rum C, the charcoal particles drops to less than 100 particles at the base of the zone before attaining an abundance of 3000 particles at the upper part of the zone.

Fig 25: Charcoal total count of all the size classes Ewaso Narok (Rumuruti)

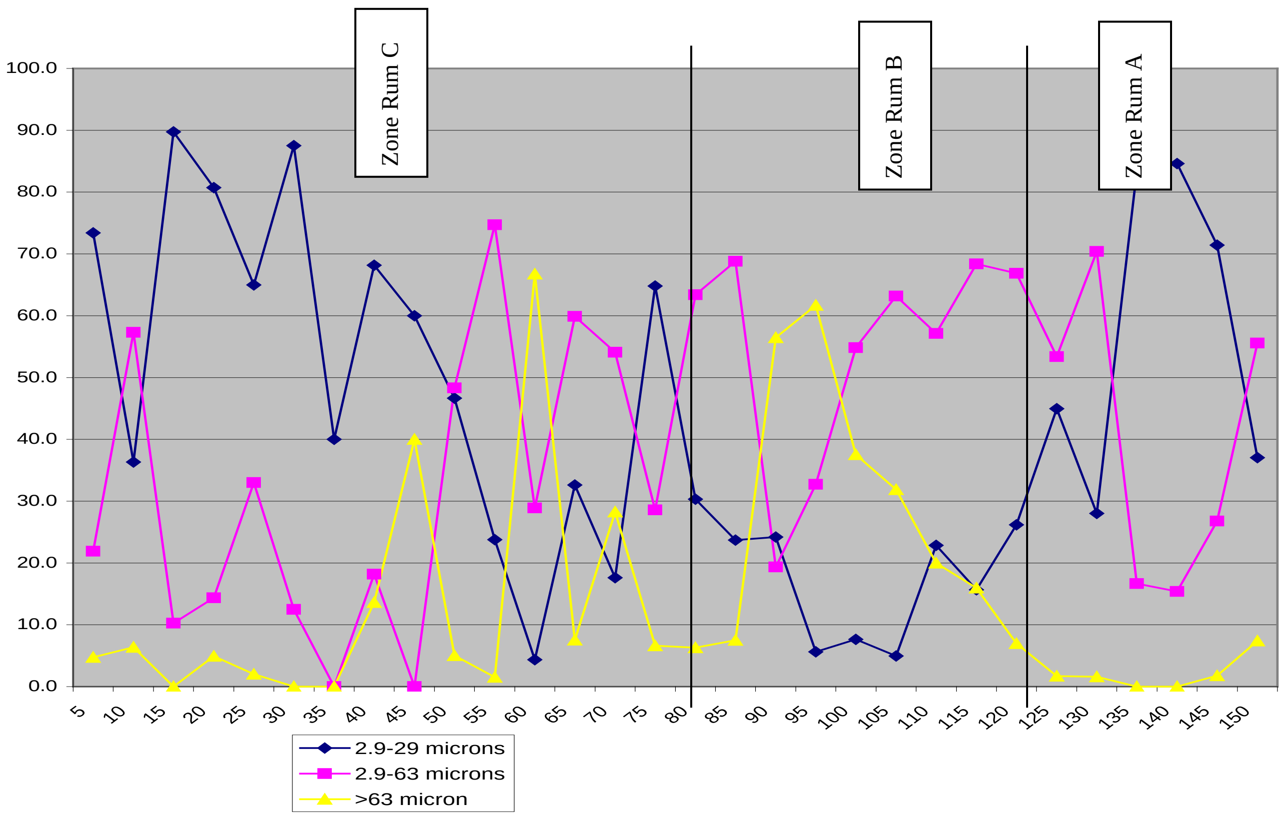


9.6.1 Upward core variation of size class Ewaso Narok

Zone Rum A: (150-125cm)

Fig 26 presents the upward-core variations in charcoal particle size classes. Particles of the size class >63µm are generally rare ranging between 1-15% at the base of the core. Particles of the size class 29-63 µm range between 15 and 70% in this zone. There is an abundance of size class 2.9-29 µm ranging between 15-85% in this zone.

Fig 26: Charcoal influx of all the size classes Ewaso Narok (Rumuruti)



Zone Rum B: (125-83cm)

There is abundance of charcoal in this zone of all the size classes (Fig 26). However, size class >63µm dominates the record in this zone. It has one peak, which is found at 95cm and ranges between 5-65%. This is followed by size class 29-63µm category, which also dominates with two peaks of 70-75%, between 85 and 55cm. The size class 2.9-29µm ranges from 5-65% within this zone.

Zone Rum C: (83-0cm)

The abundance of charcoal size class category > 63µm has just one peak in this zone, i.e. 65% at 60cm and another one at 45cm ranging 40% (Fig 26) followed by a drop to less than 5% toward the top of the core. Size class 29-63µm is also low but variable between 1-57% towards the top of the core. The 2.9-29µm categories are generally very high ranging from 38-90%.

9.6.2 Charcoal comparison between the two sites

The upward core variation of charcoal at both sites is reflected in Fig 27. It indicates generally forested conditions through less burning as indicated at the bottom of both cores. The uppermost zones from both cores shows a rapid increase in charcoal concentration in the entire zones and which form almost similar peaks around the time when the pollen record suggests that the forest became more open and the fire became frequent.

The size class 2.9-29 µm and 29-63 µm seems to have been rampant in both cores from bottom to top of the entire cores. They remained the most signficant size classes compared to any other. The size class >63 µm in both cores increased towards the top of core not necessarily conflicting with other size classes and clearly demonstrates that the fire episodes were very frequent locally in the savanna biomes as discussed in Chapter 10.

However, poor radiocarbon control does not allow chronological correlation of peaks near the top and therefore it is not certain if some of them are simultaneous.

Fig 27: Total counts for all size classes from both sites Marura, and Ewaso Narok, (Laikipia Plateau)

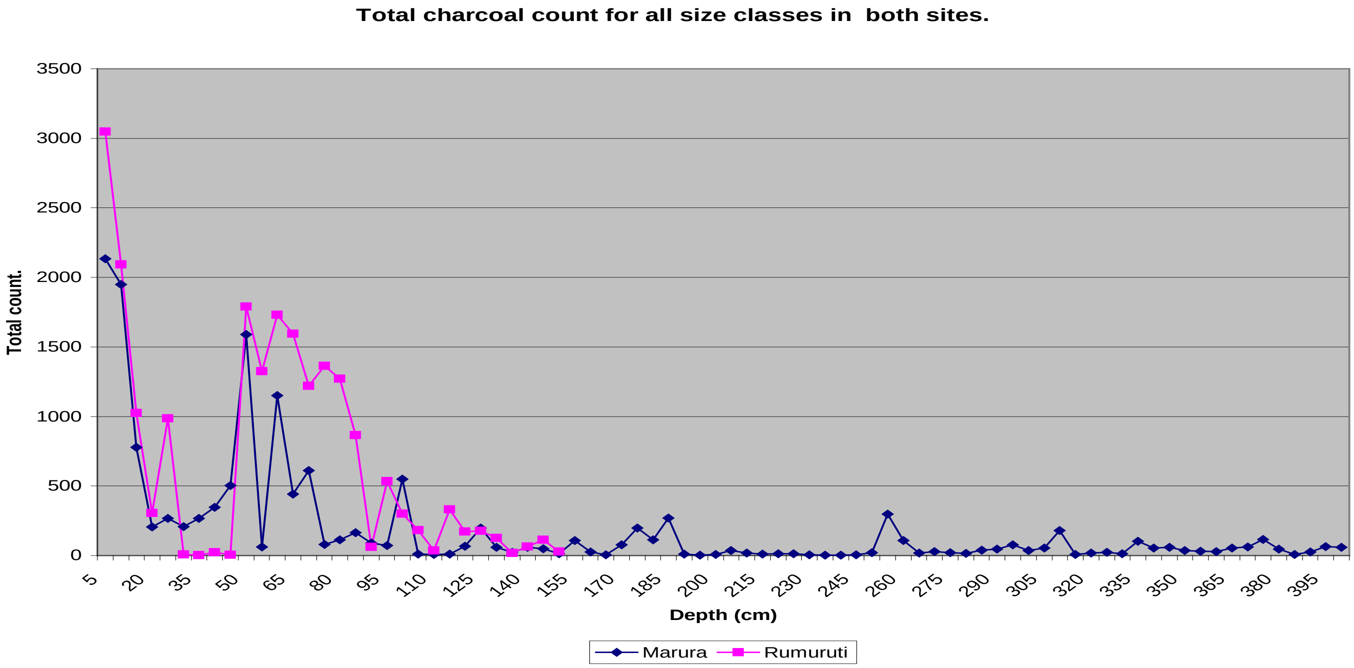


Fig 28: The summary diagram (Marura) of regional, local taxa and spores

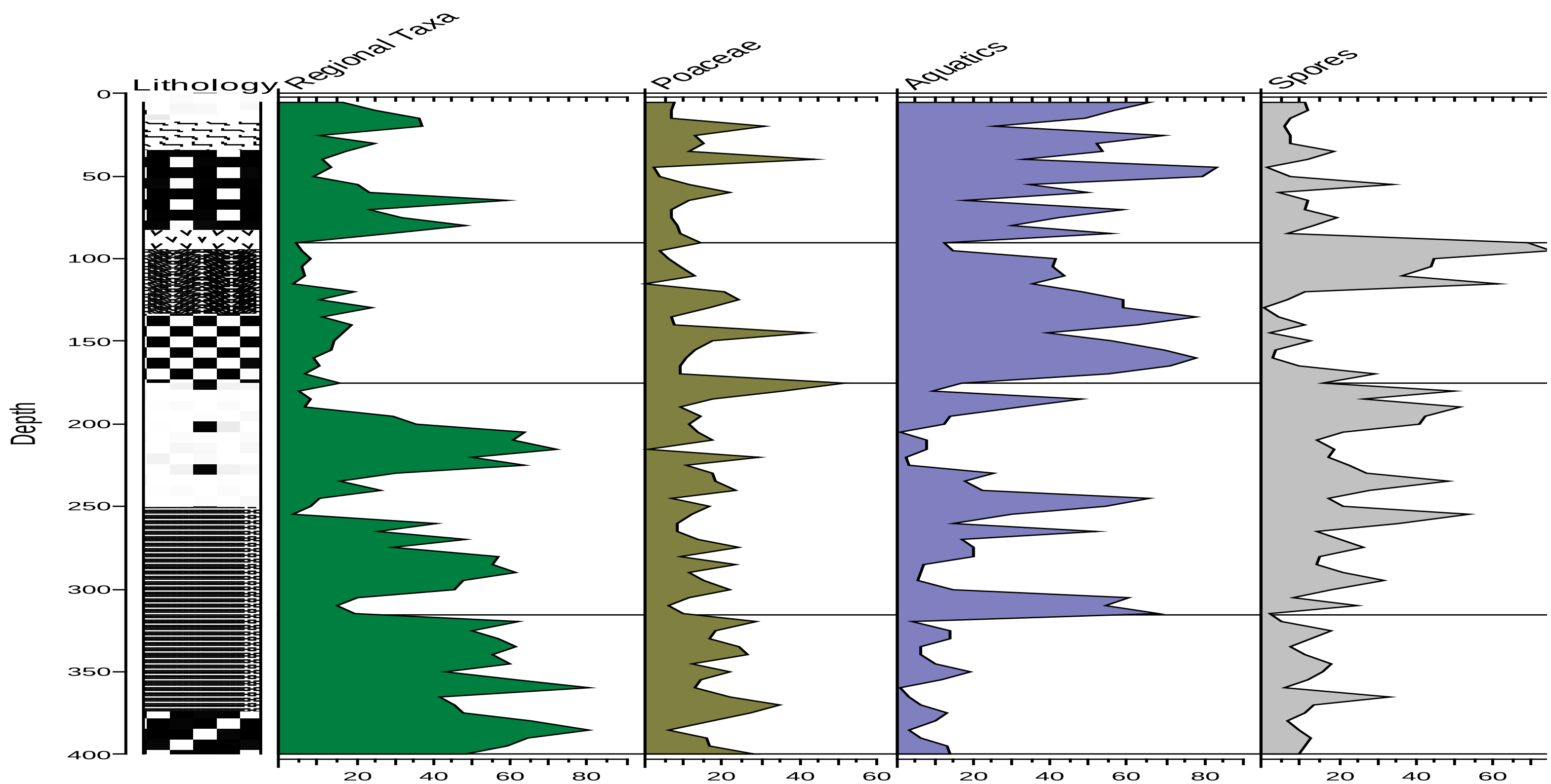


Fig 29: General diagram with all multiproxy analysis (Marura)

