Pastoralist Settlement and the Anthropogenic Savannah: the archaeo-ecology of Maili Sita, Kenya.

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I, Oliver Boles, confirm that the work presented in this dissertation is my own. Where information has been derived from other sources, this has been indicated in the text.

Abstract

Pastoralism has long been regarded difficult subject matter for archaeology, particularly in eastern Africa. Ephemeral settlements are presumed to leave little physical residue, such that reconstructions of pastoralist ethno-histories have relied on often-vague distributions of material culture. Cultural-stratigraphic approaches are limited in their capacity to explore the lifeways and social dynamics behind material expressions. As a consequence, our knowledge of how herding spread into the region and the historical development of the specialised stock-keeping communities seen today is hindered by a methodological incapacity to address what are arguably the fundamental drivers of pastoralist daily experience: mobility and landscape ecology.

This dissertation argues that the interaction of these two elements provides the foundation for pastoralist economics, politics and culture. Movement around the savannah, ostensibly in response to the needs of livestock, not only shapes herders' social interactions and experiences of environment, but also leaves a physical impact on those landscapes. While built structures may not survive archaeologically, this dissertation discusses how settlement, however temporary, affects local ecology in ways that endure and might be 'read' as a proxy record of herders' presence and practices.

With respect to the mid-second millennium site of Maili Sita, in central Kenya's Laikipia Plateau, various data are employed to assess how settlement and particular patterns of land-use have impacted soils and vegetation. Using geoarchaeological survey and satellite imagery to assess the legacy effects of human presence, alongside isotope data derived from cattle teeth and relating to mobility and resource use, I argue that Maili Sita was part of a regional phenomenon of ethno-linguistic interaction, exchange and assimilation that precipitated the paradox of the defined-yet-entangled identities which continue to characterise the pastoralist societies of eastern Africa.

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Introduction: Anthropogenic landscapes and the archaeology of pastoralism

Figure 1.1. Cattle in the northern Lolldaiga Hills, c.1965 (courtesy of R. Wells)

Popular western notions of environment and landscape remain deeply derivative of the enlightenment ideal of the nature-culture divide. This dualist dichotomy remains the dominant framework in debates over the current 'state of the planet': the 'natural' versus the 'built' environment, the 'pristine' versus the 'spoiled', 'conservation' versus 'change'; a reversal of earlier conceptions of the 'wild' versus the 'civilised'. Colonialism saw those ideas exploited as justification for the imposition of European rule; while the colonists could harness and transcend nature, indigenous groups were painted as being in thrall to it, their economic and cultural traits entirely dictated by their surroundings: 'the further removed men are from animals, … the more their effect on nature [is] premeditated, planned action directed towards preconceived ends' (Engels 1934, cited in Ingold 2000: 63).

Recent decades have seen the re-assessment of such positions, at least in academic circles. During the mid-twentieth century, the natural environment was still envisioned as something humanity must live within, a set of parameters for existence that dictates the economic decisions we can make, a position that informed many of the preoccupations of the New

Archaeology (e.g. Steward 1955; Binford 1962). Subsequently, this view has yielded to the prospect that the human-environment relationship is *interactive* rather than simply *adaptive* (David & Thomas 2008). There are various aspects to this re-conceptualisation, and it is perhaps best to begin here with the question of what constitutes an 'environment'. This discussion is linked to re-imaginings of landscape and place; where previously these concepts had been 'stripped… of cosmological, symbolic and spiritual meaning' (McNiven *et al*. 2006:14), the influence of phenomenology and concepts like Bourdieu's *habitus* (1977) encouraged considerations of how space is experienced, implicating human beings in the ontological manipulation of the places in which they live (e.g. Hodder 1982; Tilley 1994). These studies focussed on how societies define and bound their environment, as much as they themselves are bound by it, with meaning mediating ecological relationships (McNiven et al. 2006).

A common theme here is the rise of the concept of 'landscape' (Ingold 1993; Crumley 1994; Tilley 1994; Balee & Erickson 2006), wherein environments are conceived as the dominions – with emphasis on the plural – of human experience rather than passive stages for human existence. Central to this is the recognition that environments are dynamic historical entities, changing and developing over time in response to the interactions of biotic communities and abiotic conditions (e.g. Butzer 1982; Delcourt & Delcourt 1988; Redman 1999; Folke 2006). For much of its history as a discipline, and taking cue from ecology, archaeology has adopted the position that the biosphere exists in a state of static equilibrium, only changing in response to broad-scale processes of climatic and geomorphological change (Redman 2005; Briggs et al. 2006). This position assumes that environments are essentially stable but for the temporary effects of human stressors, such that a return to an original state would be possible should those stressors be removed (Folke 2006). The last thirty years or so have, however, seen the growth of a body of research suggesting that human beings are active contributors to environmental or landscape change: that the effects of human habitation accumulate over time so as to exert a powerful influence over ecological function (e.g. Crumley 1994; Stahl 1996; Balée 1998). While this may not be a particularly surprising revelation given topical concern with the impacts of global warming and the questions over the sustainability of industrial economies, its implications for how we should investigate the human past are fundamental.

The research presented here has been partly inspired by the perspectives of Historical

Ecology[1], one of the key postulates of which is that human-induced change may be "a principal mechanism of change in the natural world, a mechanism qualitatively as significant as natural selection" (Balée & Erickson 2006):5), but that it should not be considered *a priori* to be negative (Hayashida 2005; Balée 2006). Rather, Historical Ecology seeks to illuminate how humans have manipulated and transformed the physical properties of their landscapes over time, emphasising how the essential state of a society, whether extant or as represented in the archaeological record, is a product of long-term ecological interactions (Crumley 1994). That is not to deny the potential of human agency: quite the opposite. There are parallels between this position and Giddens' (1984) theory of structuration, which maintains that society operates within a set of received structures that can be manipulated and distorted – consciously or unconsciously – at the level of the individual, in turn leading to new sets of conditions being encountered by subsequent generations. In historical ecological terms, human societies operate within the parameters set by their environments, but these are not static and may be transformed by long- and short-term interactive processes