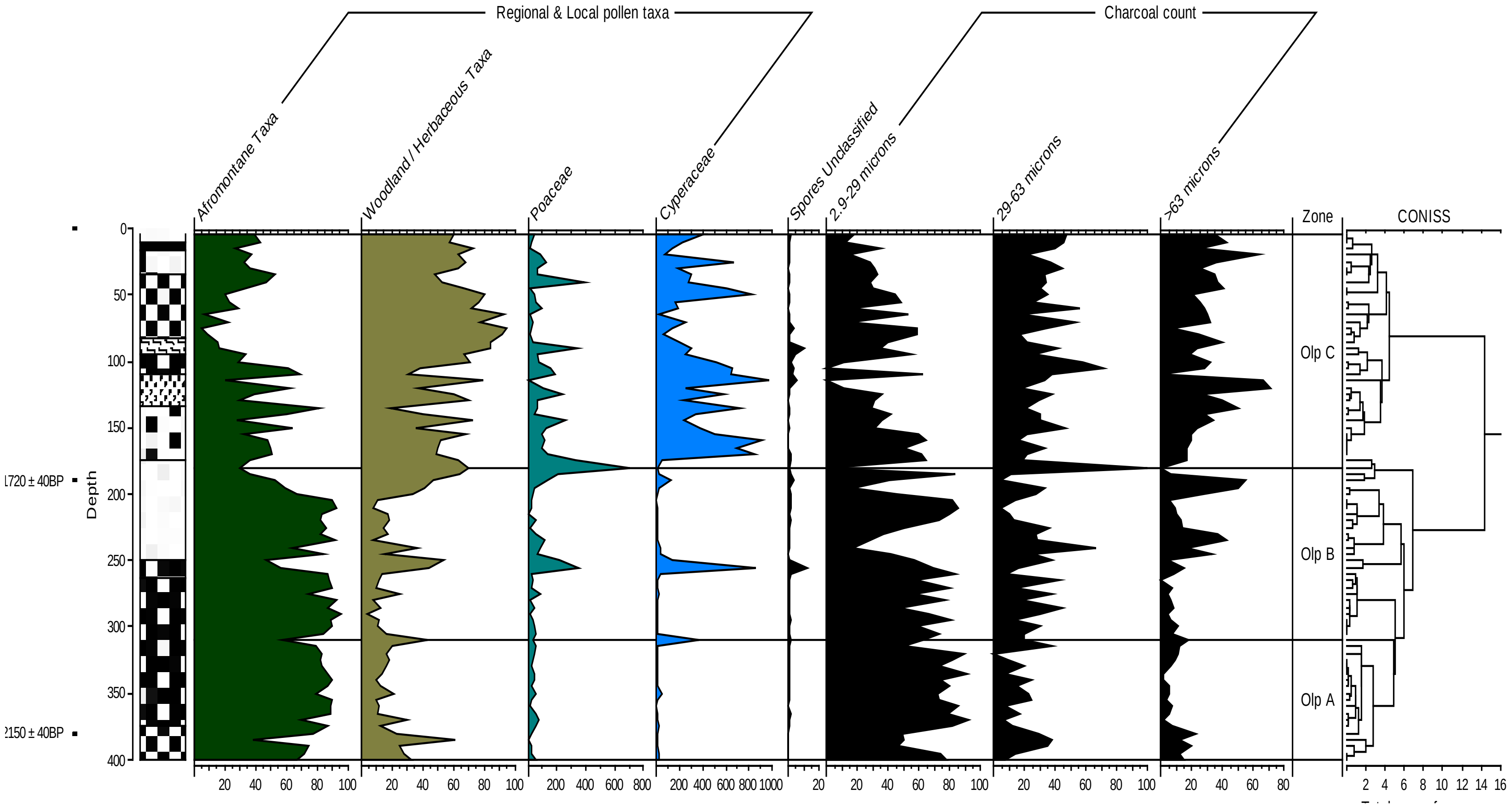
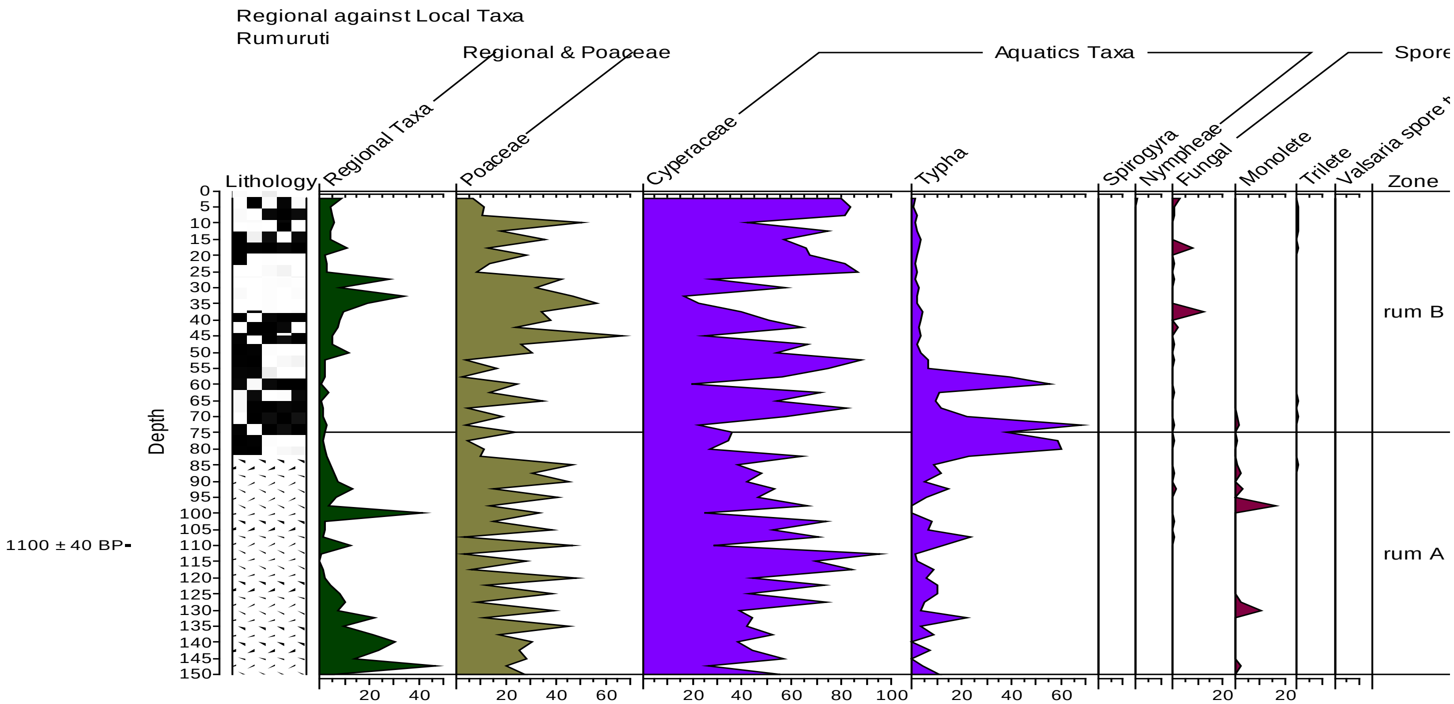


Fig 30: Regional taxa against Local taxa in Ewaso Narok Swamp.



PART THREE

CHAPTER TEN: DISCUSSION

This chapter summarises the evidence from proxy records obtained from Marura and Ewaso Narok Swamp presented in previous chapters and makes inferences that can be drawn from these concerning the environmental history of Laikipia Plateau. The chapter focuses on changes in the composition and distribution of vegetation within the study area, and indicates the possible drivers of these changes. These findings are set in context from published research from the Eastern Highlands of Kenya. The changes in environmental conditions on Laikipia Plateau are presented in a series of time slices ranging from approximately 2500 yr. BP to the present, based on zones used in the description and analysis of sub-fossil data from both sites. In addition, well-resolved archaeological records are used to compare the palaeoenviromental data.

10.1 Discussion

Sedimentary data from Marura Swamp dating from around 2200 yr BP provides a record of vegetation history of Laikipia Plateau during the Late Holocene. This reveals climate variability and impacts of anthropogenic activities associated with pastoralism and agriculture activities. These findings are broadly consistent with previously published archaeological, anthropological and palaeoenvironmental studies (Lane, in press; Mutundu, 1999; Cronk, 1989; Collett and Robertshaw, 1983; Ambrose, 1998; Taylor *et al*., 2005).

The discussion is organized around two main time periods that are related to the pollen zonation from the two sites. The first time period (2150-1700 yr BP) is only recorded in the temporally longer sequence from Marura, with the second time period (1700 yr BP to present) being covered by both records.

2200-1700 yr BP : zone Olp A and B

High amounts of montane forest taxa at the base of the core, approximately 2200 yr BP, indicates intact forest with the canopy cover being estimated to be more than 70% (Fig 15) with relatively little vegetation disturbance at the base of the record. There is also relatively low abundance of charcoal, suggesting a low incidence of fires, further indicative of a period of forested conditions (Fig 20). The data also reveals that during this period the forest is characterised by a marked expansion of *Podocarpus*. Today *Podocarpus* is found in the upland drier forests in Kenya (Beentje, 1994). Thus, the period around 2200 yr BP records a period of relatively little human impact on the environment, as registered in another pollen sequence from the region (Taylor *et al*., 2005).

The available archaeological information from around 2300 yr BP suggests that there was a pastoralist presence on the Laikipia Plateau involving herding of domestic animals (Lane, in press). However, the initiation of this phase of food production remains poorly dated. The slow replacement of Afromontane forest at this time may represent the activities of these early pastoralists. However, it is difficulty to discount the impact of climate shifts around this period since there were reduced levels of effective precipitation and possibly enhanced seasonality (Wooler *et al*., 2000). This coincides roughly with the pronounced low stands in Lake Tanganyika to around 2200 yr BP (Alin and Cohen, 2003) and Lake Edward around 2000 yr BP (Russell *et al*., 2003). The palaeoclimate data from Mt Kenya indicates that the period from 2900 to 1900 yr BP had a heavy convectional rainfall, enhanced soil erosion, neoglacial ice advances and forest expansion on the mountain (Barker *et al*., 2001). The site discussed here is in the corridor of Mt Kenya and the Aberdare Mountains where today *Podocarpus* and *Olea* are abundant. The presence of *Shefflera* and *Polycias,* wet upland forest taxa (Beentje, 1994), and the abundant presence of *Podocarpus* in the Late Holocene suggests forest cover was previously much more extensive (Hamilton 1972, Coetzee, 1967). Work done by Taylor *et al.,* (2005) at Mugie suggests that prior to c.2300 yr BP

Podocarpus made up 60 % of the canopy cover. Around 2200 yr Bp in both the Mugie cores and those presented here, *Podocarpus* has attained almost 60-70 %. This increase in *Podocarpus* and *Olea* may reflect a response to a wet climate as suggested by Kendall (1969) and Lamb *et al*., (2003). The presence of Ericaceae found in association with *Juniperus, Ilex, Podocarpus, Polyscias, Rapanea, Syzygium* and *Olea* is also an indicator of this forest expansion in the Late Holocene.

There is also a possibility that taphonomic processes, i.e. the riverine input of Afromontane and woodland taxa from channel margins may have increased during wet intervals, could account for these changes (Lamb *et al*., 2003). Rivers from the district drain northwards through the Ewaso Nyiro river with perennial tributaries such as the Sirimon, Oltalele, Liki and the Timau joining to form the Nanyuki River, all coming from Mt. Kenya. Any of these could have increased riverine input of montane forest pollen taxa. However, if this is the case then fluctuations in abundances of the main pollen taxa, such as *Podocarpus* and *Olea,* would expected to be synchronous, though it is not always the case.

As has been reported by Beentje (1994), some Ericaceae taxon such as *Agauria* are found in forest edge or secondary forest context and in high altitude bushland. The down slope shift of Ericaceae, increased abundance of *Podocarpus* and *Juniperus*, with other montane taxa, is also an indicator of relatively little anthropogenic activity in shaping vegetation communities prior to around 1850 yr BP. Around 1800 yr BP, the forest became more open with a reduction of montane taxa and increased grass cover, herbaceous taxa and aquatic taxa. The rainfall gradient of Laikipia Plateau might have also influenced vegetation in response to climate. The ratio of Poaceae compared to woodland or Afromontane taxa in semi-arid areas of East Africa is controlled by the rainfall gradient (Lamb *et al.,* 2003). In Marura, several peaks of Poaceae in the record and a decrease in the abundance of Afromontane taxa suggest a period of low rainfall.

In the Lake Tanganyika basin, there was progressive degradation of arboreal cover and concurrent increase in Poaceae pollen from 2500 BP to the present, which is probably a consequence of both increasing aridity and human influence (Vincens, 1989).

The fungal spore data (Fig 16) also support the suggestion that the Marura catchment was heavily forested before 1700 yr BP as indicated by *Trichoglossum* cf. *hirsutum* and *Glomus* spores. It is reported that these grow among taller plants causing soft-rot of wood on several tree species and, according to van Geel & Anderson (1988), are associated with forested environments. The presence of ascospores of the dung fungi are good indicators of domestic animals (van Geel, 1978; 2001; van Geel *et al*., 1982; Davis, 1987), suggesting that herbivores were present at the site again pointing towards an increasing human impact on environment. *Ustulina* spores commonly occur on herbivore dung and on decaying wood, although also recorded on herbaceous stems and leaves; it is reported to be a good indicator of herbivore dung (van Geel, 1978; 2001; van Geel *et al*., 1982). *Valsaria* fungus is also reported to be associated with herbivore dung (Davis, 1987), and has been found to be common on the dung of domestic herbivores, such as cattle, sheep and goats, these spores are also recorded on dung of wild herbivores and on decaying wood (Ahmed & Cain, 1972). Given the age of the sediments containing fungal spores from plants, which may have been growing on herbivore dung, it is likely that wild herbivores and domestic livestock produced the dung. The archaeological evidence available shows that domestic stock in Laikipia Plateau was present at Ol Ngoroi in the Lolldaiga Hills around 4000 yr BP. The evidence presented is therefore consistent with the archaeological sequence that points to an expansion of pastoralism from around 3000 yr BP, although it was not until some 1000 years later that this activity reached a level to signicantly impact on the ecosystem around Marura Swamp.

1720 yr BP - to present: zones Olp C, RUM A and RUM B

Around 1700 yr BP, forest pollen spectra characterized by few montane rainforest taxa with scattered secondary species that included *Croton, Rapanea* and *Cyathea* that grows in moist evergreen forests and swampy sites is apparent in Marura pollen record. Relatively high percentages of *Cyathea* and other ferns such as *Pteris* are indicative of a generally moist climate around this time. Such oscillations of *Cyathea* and other ferns are thought to represent slightly wetter periods (Hamilton, 1982).

This same period, from around 1700 yr BP, marks the onset of montane forest decline and an increased abundance of Poaceae at Marura. Herbaceous taxa in the sediment records increased at the expense of montane forest taxa. This shift suggests a change to a more open vegetation type as in the case of the Ewaso Narok pollen diagram, which dates to around 1100 yr BP and records an open vegetation type throughout the core. The grass flora currently growing in the study area today is dominated by *Panicum maximum*, *Pennisetum purpureum* and *Setaria sphacelata*, which according to Langdale *et al*., (1964) and Lind & Morrison (1974) are associated with human disturbance. Evidence of human disturbance at both sites is supported by the increased amounts of *Justicia* and Asteraceae pollen, which are often associated with agricultural activities (Lind & Tallantire, 1971). The sites of Ewaso Narok and Marura show similar trends in land use change as herbaceous taxa increased in the same period from around 1700 yr BP to the present suggesting regional change in vegetation. The presence of *Phyllanthus*, which is commonly associated with cleared forests, is a fruther indicator that the reduction of the montane forest resulted from anthropogenic activities.

Spirogyra is present in sediments from both Marura and Ewaso Narok, since this spore is common in fresh water flooding (van Geel *et al*., 1982-83) and its presence suggests relatively wet conditions. The presence of relatively wet conditions close to the coring site is also indicated by an abundance of *Sordaria*-type 55 spores, which are reportedly associated with damp, mesotrophic to eutrophic environments (van Geel, *et al*., 1982-83).

Such locallised increase in water level either may result from a relatively wet climate phase or increased surface water following regional vegetation clearance. As there is little regional evidence for the former, it could be the case that regional land cover changes resulted in localised higher water tables.

These changes in vegetation coincide with archaeological evidence for major increases in human population levels and activities relating to the production of food and iron at round 1100 yr BP. Arable farming is indicated by the cultivation of cereals recorded at both Marura and Ewaso Narok around 1100 yr BP. This is thought to be millet or sorghum crops that today do well in areas surrounding Mt Kenya under similar environmental conditions. In Ewaso Narok core, there is evidence for cultivation of *Ricinus communis*; this is often grown around settlement areas or planted as a crop for its oil (Edwards *et al*., 1995). These taxa were widespread, possibly an indicator of its importance to both communities. A marked increase in the proportions the dung-colonizing fungi *Cercophora* occurs in Marura sediments during the period of forest decline after 1700 yr BP. This suggests an increase in the number of herbivores in the area, and most likely domestic animals, notably cattle. The timing of this finding is contemporaneous with the archaeological evidence from elsewhere on the Laikipia Plateau that shows an increase in communities who were herding cattle along with other domesticated animals (Lane, 2004). The proportion of *Sardoria*-type 55 fungus remains relatively high in the record, indicating the continued presence of edaphically wet conditions close to the coring sites.

High percentages of *Sordoriaceae* ascospores in modern and Iron Age cow dung from southern Africa (Carrion *et al*., 2000) suggest that members of this family of fungi are also indicators of grazing. Thus, it is difficult to disentangle increased moisture supply and increase pastrol activity. However, given the added information from archaeology it is likely these changes would have resulted from an increase in human activity that affected the ecosystem.

The increase of the Reniform spores and fern spore (Fig 16) in this same zone further demonstrates the forest clearance, as it is normally associated with disturbed ground and open habitats. Furthermore there is increased percentages of charcoal recorded in the sediments from this time period (Fig 9); increased burning of vegetation on the Laikipia Plateau may be linked to clearing forest and woodland to improve and extend grazing land and possibly reducing the threat of insect-borne diseases such as Trypanosomiasis (Gifford-Gonzalez, 1998), at round 1700 yr BP. This period of increased charcoal corresponds to declining forest vegetation in the catchment's area thus probably indicating increased human activities in the region from around 1700 yr BP to present.

The character of the charcoal particles is also interesting; the relatively more abundant charcoal particles with size greater than 63 μm at Ewaso Narok and Marura, suggests that the fires may have originated from the adjacent local areas. According to Clark & Royall (1995), Clark & Hussey (1996) and Thevenon *et al.*, (2003) charcoal particles with size greater than 63 μm reflect local burning, as they are often not transported far, unlike smaller particles (< 29 μm), which are usually transported for longer distances by wind and are often from regional and extra-regional fires. Smaller charcoal particles (<63 μm) are interpreted as having possibly originated beyond this "local" area; however, it must be borne in mind that small charcoal fragments produced locally will also be evident in the overall trends of relative increases in charcoal total when both point-counting and size-class analysis are taken into account. Overall, the charcoal results show a high level of burning regionally and particularly from around 1700 yr BP (Fig 30).

This period incorporates the later stages of the PN and the early part of the PIA in the region, and therefore the increasing use of iron implements and possible importance of cereals (Bower, 1991). The earlier part of the period also coincides with archaeological information that indicates greater settlement mobility. However, impact of regional climate change should not be discounted, the evidence of low lake levels and effective precipitation i.e. water levels in Lake Tanganyika were low AD 200-500, and again at AD 700-850 (Alin and Cohen, 2003).

Thus, the charcoal data that are > 63 µm probably reflect the expansion of *Acacia* bush land and fire-adapted C_4 grassland (Taylor et. al., 2005) as observed from the record in this zone.

Combining results from charcoal, pollen and spores evidence (Fig 29), provides a record of the relative vegetation change occurring in the study area in the context of changing land uses and settlement patterns, during the late Holocene. The sudden increase in charcoal abundance at the base (Fig 30) of zone Olp C towards the top of the core corresponds to increased Poaceae and other herbaceous taxa when the Afromontane vegetation became open with increased anthropogenic fire episodes giving rise to expansion of grasslands and woodlands. The onset of Pastoral Iron Age settlement in the area began by around 850 BP (Siiriäinen, 1971), at which time the hunter-gather populations were apparently already displaced to the upland hilly areas as Pastoral Neolithic herders had already occupied the other areas of the Laikipia Plateau. The timing of deforestation on the Laikipia Plateau and the environs corresponds with archaeological data from major excavations in the region (Mutundu, 1999). Ethnographic surveys done by Cronk, as well as historical linguistic evidence (Cronk, 1989, 2004), indicate that there was considerable immigration to the region by people who were reliant on cattle and other forms of food production and thus demanding land for these activities.

Evidence from Mugie suggests that the onset of deforestation on Laikipia Plateau started approximately 1200-1100 yr BP (Taylor *et al*., 2005) although it is recorded a little later at Ewaso Narok and Marura. Major forest clearance on Laikipia Plateau and associated burning appear to have been part of much more widely felt changes in vegetation cover along the western part of Mount Kenya and part of the Rift valley at around 1200 yr BP (Baker et al., 2004). Later some of the cleared forests were planted with exotics.

The presence of *Pinus* pollen in the Marura core (see pollen diagram Marura zone Olp C1) indicates the period when these exotics species were introduced. As early as 1915 (Bussmann, 1994) exotic forests were established in the Mt Kenya region. Later, they are associated with expansion and conversion of swamps and marginal land to large-scale agriculture. The presence of exotic forests encouraged the increase of herbaceous taxa in recent times. It is now clear that high accumulation of charcoal, reduction in forest taxa and introduction of cereals in the Late Holocene coincides with immigration of the Kikuyu in Mt. Kenya region around 1730 AD (Muriuki, 1974). The Kikuyu have been held accountable for clearing large expanses of montane forest for agriculture (Lamb *et al.,* 2003). The destruction of forests expanded during the nineteenth century AD when large areas were cleared (Hoehnel, 1894).

The Wameru arrived in the eastern part of Mt Kenya in 14th century (M'Imanyara, 1992). However, it was established by Ole Sankan (1971) that the areas around Nanyuki and Nyeri were occupied by the Ilaikipiak and Ilpurko Maasai who were separated from the Kikuyu by a corridor of forest that acted as a buffer zone (Muriuki, 1974). This was near Naromoru, close to the cored site where this research has been carried out. The Maasai called this place Dondole a place of 'everyone's land' (Thomson, 1885). The Maasai used to burn these forests for grazing purposes destroying most of the northern part of Mt. Kenya forest so as to create forest gaps (Bussmann, 1994). Localized clearance of montane forest and lower-altitude woodland is indicated by the decrease in *Podocarpus*, *Olea* and in general, all Afromontane taxa. Clearance may also to some extent reflect expansion of Maasai pastoralists onto the Laikipia Plateau and Rift Valley (Spear, 1981), who tend to spend the dry season in the forest at higher elevations.

10.2 Implications findings for land management

Across Africa, conservation policies often lack important information pertaining to long term environmental change and patterns of land use (Brockington and Homewood, 2002; Gillson and Lindsay, 2002; Leach and Mearns, 1996). Adequate knowledge is needed for policy makers to implement effective land use management schemes to protect both wildlife and the ecosystem that sustain them. At the same time, local concerns regarding ancestral rights to land, natural resources and other kinds of common property must also be addressed (Causey & Lane, 2005). Laikipia Plateau is among the best-known rangeland in East Africa. Rangelands comprise bushland, grassland, bushed and wooded grassland and woodlands and these could be one of Laikipia Plateau's most valuable assets. An increase in wildlife on Laikipia Plateau since 1970s, have resulted in changing management regimes and growth of high wildlife tourism. However, this has not always benefited lower income farmers and pastoralists whose land neighbours these ranches. Also human-animal conflicts that will undermine the tourism industry are widespread. Today some of the Laikipia Plateau ranches are to be subdivided to settle the landless which may resolve local subsistence needs but could affect negatively overall biodiversity.

It is apparent from the study of fossil records that some general rules apply to most terrestrial ecosystems. The organisms must be adapted to accept the range of variability of climate that they will experience within their life span and will respond to a persistent change in mean climate conditions by some combination of adaptive evolution and migration. The historical record shows that the pre-industrial human population were also susceptible to climatic changes and supports the contention that humans have at times migrated in response to such changes. The archaeological record provides evidence of shifts in settlement and other patterns of human distribution that similarly may reflect vegetation responses to past climate changes. In addition, it is possible that some of the major cultural changes seen in the archaeological records reflect adaptive responses to climatic changes like changing from pastoralism to agriculture or *vice versa*.

CHAPTER ELEVEN: CONCLUSIONS

The regional vegetation, especially the relative abundances of grassland and woody species can be seen as vertical and horizontal movement between the savanna ecotone and Afromontane biomes. Grazing and browsing by domestic stock, wildlife, destruction of woodland and forest for the extension of both pasture and arable land have all had an impact on the composition of the vegetation on the Laikipia Plateau.

There have been large variations in the relative abundance of grass and forest cover on the Laikipia Plateau over the last 2200 years. It is clear that some 2000 years ago there was greater abundance of montane forest taxa within the Marura Swamp catchment. This vegetation is thought to reflect a relatively moist climate; such a suggestion is also supported by the relatively few aquatic taxa and very low level of charcoal at Marura. The presence of herbivore fungal spores suggests the presence of pastoralists in these forests but at low levels with less burning as reflected by low levels of charcoal. Charcoal evidence indicates that most of the fires in the forest were regional and that charcoal came probably from burning of savanna for new pastures and for fighting animal diseases. Therefore, pastoralists played a significant role in diminishing Afromontane forests from 2200 to 1700 yr BP.

Human impact on vegetation played a major role compared to vegetation response to climatic changes in the second part of the Marura sequence. The period from around 1700 yr BP to present at Marura show clear signals of human impact on the vegetation, charcoal evidence suggests intensive clearance and burning, possibly associated with the introduction of agriculture and increased pastoral activity. The Afromontane forest became much more open as savanna taxa, grasses and herbaceous taxa increased.

Acacia expanded replacing the Afromontane taxa as fire intensity increased in Afromontane forests. The increase in *Acacia* may reflect the relative fire tolerant nature of these taxa.

Cereals and taxa reflecting human impact appear commonly around 500 yr BP at Ewaso Narok with a similar timing of more common ruderal taxa at Marura – these different signals may reflect the type of land-use and different environmental regime of the two sites. Systematic archaeological survey in the vicinity of these sampling locations is now needed to test this suggestion. Land use changes associated with the colonial administration are also detected in the area as these introduced exotics to replace the cleared Afromontane forests from around 1915.

Acknowledgements

I would like to thank my late husband Simon Waruingi for giving me necessary support, encouragements and more to it bearing with our two kids Tevin Ndirangu and Mitchell Nyawira when I was very busy doing my studies. Secondly, thanks are due to the Director General, National Museums of Kenya, Dr Idle Farah for giving me the necessary support especially the use of the adequate facilities in the institution with no limitations. My special thanks go to the entire Palynology Section staff, that is, Rahab Kinyanjui, Rose Warigia and Simon Kangethe, who worked tirelessly to give me their support at all times. My special thanks go specifically to Stephen Rucina who tirelessly worked with me, making comments and suggestions, even offering to take me to the field while he was doing his PhD. Thanks also to the driver of the National Museums of Kenya, Mr Antony Mukiri, for his assistance in the field. I would also like to thank the British Institute in Eastern Africa (BIEA) and its former director, Dr. Paul Lane for his tremendous support in supervising my work, facilitating my initial fieldwork, providing funds for carbon dating and buying of chemicals. Without his support, it would have been impossible to carry out this research.

Many thanks go to Prof. Louis Scott of the University of Free State for supervising and for the attention; he gave me whenever I needed any information from the University.

Above all, I would like to thank Dr. Robert Marchant from York University for his financial support in paying for the studies. His supervision, guidance and support from the start of this research, are all highly appreciated. Thanks to Ol Pejeta Conservancy and the entire staff for allowing me to carry out my research in the ranch and for giving me much needed support during this time. My thanks also go to my many friends who are not mentioned in this thesis for their encouragement.

REFERENCES

Ahmed, S. I. & Cain, R. F. (1972). Revision of the genera *Sporormia* and *Sporormiella*. *Canadian Journal of Botany*, **50**: 419-477.

Alin, S. R. & Cohen, A. S. (2003). Lake-level history of Lake Tanganyika, East Africa, for the past 2500 years based on ostracode-infferred water-depth reconstruction. *Palaeogeography Palaeoclimatology and Palaeoecology*, **199**: 31-49.

Ambrose, S.H. (1984). The introduction of Pastoral adaptations to the Highlands of East Africa. In *From Hunters to Farmers: The causes and Consequences of Food Production in Africa*.

Ambrose, S.H. (1998). Chronology of the Later Stone Age and Food Production in East Africa. *Journal of Archaeological Science* **25**: 377-392.

Barker, P.A. Street-Perrot, F.A., Leng, M.J., Greenwood, P.B., Swain, D.L., Perrott, R.A., Telford, R.J. and Ficken, K.J. (2001). A 14,000-year oxygen isotope record from diatom silica in two alpine lakes on Mt. Kenya.

Barthelme, J.W. (1985). *Fisher-Hunters and Neolithic Pastoralists in East Turkana, Kenya*. BAR International Series, 254. Oxford: British Archaeological Reports.

Battiscombe, E. (1936). *Tree and Shrubs of Kenya colony; A Revision and Enlargement of Battiscombe 1926*, Nairobi; Government Printers.

Beentje H.J. (1994) *Kenya Trees, Shrubs and Lianas*

Benninghoff, W.S & Kapp, R. O. (1962). Suggested notation to indicate identification status of fossil pollen. *Pollen and Spores*, **4**: 332

Brockington, N. R. (1961). Studies of the growth of *Hyparrhenia*-dominated grassland in Northern Rhodesia, f.Br. *Grassld. Soc.*, **16**: 54-64.

Brockington, D., & Homewood K. (2001). Degradation debates and data deficiencies: The case of the Mkomazi game Reserve, Tanzania. *Africa* 449-480.

Boyd, W.E. and Hall, V.A. (1998). New Frontiers and applications in palynology: 1X International Palynological Congress, Houston, Texas, USA, 23-25 June 1996. *Review of Palaeobotany and Palynology*, **103**: 1-83.

Bonnefille, R., Mohammed, U. (1994). Pollen-inferred climatic fluctuations in Ethiopia During the last 3000years. *Palaeogeography, Paleoclimatology and Palaeoecology*, **109**: 331–343.

Bonnefille, R. and Chalie, F. (2000). Pollen-inferred precipitation time-series from equatorial mountains, Africa, the last 40 kyr BP. *Global and Planetary Change,* **26**: 25-50.

Bower, J., Nelson, C.M., Waibel, A.F, Wandibba, S. (1977). The university of Massachusetts' Later Stone Age / Pastoral "Neolithic" Comparative study in Central Kenya; an overview. *Azania* **12**, 119-146.

Bower, J. and Nelson, C.M., (1991). The Pastoral Neolithic of East Africa. *Journal of World Prehistory* **5**:49-82.

Butzer, K. (1971). Recent History of an Ethiopian Delta : the Omo Delta and the level of Lake Rudolf. Research Papers, Vol. 136. Chicago.

Bussmann, R.W. (1993). *The forests of Mount Kenya (Kenya) -A phytosociological approach with special reference to ecological problems*. Diplomarbeit, Universitat Tubingen, pp. 1-119 S tab.

Bussmann, R.W. & Hansen, C. (1968). Desert and River in Nibia. Geomorphology and Prehistoric Environments at the Aswan Reservoir. Madison.

Bussmann, R.W. & Beck. E. (1993). The forest communities of Mount Kenya, Proceedings of the third international congress of the African Mountains Association, Nairobi 4-17.3.

Carrion, J. S., Scott, L. Huffman, T. & Dryer, C. (2000). Pollen analysis of Iron Age cow dung in southern Africa. *Vegetation History and Archaeology*, **9**: 239-249.

Casanova, J. & Hillaire-Marcel, C. (1992). Late Holocene hydrological history of Lake Tanganyika, East Africa, from isotopic data on fossil stromatolites. *Palaeogeography*, *Palaeoclimatology and Palaeoecology*, **91**: 35– 48.

Chami, F., (1999). Graeco-Roman Trade Link and the Bantu Migration Theory. *Anthropos* 94: 205.

Clark, J. D., (1970). The prehistory of Africa. New York: Praeger.

Clark, J. D., (1976). African origins of man the toolmaker in "Human Origins" (G.L. Isaac and E.R. Mc Cown, eds), pp. 1-53. W.A. Benjamini, California.

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

Clark, J. S. & Royall, P. D. (1995). Particle–size evidence for source areas of charcoal accumulation in the late Holocene sediments of Eastern North America lakes. *Quaternary Research,* **43**: 80-89.

Clark, J. S. & Hussey, T. C. (1996). Estimating the mass flux of charcoal from sedimentary records: effects of particle size, morphology and orientation. *The Holocene,* **6**: 129-144.

Coetzee, J. A. (1967). Pollen analytical studies in East and Southern Africa. *Palaeoecology of Africa,* **3:** 1-146.

Coetzee, J. (1964). Evidence for a considerable depression of the vegetation belts during the Upper Pleistocene of the East African mountains. *Nature* **204**.564-566.

Conway, D. (2002). Extreme rainfall events and lake level changes in East Africa: Recent events and historical precedents. *In* Odada, E. O. and Olago, D. O. (editors), *The East African Great Lakes: Limnology, Palaeolimnology and Biodiversity*. Kluwer Academic Publishers, Netherlands, 63-92.

Cole, S. (1964). *The Prehistory of East Africa*. London; Weidenfeld and Nicolson.

Cole, J.M. and Higgs, E.S. (1969). "*The Archaeology of Early Man*" Penguin, England. 454pp.

Cronk, L. (1989). From hunters to herders: subsistence change as a reproductive strategy among the Mukogodo. *Current Anthropology,* **30**: 224-34.

Cronk, L. 2004. *From Mukogodo to Maasai: Ethnicity and cultural change in Kenya.* Boulder, Colorado: Westview Press.

Davis, O. K. (1987). Spores of the dung fungus *Sporormiella*: increased abundance in historic sediments and before Pleistocene megafaunal extinction. *Quaternary Research,* **28**: 290-294.

Davies, W. (1961). 'Temperature and Tropical grassland', Proc. 8th International Grassland Congress, Reading, England.

Darbyshire, I., Lamb, H. and Umer, M. (2003). Forest clearance and re-growth in northern Ethiopia during the last 3000 years. *The Holocene,* **13:** 537-46.

Denbow, James, (1990). Congo to Kalahari: Data and Hypotheses about the Political Economy of the Western Stream of the Early Iron Age. *The African Archaeological Review,* **8**:139-176.

Dickson, D.B. and Gang, G-Y. (2002). Evidence of the emergence of modern behaviour the Middle and Later Stone Age lithic assemblages at Shurmai rockshelter (Gnjml) and Kakwa Lelash rockshelter (Gnjm2) in the Mukogodo Hills of north-central Kenya. *African Archaeological Review*, **19**: 1-26.

Dickson, D.B., Pearl, F.B., Gang, G-Y., Kahinju, S. and Wandibba, S. (2004). Site Reconnaissance in the Kipsing and Tol River watersheds of Central Kenya: Implications for Middle and Later Stone Age land-use patterns. *African Archaeological Review* **21**: 153-191.

Edwards, S., Tadesse, M. and Hedberg, I., editors (1995). Flora of Ethiopia and Eritrea. Volume 2, Part 2: Conellaceae to Euphorbiaceae. Addis Ababa: The National Herbarium, University of Addis Ababab.

Erdtman. G. (1960). The acetolysis method. A revised description. Svenk. Bot. Tidsk. **54**: 561-564.

Ehret, Christopher, (1971). southern Nilotic History. Lingustic Approaches to the study of the Past.

Evanston (1998). An African Classical Age: Eastern and Southern Africa in World History, 1000 BC to Ad 400. Charlottesville: University of Virginia Press.

Evanston (1974). Ethiopians and East Africans. The problem of contacts. Nairobi.

Faegri, K. and Iversen, J. (1989). *Text of Pollen Analysis*, Chichester: John Wiley and Sons.

Faugust, p. & Sutton, J. (1966). The Egerton Care on the Njoro River –Azania 1

Findlater, J., (1968). Cross-equatorial jet streams at low-levels over Kenya. *Meteorological .Mog*., **95**: 353-364.

Flohn, H. (1987). East African rains of 1961/62 and the abrupt changes of the White Nile discharge. *Palaeoecology of Africa*, **18**: 3-18.

Gardner, H.M. (1932) conifers of Kenya, Pp. 281-4 in Report of the Royal Horticultural Society Conference.

Gang, G-Y. (2001). The Middle and Later Stone Ages in the Mukogodo Hills of Central Kenya. BAR International Series 964. Oxford: Archaeopress.

Gakahu, C.G. & COX, G.W. (1984). The occurrence and origin of mima mound, terrain in Kenya. *African Journal of Ecology*, **22** (1): 31-42.

Gifford-Gonzalez, Diane, (1998). Early Pastoralists in East Africa: Ecological and Social Dimensions. Journal of Anthropological Archaeology **17**(2):166-200.

Gifford-Gonzalez, Diane, (2005). *Patoralism and its Consequences*

Gillet, A.C. (1951) Northern Frontier Kenya, District Tour. Pp.14. Nairobi; Kenya Forest Department. Cyclostyled.

Gillson, L. and K. Lindsay (2002) Ivory and ecology- changing perspectives on elephant management and the international trade in ivory. *Environmental Science and Policy* **6**:411-419.

Gregory, J.W. (1896). The Great Rift Valley. London.

Gregory, J.W. (1921). The Rift Valleys and Geology of East Africa. London.

Griffiths, J.F. (1958). Climatic zones of East Africa. East African Agricultural Journal, **23**: 179-185.

Griffiths, J.F. (1972). Eastern Africa. In: Griffiths, J.F. (Ed.): Climate of Africa Vol. 10, Amsterdam: Elsevier.

Government of Kenya, (1994). District Development plan, Laikipia District. Government Press, Nairobi, Kenya.

Hacman, B.D. (1988). Geology of the Baringo-Laikipia area. Report 104. Nairobi; Ministry of Environment and Natural Resources, Mines and Geological Department.

Hamilton, A. C., Taylor, D. & Vogel, J. (1986). Early clearance and environmental degradation in southwest Uganda. *Nature*, **320:** 164-167.

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

Hamilton, A. C., (1976). Identification of East Africa Urtricaceae pollen. *Pollen et Spores*, **18**: 27-66.

Hamilton, A.C. (1982). Environmental History of East Africa. London: Academic Press.

Harlan, J.R., Wet, J.M.J. de and stemler, A.B.L. (1976). Plant domestication and indigenous African agriculture. In “Origins of African Plant domestication” (J.R.

Harlan *et al*., eds), Pp. 3-19. Mouton Publishers, The Hague and Paris 498 PP.

Herring, R. S. (1979). Hydrology and chronology: The Rhodah Nilometer as an arid dating Interlacustrine History. **In** Webster, J. B. (editor), *Chronology, Migration and Drought in Interlacustrine Africa*, 39-86.

Hedberg, O. (1964). Features of Afroalpine plant ecology; *Acta phytogeogr. Suec*., **19**, 1- 144.

Hoehnel. L. V. (1894). Discovery of Lakes Rudolph and Stefanie, 1887-1888. London.

Innes, J. B. & Blackford, J. J. (2003). The ecology of late Mesolithic woodland disturbances: model testing with fungal spore assemblage data. *Journal of Archaeological Science*, **30**: 185-194.

Jacobs, A. (1972a). New archaeological sites in the Mukogodo area, Laikipia District. Msc. University of Nairobi, Inst. of African studies.

Jacobs, A. (1972b). The discovery and Oral history of the Narosura site. Appendix A in odner, K, Excavations at Narosura, a stone bolw site in the southern Kenya highlands. *Azania* **vii**.

Jolly, D. Bonnefille, R. & Roux, M. (1994). Numerical interpretation of a high resolution of Holocene record from Burundi. *Palaeogeography, Palaeclimatology and Palaeoecology,* **109:** 357-370.

Jolly, D. Taylor, D., Marchant, R., Hamilton, A., Bonnefille, R., Buchet, G. & Riollet, G. (1997). Vegetation dynamics in central Africa since 18,000 yr BP: Pollen records from the Interlacustrine highlands of Burundi, Rwanda and western Uganda. *Journal of Biogeography*, **24:** 495-512.

Kenworthy, J.M. (1966) ‘Temperature conditions in the tropical highland climates of East Africa; E. Afr. Geogr. Rev., **4**, 1-11.

Kendall, R.L. (1969) ‘An ecological history of the lake Victoria Basin; *Ecol Monogr*. **39**, 121-176.

Kinuthia, J. H., (1992). Horizontal and vertical structure of the Lake Turkana jet .J. Appl. Meteorological., 31, 1248-1274.

Kinuthia, J. H , G.C. Asani, (1982). A newly found jet in North Kenya (Turkana channel). Mon. wea. Rev., 110, 1722-1728.

Kiteme, B.P., (1998) Land cover change Detection in savanna. Ecosystem: A G I S and Remote sensing Approach. A case study of Laikipia District, Kenya

Kiteme. B.P., & Muthuva, J.M. (1997). A Pre-drainage Environmental Impact Study (PDEIS) for Laikipia Wetlands, Laikipia District. ASAL Development Programme, Laikipia Research Programme and institute of Geography University of Berne Switzerland.

Kiyaga-Mulindwa, D., (1993). The Iron Age Peoples of East- Central Botswana. In The Archaeology of Africa: Food, Mental, and Towns. Thurstan Shaw, Paul Sinclair, Bassey Andah, and Alex Okpoko, eds.pp. 386-390. London: Routledge.

Koch, Christopher P., (1994). The Jaragole Mortuary Tradition: New Light on Pastoral Neolithic Burial Practices: Presented at the South Africa Archaeological Association Annual Meetings.

Lamb, H. (1982). Climate, history and the modern World. Mathuen, London.

Lamb, H., Darbyshire, I. and Verschuren, D. (2003). Vegetation response to rainfall Variation and human impact in Central Kenya during the past 1100years. *The Holocene* **13:** 285-92.

Laikipia Research Programme, (1996). District Atlas Laikipia Research Programme and the Ministry of Land Reclamation Regional and water Development Programme, Laikipia Research programme and Institute of Geography University of Berne Switzerland.

Landsat Images, (1980).General land use classes from landsat data by the Japan International Co-operation Agency, JICA, and National Water Master Plan Kenya.

Lane, P.J (in press) The later Holocene Archaeology of Laikipia Plateau, Kenya and Evidence for Enviromental Change.

Langdale- Brown, I. Osmaston, H.A and Wilson, J.G. (1964). The vegetation of Uganda and it's Bearing on land use. Pp. 159. Entebbe: Government Printer.

Leach, M., and R. Mearns (1996). Environmental change and policy: challenging received Wisdom in Africa. In M. Leach and R. Mearns, editors, The lie of the Land: Changing received wisdom on the African environment. Oxford: James Currey, Pp.1-33.

Leakey, L. S. B. (1931). The Stone Age Cultures of Kenya Colony. Cambridge.

Leakey, L. S. B. (1992). The climatic sequences of the Pleistocene in East Africa.

Livingstone, D. A. & Clayton, W. D. (1980). An altitudinal cline in tropical grass floras and its palaeoecological significance. *Quaternary Research*, **13**: 392-402.

Livingstone, D. A. (1967) Postglacial vegetation of the Ruwenzori mountains in equatorial Africa, Ecol. Monogr., 37, 25-52.

Livingstone, D.A. (1975). Late Quaternary Climatic Change in Africa. Ann. Rex. Ecol. Syst., **6**. 249-280.

Lind, E.M. & Morrison, M.E.S. (1974). East African Vegetation. London: Longman.

Lind, E.M. and Tallantire, A. C. (1962). some common flowering plants of Uganda. (Pp.257.) London Oxford University press.

Long, C.J., Whitlock, C., Bartlein, P. J. and Millspaugh, S.H. (1998). A 9000-year fire history from the Oregon coast Range based on high-resolution charcoal study. *Canadian Journal of Forest Research* **28**: 774-87.

Lowe, J. J & Walker, M. J. C. (1997). *Reconstructing Quaternary environments*. 2nd edition. Longman Group Ltd.

Lynch, M. and Robbins, L.H. (1977). Animal brands and the interpretation of rock art in East Africa. *Current Anthropology,* **18**: 538-539.

Maitima, M. J. (1997). Prehistoric fires and land-cover change in western Kenya: evidence from pollen, charcoal, grass phytoliths and grass cuticle analysises. *The Holocene,* **7:** 409-417.

Mapunda, B. B. (2003). Fipa Iron Technologies and their Implied Social History. In East Africa. Archaeology: Foragers, Potters, Smiths, and Traders. Chapurukha M. Kusimba and Sibel Kusimba, eds, pp.71-86. Philadelphia: University of Pennsylavania Museum Publications.

Marean, Curtis W. (1992) Hunter to Herder: Large Mammal Remains from Hunter-Gatherer Occupation at Enkapune ya Muto Rockshelter, Central Rift Valley, Kenya. *The African Archaeological Review,* **10**: 65-127.

Marchant, R. (1997). *Late Quarternary vegetation dynamics in Bwindi-Impenetrable forest, Central Africa.* Ph.D thesis, University of Hull, London.

Marshall, Fiona B., (1990). Origins of Specialized Pastoral Production in East Africa. *American Anthropologist,* **92**: 873-894.

Marshall, Fiona B., (1998). Early Food Production in Africa. *The Review of Archaeology,* **19**(2): 47-59.

Marshall, F.B., Barthelme J.W., and Stewart, K. (1984). Early Domestic Stock at Dongodien. *Azania*, **19**: 120-127.

Melville, B. (1958). Gymnospermae. In *Flora of Tropical East Africa*. (Polhill, E. R. ed.). Crown Agents, London.

Mehlman, M.J., (1997). Excavations at Nasera Rock, Tanzania. *Azania* **12**:111-118.

Mehlman, M.J., (1989). Late Quaternary Archaeological Sequences in Northern Tanzania. Ph.D Dissertation, Department of Anthropology, University of Illinois, Urbana-Champaign.

Muriuki, G. (1974). A History of the Kikuyu 1500-1900. Nairobi

Mutundu, K.K. (1999). Ethnohistoric archaeological of the Mukogodo in north central Kenya. BAR International Series 775.Oxford: Archaeopress.

M Imanyara, A.M. (1992). The restatement of Bantu origin and Meru history. Nairobi: Longman Kenya.

Morrison, M. S. E. & Hamilton, A. C. (1974). Vegetation and climate in the uplands of south-western Uganda during the later Pleistocene period. *Journal of Ecology*, **62**: 1-31.

Moreau, R.E. (1963). Pleistocene climatic changes and the distribution life in East *African Journal of Ecology*, **21**: 415-435.

Nicholson, S. E. (1996a). A review of climate dynamics and climate variability in eastern Africa. **In**: Johnson, T. C. & Odada, E. O. (editors), *The limnology, Climatology and Paleoclimatology of the East African Lakes*. Gordon and Breach Publishers, The Netherlands.

Nicholson, S.E. (1998): Historical fluctuations of Lake Victoria and other lakes in the northern Rift Valley of East Africa **In**: Lehman, J. T. (editor), *Environmental Change and Response in East African Lakes*. Dordrecht: Kluwer Academic, 7-35.

Nilsson, C. (1979). Early Pottery and Pastoral cultures of the Central Rift Valley, Kenya.

Nilsson, E. (1935). Ancient changes of climate in East Africa. *Geografiska Annaler*. **17**: 1-21.

Nilsson, E. (1940). Changes of climate in British East Africa. *Geografiska Annaler*. **22**: 1-79.

Nilsson, Charles M., (1993). Towards Understanding Trade and Social Structure in an Early Pastoral Neolithic Communities in the Lake Turkana Basin. World Archaeological Congress Intersession, Mombassa, Kenya, 1993.

Odak, O., (1977). Kakapeli and other recently discovered rock paintings in the western Highlands of Kenya. *Azania* **12**: 187-192.

Ole Sankan, S.S. (1971). The Maasai, Nairobi: Kenya Literature Bureau.

Oliver, R. and Fagan, B.M. (1975). African in the Iron Age. Cambridge University Press. 228pp.

Onyango-Abuje, J.C. (1977). Crescent Island : a Preliminary report on excavations at an East African Neolithic site. *Azania* **12**: 147-159.

Patterson III, W.A., Edwards, V.J. and Maguuire, D.J (1987). Microscopic charcoal as an indicator of fire. *Quaternary Science Reviews*, **6**: 3-23.

Patterson, J. (1909). In the grip of the Nyika. Further Adventures in British East Africa London.

Peal, F.B. (2001). Late Pleistocene archaeological and geoarchaeological investigations in Mukogodo Hills and Ewaso Ngiro Plains of Central Kenya. Unpublished doctoral dissertation, Texas A & M University Collage Station, TX.

Phillipson, G. & Bachuchet, S. (1995). Cultivated crops and Bantu migration in central and eastern Africa: A linguistic approach. *Azania*, **30**: 103-120.

Phillipson, D. (1969): The Prehistoric sequence at Nakapapula rock-shelter, Zambia. *Proceedings of the Prehistoric* Society **35**: 172-202.

Phillipson, D. (1977a). Lowasera- *Azania* **X11**: 1-41.

Phillipson, D. W. (1977b). *The Later Prehistory of Eastern and Southern Africa* London.

Phillipson, D. W. (1975). The chronology of the Iron Age in Bantu Africa. *Natural History* **16**: 321-342.

Reid, D. A. M. (1990). Ntusi and its hinterland: further investigations of the Later Iron Age and pastoral ecology in southern Uganda. *Nyame Akuma*, **33**: 26-28.

Richardson, J. (1966). Changes in the level of Lake Naivasha, Kenya, during the Post- glacial times. Nature **209**: 290-291

Rhodes, A. N. (1998). A method for the preparation and quantification of microscopic charcoal from terrestrial and lacustrine sediment cores. *The Holocene*, **8**: 11-117.

Robertshaw, P. T (1997). Munsa Earthworks: A preliminary report on recent excavations. *Azania,* **32**: 1-20.

Robertshaw, P. & Taylor, D. (2000). Environmental change and the rise of political complexity in Western Uganda. *The Journal of African History,* **41**: 1-28.

Robin, Lawrence H., (1980) Lopoy and Lothagam. Publications of the Michigan State University Museum, vol. 3, nos. 1 and 2. East Lansing: Michigan State University.

Russell, J. M., Johnson, T. C., Kelts, K. R., Laedal, T. & Talbot, R. M. (2003). An 11,000-year lithostratigraphic and paleohydrologic record from Equatorial Africa: Lake Edward, Uganda-Congo. *Palaeogeography, Palaeoclimatology Palaeoecology*, **193**: 25-49.

Sansom, H.W. (1954). The climate of East Africa, based on Thornthwaite's classification. *East African Meteorology Department Memoirs*, **3**: 1-49.

Schmitt, P. R. (1997). Archaeological views on a history of landscape change in East Africa. *Journal of African History*. **38**: 393-421.

Schmitt, K. (1991). The vegetation of the Aberdare National Park, Kenya (Hochgebirgs for Schung. Band 7, 1-250). Inn sbrack: Wagner.

Shaw, T. (1976). Early crops in Africa: a review of the evidence. In "Origins of African plant Domestication" (J.R. Harlan *et al*., eds), Pp 107-153 Mouton Publishers, The Hugue and Paris.

Siiriäinen, A. (1971). The Iron Age site at Gatung'ang'a, Central Kenya. *Azania* **6**: 199-232.

Smith, A.B. (1980). The Neolithic tradition in the Sahara. In "The Sahara and the Nile" (M.A.J. Williams and H.Faure, eds), Pp. 451-465. Balkema, Rotterdam.

Street-Perrot, A. F. and Perrot, R. A. (1990). Abrupt climatic fluctuations in the tropics, the influence of Atlantic Ocean circulation. *Nature*. **343:** 607 - 612.

Sutton, J.E.G. (1974). The aquatic civilization of middle Africa. *Journal of African History* **15**: 572-546.

Sutton, J.E.G. (1964). A review of pottery from the Kenya highlands. *South African Archaeological Bulletin* **19**: 27-35

Sutton, J.E.G. (1973). The Archaeology of the Western Highlands of Kenya. Memoir No.3 of the British Institute in Eastern Africa. Nairobi.

Ssemmanda, I. & Vincens, I. (2002). Vegetation changes and their climatic implications for the lake Victoria region during the late Holocene. **In**: Odada, E. O. & Olago, D. O. (editors). The East African lakes: *Limnology, Palaeoliminoloy and Biodiversity*. Kluwer Academic Publisher. London.

Ssemmanda, I., Ryves, D., Bennike, O., and Appleby, P.G. (in press). Vegetation history in western Uganda during the last 1200 years: a sediment-based reconstruction from two crater lakes. *The Holocene.*

Stager, J. C., Cumming, B. & Meeker, L. (1997). A high resolution 11,400 – Yr diatom record from Lake Victoria, East Africa. *Quaternary Research*, **47**: 81-89.

Stager, J. C., Cumming, B. F. & Meeker, D. L. (2003). A high resolution record from Pilkington Bay, Lake Victoria, east Africa. *Quaternary Research*, **59**: 172-181.

Stemler, A.B. (1980). Origin of plant domestication in the Sahara and the Nile Valley. In “The Sahara and the Nile” (M.A.J. Williams and H. Faure, eds), pp.503-526 Baikema, Rotterdam.

Siiriäinen, A. (1977). Later Stone Age investigation in Laikipia highlands, Kenya: a preliminary report. *Azania* **12**, 161-86.

Siiriäinen, A. (1984). *Excavations in Laikipia: an archaeological study of the recent prehistory in the Eastern Highlands of Kenya*. Helsinki: Suomen Muinaismuistoyhdistksen Aikakauskirja Finska Fornminnesorenengens Tidskrift.

Taiti, S.W., (1992a). Livestock Numbers and Enterprises in Laikipia District Central Mukogodo Divisions. Laikipia -Mt. Kenya Paper D-7 Laikpia Research Programme Nanyuki.

Taiti, S.W., (1992b). The vegetation of Laikipia District, Kenya. Laikipia-Mt. Kenya Papers B-2 Laikipia Research Programme, Nanyuki.

Taylor, D.; Marchant, R. A. & Robertshaw, P. (1999). A sediment-based history of medium altitude forest in central Africa: a record form Kabata swamp, Ndale volcanic field, Uganda. *Journal of Ecology*, **87**: 303-315.

Taylor, D. (1988). *Environmental history of Southwest Uganda*. PhD. Thesis, University of Ulster, Colraine, UK.

Taylor, D.; Marchant, R. A. & Robertshaw, P. (1999). A sediment-based history of medium altitude forest in central Africa: a record form Kabata swamp, Ndale volcanic field, Uganda. *Journal of Ecology*, **87**: 303-315.

Taylor, R. (1966). The Gumba and Gumba Pits of the Fort Hall District; Kenya – *Azania* **1**: 111-117

Taylor, D., P.J. Lane, V. Muiruri, A. Ruttledge, R. Gai McKeever, T. Nolan, P. Kenny, and R. Goodhue (2005). Holocene vegetation dynamics on the Laikipia Plateau, Kenya. *The Holocene* **15**: 837-846.

Thenya, T., (1998). Some Ecological Aspects, Bio-economic values and Human Impact of a Tropical Papyrus Wetland, Ewaso Narok Swamp Laikipia District, Kenya. MSc. Thesis Department of Geography, University of Nairobi.

Thevenon, F., Williamson, D., Vicens, A., Taieb, M., Merdaci, O., Decobert, M. and Buchet, G. (2003). A late-Holocene charcoal record from Lake Masoko, SW Tanzania: climatic and anthropogenic implications. *The Holocene*, **13**: 785-792.

UNEP/GRID. (2000). Database derived from the Exploratory Soil Survey Report number E1, Kenya Soil Survey, Nairobi

van Geel, B. (1986). Application of fungal and algal remains and other microfossils in palynological analysis. **In**: Berglund, B. E. (editor), *Handbook of Holocene Palaeoecology and Palaeohydrology*, Chichester: John Wiley, 497-505.

van Geel, B. (2001). Non-pollen palynomorphs. **In**: Smol, J. P., Birks, H. J. B. & Last, W. M. (editors), *Tracking environmental change using lake sediments. Volume 3: Terrestrial, algal and siliceous indicators*. Kluwer Academic Publishers,

Van Geel, B. & Anderson, S. T. (1988). Fossil ascospores of the parasitic fungus Ustulina deusta in Eemian deposits in Denmark. *Review of Palaeobotany and Palynology*, **56**: 89-93.

van Geel, B., Hallewas, D. P. & Pals, J. P. (1982). A late Holocene deposit under the westfriese zeedijk near Enkhuizen (Province of Noord-Holland, the Netherlands): Palaeoecological and archaeological aspects. *Review of Palaeobotany and Palynology*, **38**: 269-335.

Van Zinderen Bakker Sr., E. & Coetzee, J. (1972). A re-appraisal of Late-Quaternary climatic evidence from tropical Africa. *Palaeoecology of Africa* **V11**:151-181

Vansina, Jan, (1995). New Linguistic Evidence and the Bantu Expansion. *Journal of Africa History*, **36**: 173-195.

Vanessa, J. (2003). Banana in Cameroun ca. 500 BCE? Not proven. *Azania*, **38**: 174-176.

Verschuran, D., Laird, K. R. & Cumming, B. F. (2000). Rainfall and drought in equatorial east Africa during the past 1,100 years. *Nature*, **403**: 410-414.

Vincens, A. (1989). Paléoenvironments du basin Nord-Tanganyika (Zaïre, Burundi, Tanzania) au cours des 13 derniers mille ans: apport de la palynologie. *Review of Palaeobotany and Palynology,* **61**: 69-88.

Waller, R. (1990). Tsetse fly in Western Narok, Kenya, *Journal of African History*, **31**: 71-90.

Washbourn-Kamau, C. (1975). Late Quaternary shorelines of Lake Naivasha, Kenya. **–** *Azania* **X**:77-92

Waddington, J. C. B. (1969). A stratigraphic record of the pollen influx to a lake in the Big woods of Mimnnesota. *Geological Society of America*, *Special paper*, **123**: 263-282.

Webster, J. B. (1979). Noi! Noi! Famines as an aid to Interlacustrine chronology. **In** Webster, J. B. (editor), *Chronology, Migration and Drought in Interlacustrine Africa*. Longman Group Ltd, London, 1-37.

Wendorf, Fred, and Romuald Schild, (1998). Nabta Playa and its Role in Northeastern African Prehistory. *Journal of Anthropological Archaeology,* **17**(2): 97-123.

Western, David, and T. Dunne, (1979) Environmentat Aspects of Settlement Site Decisions among the Pastoral Maasai Models, Analogies and Theories. Human Ecology, **31**: 328-350.

White, F. (1983). *The vegetation map of Africa. A descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map.* UNESCO, Paris, 356pp.

Winkler, M. G. (1985). Charcoal analysis for paleoenvironmentlal interpretation: a chemical assay. *Quaternary Research*, **23**: 313-326.

Wooler, M.J., Street-Perrott, F.A. and Agnew A.D. Q. (2000). Late Quaternary fires and grassland palaeoecology of Mount Kenya, East Africa: evidence from charred grass cuticles in lake sediments. *Palaeogeography, Palaeoclimatology, Palaeoecology* **164**: 207-30.

Appendix 1

Table 3 Showing total charcoal counting results per slide (Marura)

Depth (cm)	Fieldof view	Point count	2.9-29 µm	29-63 µm	>63 µm
5	875	140	385	1000	750
10	895	320	240	875	835
15	1669	132	270	309	199
20	870	30	30	45	130
25	1106	22	74	97	96
30	1023	22	64	91	52
35	895	15	87	88	93
40	983	35	99	118	129
45	930	34	149	150	204
50	940	255	700	555	335
55	707	8	30	16	16
60	775	190	185	640	325
65	1052	23	233	77	131
70	805	85	90	325	195
75	678	9	46	27	6
80	765	8	66	19	28
85	611	23	65	35	65
90	698	17	31	37	21
95	513	13	39	19	13
100	960	125	60	315	175
105	520	1		5	2
110	408	0	5	3	
115	358	3		3	6
120	447	10	7	12	47
125	534	22	72	75	52
130	353	5	18	17	23
135	347	4	7	5	12
140	407	10	25	18	17
145	278	8	18	15	17
150	475	5	4	6	3
155	479	15	64	23	21
160	376	4	16	4	5
165	218		3	2	1
170	440	9	48	17	13
175	453	32	128	38	33
180	263			3	
185	300	39	224	30	16
190	227	3	9	1	
195	349		2		
200	375		5	3	
205	314	8	30	5	2
210	348	7	18	1	

215	718		8	1	1
220	318	3	11	2	
225	274	3	7	5	
230	289		4		
235	178				
240	282		1		1
245	256	2	5		
250	357	4	12	8	1
255	433	31	205	48	45
260	309	6	91	9	9
265	237	1	11	8	
270	228	4	23	4	2
275	254	4	12	8	
280	280	8	13	3	
285	264	6	18	17	3
290	238	14	31	14	2
295	299	27	63	10	5
300	253	4	21	11	4
305	340	12	40	11	4
310	305	33	113	36	32
315	254	2	4	3	
320	258	6	16		2
325	223	6	18	2	2
330	202	5	11	3	
335	256	16	93	7	2
340	270	10	39	13	1
345	259	15	47	9	3
350	204	8	26	8	2
355	281	9	24	8	
360	222	7	23	2	2
365	282	9	43	9	3
370	274	9	56	4	1
375	325	30	94	14	8
380	316	17	22	13	10
385	227	5	4	3	1
390	210	12	12	9	5
395	213	24	47	9	8
400	197	27	62	6	12

Table 4 Showing total charcoal counting results per slide (Ewaso Narok.)

Depth (cm).	Field of view	Point count	2.9-29 µm	29-63 µm	>63 µm
5	1445	234	2237	667	144
10	1145	89	761	1200	133
15	1150	35	920	105	
20	1130	10	247	44	15
25	1180	30	640	325	20
30	1290	1	7	1	3
35	870	2	6	4	4
40	1080	4	15	4	3
45	1015	2	3	3	2
50	930	65	835	865	90
55	930	5	315	990	20
60	1075	50	75	500	1155
65	925	167	520	955	120
70	1005	115	215	660	345
75	830	26	884	390	90
80	855	40	385	805	80
85	975	100	205	595	65
90	745	3		12	35
95	1050	50	30	175	330
100	945	40	23	165	113
105	450	10	9	115	58
110	10	5	8	20	7
115	480	26	52	227	53
120	435	10	45	115	12
125	655	30	80	95	3
130	315	5	35	88	2
135	650	5	20	3	3
140	470	9	55	10	2
145	405	10	80	30	2
150	370	2	10	15	2

Appendix 2

Selected pollen taxa which has values as indicators of past vegetation

The concept that certain pollen types have more value as indicators of past vegetation or environment has often been used in pollen diagrams. Some of these types are described below-

Acalypha

The pollen is derived from a wide range of herbs, shrubs and occasionally trees (Langdale-Brown *et al*., 1964; Livingstone, 1967; Lind & Morrison, 1974). The genus inhabits a wide variety of habitat types and members are reported to be common colonizing species of lowland secondary forests (Lind & Morrison, 1974). The members of this genus are found to be abundant in lower altitude environments on Mt. Kenya (Beentje, 1964). *Acalypha* pollen is reported to be well-dispersed (Hamilton, 1972; Lind & Morrison, 1974), and it is possible that some of this pollen type has been transported from forests elsewhere in the region. Over thirty species of *Acalpha* have been reported in East Africa, most of which occur in forest and forest edges (Smith, 1987). However, *A. fruticosa* is found to be a common species of grassland and woodlands savannas (Lind & Tallantire, 1971; Kendall, 1969; H.J.Beentje, 1964). *A. ornata* and *A. neptunica* are reported to be the most abundant forest species of *Acalypha* and the latter is reported to be common in Mt. Kenya and Aberdare forest (Hamilton, 1991; Beentje, 1964).

Acanthaceae

Spiny members of the Acanthaceae such as *Barleria* and *Blepharis* are found in very dry bush-land and many bulbous plants and creeping herbs such as *Tribulus terrestris* that is not in Acanthaceae family is well named because its spiny fruits on the ground surface are a problem to barefooted people.

Artemisia

The presence of *Artemisia* pollen in Marura sediments indicates relatively warmer climatic conditions. *Artemisia* pollen is an indicator of dry and sub-humid conditions in montane forests as Coetzee (1967), Livingstone (1967), Kendall (1969) and Hamilton (1982) suggested. This genus is also reported to be associated with upper montane vegetation types (e.g. Afro-alpine conditions) (Livingstone, 1967). *A. afra*, the only known species in East Africa (Livingstone, 1967; Kendall, 1969; Lind & Morrison, 1974), is the probable source of this pollen type. This pollen type is reported to be moderately well dispersed (Hamilton, 1972) and can be over-represented in pollen counts.

Capparidaceae,

Members from this family are *Boscia*, *Cadaba*, *Capparis* and *Maerua*. The associated species are *Grewia* (Tiliaceae). They are very common in bushland being either a shrub or a small tree. Nevertheless, one common bush-land species (*Grewia similis*) has bright mauve flowers. Between the woody vegetation, the ground is covered with annual grasses and ephemeral herbs. These come up after the rains and are then heavily grazed, so that for much of the year the ground is bare between the shrubs.

Canthium.

Canthium jueinzii Sond. (Rubiaceae) as differential species are found only found in dark forests. *Neoboutonia macrocalyx* occurs only very sporadically in sub-association with it. It is also frequently found with higher cover abundance in this forest type. (Bussmann, 1994).

Celtis

Celtis type pollen is found in many pollen diagrams from montane East Africa but is relatively abundant only in those from Mount the Kenya and Aberdare’s, which is situated in a climatically moist area and in Kakamega, which is also a moist evergreen forest.

East African pollen diagrams show a relatively large decrease in *Celtis* and a relatively large increase in Poaceae pollen at the supposed time of forest clearance; providing convincing evidence that this type of pollen is produced largely by species growing in lowland forest. *Celtis* type pollen appears and becomes common in the Lake Victoria pollen diagram after around 1200 (Kendall, 1969) and is regarded as having originated from lowland forest.

Celtis and *Croton* are common components of lowland moist forests in Kenya today (Livingstone, 1967; Lind & Morrison, 1974; Hamilton 1982, 1991). *Celtis* is reported to be more abundant in semi-deciduous forests than evergreen forests (Langedale-Brown *et al*., 1964); its pollen type is likely to be derived from two potential sources; *C*. *africana* and *C*. *duandii*. *C*. *africana* is reported to be associated with drier forest types, while *C*. *durandii* is more abundant in moist forest types (Hamilton 1982).

Croton

Thirteen species of *Croton* (*C*. *alienus*, *C*. *dichogamus*, *C*. *macrostachyus*, *C*. *megalocarpoides, C.megalocarpus, C. menyharthii*, *C*. *polytrichus, C*. *pseudopulchellus*, *C*. *scheffleri*, *C*. *somalonsis*, *C*. *sylvaticus*, *C*. *talaeporos*, and C. zambesicus are reported to be in Kenya today (Beentje 1994). *C*. *dichogamus*, *C*. *sylvaticus*, *C*. *megalocarpus* and *C*. *macrostachyus* are reported to be abundant in this particular area i.e. Laikipia Plateau. *C*. *dichogamus* is a small tree up to 10 m tall, common in secondary forest and on forest edges over a broad altitudinal range (Lind & Morrison, 1974). The pollen is poorly dispersed (Hamilton, 1972) and can therefore be under-represented in the pollen spectra as reflected in both sites Marura & Ewaso Narok.

Cyathea

Cyathea and *Rapanea* are common components of swamp forests (Hamilton, 1991). *Cyathea* spores are presumably derived from *Cyathea maniana*, which is a tree fern (Hamilton, 1991) growing in riverine forest locally.

Cyathea maniana is also reported to occur on the lower slopes and bottoms of valleys and in wetter areas at higher altitudes (Lind & Morrison, 1974; Hamilton 1991). The spores are reported to be poorly dispersed (Hamilton, 1991), and thus can be under-represented in the pollen counts. Taylor (1998) reported that a high level of *Cyathea* spores in a sediment record might not necessarily reflect the common occurrence of the parent taxa, but may be attributed to greater resistance of the spores to physical damage during transportation prior to deposition.

Ericaceae

It is a tetrad type of pollen produced by the shrubs and trees of the genera, *Erica*, *Philippia*, which is sometimes included in the Ericaceae; Ericaceae (especially *Philippia*) are abundant in the Ericaceous Belt (c. 3300-3650m).

Pollen of Ericaceae is sometimes abundant in surface samples. In case of Mt Kenya, and the Aberdare's, high values of Ericaceae pollen have been found only in surface samples from Ericaceae thickets. The pollen is very rare elsewhere except in forest edge or secondary forest, high-altitude bush-land. In other land species, the presence of Ericaceae pollen in pollen diagrams from sites in the Montane Forest Belt is sometimes believed to be due to past depressions of the vegetation belts. Ericaceae pollen is probably a better indicator of such depression in drier areas in which Ericaceous species are more or less absent from montane vegetation. It is common in rocky high-altitude bushland and co-dominant in a zone above the *Hagenia* belt in high mountains, bushland with rocky or eroded hill slopes (H.J. Beentje 1994).

Euphorbia

Within a subtype of bush-land, in scattered thickets the candelabra tree (*Euphorbia candelabrum*) commonly occurs. Another common succulent is *Cissus quadrangularis* a square-stemmed straggling plant (Vitaceae) while the sword-shaped, mottled leaves of *Sanseviera ehrenbergiana*, much liked by rhino, are nearly always to be found among the thicket vegetation.

Except in the very driest bush-land, there are scattered *Acacia* trees. *Balanites aegyptica* also occurs frequently as a tree in association with *Acacia*.

Hagenia

Hagenia pollen is a readily identified type produced only by *Hagenia abyssinca*. It is a big tree of about 25m height and it cannot do well in a closed canopy for it requires light. It very common in the upper montane forest zone of Mt Kenya and Aberdare's and it is dominant in the woodland zone just above bamboo zone. It is also prominent in moist forest below the bamboo zone. *Hagenia* is more abundant in this zone (c. 3000-3300m) where it forms a more or less continuous canopy over *Rapanea*, than on the drier eastern slopes of Mt Kenya, where although still common, it is more closely restricted to the forest margins and clearings (Beentje 1994).

In most of the East African pollen diagrams, *Hagenia* pollen is prominent and therefore it is apparently moderately well dispersed in the atmosphere. It is sometimes common in pollen diagrams and high values appear to indicate the presence of upper montane forest or bamboo forest close to the site. In some cases, increases in *Hagenia* in pollen diagrams can be attributed to human disturbance.

Hyphaena

In damp areas the dichotomously branched doum palm (*Hyphaene coriacea*) may be seen in the associations of baobab trees (*Adansonia digitata*) Greenway (1969).

Ilex

This genus from the Aquifoliaceae occurs where rainfall is 200-1500 at altitudes of 2420-24580m. *Ilex* pollen is very distinct and there is only one species, i.e. *Ilex mitis*. This interesting association occupies only very restricted areas near Meru on Northern Mount Kenya, where it grows on extremely steep slopes of more than 40^{o}C.

Juniperus

In Kenya, there are only fragmentary records of the species associated with Juniperus. On hills in the northern frontier region with an annual rainfall in the range 559-635mm. Gillett (1951) recorded juniperus with *Olea africana*, *Podocarpus gracilor*, and *Croton megalocarpus*. Gardner (1932) was of the opinion that *Olea africana* occurs with *Juniperus* in the drier areas while *O. hochstetteri* occurs in the more moist regions.

From the generally more moist areas of Kenya Battiscombe (1936) recorded that *Juniperus* was generally associated with *Podocarpus gracilior, P. milanjianus, Olea africana*, and *O. capensis.* Other hard woods noted a moist variant of *Juniperus* forest on the Mau Elgeyo, Elgon and Cherangani regions, and it occurs on Mt. Kenya, were: *Allophylus abyssinicus, Celtis Africana*, *Cassipourea malosana, Dombeya goetzenii, Ekebergia capensis, Faurea saligina*, *Hypericum revolutum*, *Myrsine africana, Nuxia congesta, Olinia usambarensis, Teclea spp* and *Warburgia ugandensis*.

The largest areas of the Mt. Kenya forest belt have been formerly occupied by the *Juniperus procera*. Although extensive parts of it have been already destroyed or are still heavily disturbed, mainly due to intensive logging, forests of this type are still found in abundance on the western, northern and north-eastern slopes of the mountain as well as in some small areas of the other sides.

Juniperus procera is included in a variety of different forests with a wide range of ecological conditions from very dry to fairly wet, along a broad latitudinal range of about 800m. Most of the forest types described by Schmidt (1991) for the Aberdare National Park belong to this class, although most of them are of secondary character and show clear floristic differences to those of Mount Kenya. Nevertheless, some associations are identical to the community of Schmidt. In such cases, his nomenclature has been taken into account has been as far as possible under the code of phytosociological nomenclature.

The natural single or double storeyed forests of the *Juniperus procera* and their disturbed counterparts are clearly differentiated by this tall tree, which grows tall under favourable conditions. *Sanicula elata* (Umbelliferae) and *Stipa dregeana* Seud. (Poaceae) are further undifferentiated. *Parochetus communis* (Leguminosae), *Geranium arabicum* Forssk. (Geraniaceae), *Berberis holstii* (Berberidaceae), *Isoglossa gregorri* (Acanthaceae) and *Achyranthes aspera* (Amarathaceae) are character species.

Alt. Range 2150-2250m, occupying mainly slopes with southwestern exposition in the same area as the association described previously. *Cassipourea* which is regarded as vicariant to the previous association, is showing a higher humidity, which leads to a more diverse floristic composition. *Juniperus procera* and *Olea europaea ssp. cuspidata* are found with lower cover abundance in this association, whereas *Sanicula elata* often forms dense ground layers, indicating the high humidity. *Cassipaurea malosana* shows its highest cover abundance in this association and *Olea capensis* ssp. *hochstteri* is a dominant canopy species. The rare fern *Amauropelta oppositiformis* (Thelypteridaceae) is found as differential and *Hypoestes aristata*, after covering large areas on the forest floor, as character species.

Myrica

Myrica pollen is normally easily recognizable although similar to *Casuarina*. Only two species which are found in Kenya, *Myrica salicifolia* var. *salicifolia* (incl. *M. kandtiana* are widely distributed and it is likely that one or both of these constitute the source of *Myrica* pollen found in pollen diagrams. *Myrica kandtiana* is a swamp plant found at relatively low altitudes, usually below 2000m and with a highest known occurrence at 60m on Mt Kenya on dry rock bushland on eroded slopes of Mt Kenya, it is well distributed from K2-K7 (these are Kenya Geographical Flora Regions) 750-3050m together with *Philippia*. Relatively abundant *Myrica* before ca. 12,000 - 10,000 BP, as seen in East Africa, is attributed to the widespread occurrence of open dry forest or dry montane woodland on the mountains under a generally rather arid climate.

Macaranga

Species of this genus include *Macaranga capensis*, *M. conglomerate,* and *M. kilimandscharica*

The latitudinal range where it can be found is 1980-2370 m. It is very common in forests disturbed by heavy exploitation and thus where secondary vegetation is frequent. It is found within the range of *Ocotea*, where it is even more abundant than the primary forest types, which are restricted to steep slopes in remote areas with difficult access. The secondary forests are clearly demarcated by *Macaranga kilimandscharica* this plant often totally dominates the canopy, forming dense pure stands as a very fast growing species suppressing the regeneration of other trees. Under similar ecological conditions two associations can be differentiated the *Macaranga kilimandscharica* and *Drynaria volkensii* types.

Nuxia

Nuxia is typical at altitudes of 2650-3200 with a rainfall of 750-1250m. The most abundant pollen peaks can only be derived from *Nuxia congesta* in the transition zone of *Juniperus* and *Hagenia*, clearly differentiated by the high frequency of *Juniperus* (Cupressaceae), *Olea europaea, ssp. Cuspidata* cifferri (Oleaceae), *Nuxia Congesta* (Loganiaceae) and especially *Rapanea melanophoeos* (Myrsinaceae) as differential species. *Hagenia abysinicus* occurs as co dominant canopy species.

Olea

This genus is relatively abundant in Marura site compared with Ewaso Narok site. *Olea* are an important colonizing genus commonly occurring on forest edges (Livingstone, 1967; Kendall, 1969) and are reported to grow in wide spectra of forest type (Livingstone, 1967; Lind & Morrison, 1974; Hamilton, 1982, 1991). According to Hamilton (1972; 1982), *Olea* pollen has moderate export ability and can therefore be well represented in the pollen counts.

This pollen type may have been derived from two species *O. europea* ssp. *africana* and *O. capensis* which are important colonizing species in forests edges, predominantly found between 1500m to 2500m and up to 3000m (Livingstone, 1967; Lind & Morrison, 1974; Hamilton, 1982; 1991). *Olea capensis* is reported by Eggeling (1947), Kendall (1969) and Hamilton (1982) as a common colonizing species of poor and shallow soils on forest edges of Mt. Kenya.

Podocarpus

Podocarpus pollen in the sediments is derived two species that exist in Kenya and they are impossible to distinguish in the pollen record; *P. gracilior*, *P. milanjianus* (Livingstone, 1967 Kubd & Nirrusibm 1974). *Podocarpus gracilior* occurs in a dry montane forest (Beentje 1994).

Of the four species of *Podocarpus* found in East Africa (Melville, 1958) only two are widely distributed, *P. gracilior* being typical of drier montane forests than those that contain *P. milanjianus* from western Rift montane areas. Both species occur on many of the Kenyan Mountains and the distribution of the two on Mt. Kenya illustrates their differences in moisture relationships. *P. gracilior* is the only species present on the drier north and east slopes and P. *milanjianus* the only species present on the wetter western slopes both species grow together on the Kimilili transect on the south, where the climate is moist, though not as moist as on the west. In the case of western Rift montane area, the increase is presumably related to *P. milanjianus*, which may have been able to expand its numbers on ridge sites under a drier climate (Hamilton A.C. 1982). The pollen is well dispersed and may be over-represented in sub-fossil pollen spectra in the Marura core.

Poaceae

Poaceae pollen is readily identifiable, but difficult to subdivide usefully. Several authors (Coetzee, 1967; Hamilton, 1972; Morrison, 1968; Osmaston, 1978) have attempted to use size statistics to distinguish between different grass species on groups of grasses characteristic of various vegetation types, but this approach has yielded little success. Measurements of grass pollen in surface samples have shown that mountain bamboo, *Arundinaria alpina*, produces little pollen (Hamilton, 1972; Osmaston, 1958). Poaceae are present and, indeed, often abundant in almost all vegetation types in East Africa, leading to doubts as to the interpretability of changes in the Poaceae curves in pollen diagrams (Livingstone, 1967).

Polyscias.

This genus is typical tree at altitudes of 2380-2880 m with a rainfall of 1000-1100 mm.

In the deep sirimon river gorge on northwestern Mount Kenya, the *Polyscias kikunyensis* is found as vicariant of the *Afrocrania volkensii* - *Dombeya torrida* community mentioned by Schmidt (1991) for the Gura Gorge in Aberdare National Park. It pollen is evenly distributed.

Rapanea

Rapanea pollen, which is well distributed in the pollen diagram, is reported to be a common component of high altitude forests and characterizes the *Hagenia* - *Rapanea* zone (Lind & Morrison, 1974; Hamilton, 1982). The pollen type is derived from two species *R. rhododendroides* and *R. pulohra*, commonly distributed from Kenya geographical flora regions, which are divided from K1-K7 widespread in upland forest to edge of moorlands. They are both abundant on swamp forests of Mt. Kenya. Despite its dominance in montane forest, *R. rhododendroides* has been recorded in lowland swamps forests in central Kenya and along the shores of Lake Victoria (Lind & Morrison, 1924; Hamilton, 1991).

Declaration

"I declare that the thesis hereby submitted by me for the MSc. degree at the University of the Free State is my own independent work and has not previously been submitted by me at another University. I further more cede copyright of the thesis in favour of the University of the Free State".

Muiruri Veronica M.
Department of Plant Sciences
University of the Free State
Bloemfontein.
South Africa

Dedication

To my mum Teresia, my son Tevin and daughter Mitchell

List of Figures

List of Tables

List of Plates

List of Appendices

List of abbreviations and acronyms

AD	anno domino
AMS	accelerated mass spectrometer
BP	radiocarbon years before present (1950)
a.s.l.	above sea level
ca.	circa
cal	calibrated
cm	centimetre
DCA	detrended correspondence analysis
g	gram
Km	kilometre
Mt	mount
yr.	year
µm	microns

ABSTRACT
Pollen, spore and charcoal analysis of deposits from Marura and Ewaso Narok swamps in Laikipia, Kenya, reveals anthropogenic activities and climate variability during the Late Holocene. Specifically, there was a shift from relatively closed to open woodland dominated by *Acacia* and grassland as suggested by an increase in Poaceae and herbaceous taxa indicative of an increase in disturbance. The reduction of Afromantane taxa such as *Podocarpus*, *Olea* and *Rapanea*, and the increase of *Justicia* and Asteraceae support the indication of an increase of human activities. This ecosystem change may result from a period of disturbance of bush clearance and agriculture intensification and/or climate variability during the last 2000 years. This ecosystem shift may further have been as a result of associated fire intensity in the savanna biome as indicated by increases in charcoal.

UITTREKSEL
Stuifmeel-, spoor- en houtskoolanalise van afsettings van die Marura en Ewaso Narok vleilande in Laikipia, Kenya, dui op antropogeniese aktiwiteite en klimaatswisseling gedurende die Laat-Holoseen. In die besonder was daar 'n verskuiwing van ’n relatief geslote na oop bosveld gedomineer deur *Acacia* en grasveld soos weerspieël word deur meer Poaceae en kruidagtige taksa wat 'n toename in versteuring aandui. Die afname van Afromontane taksa soos *Podocarpus*, *Olea* en *Rapanea* en die toename van *Justicia* en Asteraceae ondersteun die aanduiding van 'n toename in menslike aktiwiteite. Hierdie ekosisteemverandering kon die gevolg gewees het van 'n periode van versteuring deur bos-opruiming en 'n toename in landbou en pastorale aktiwiteite en/of klimaatswisseling gedurende die laaste 2000 jaar. Die ekosisteeemverandering kon verder die gevolg gewees het van 'n toename in geassosieerde vuurintensiteit soos aangedui deur 'n toename in houtskool.

Key words: Laikipia, Ecosystem, Climate, anthropogenic, Pollen, Charcoal, Spores, Holocene.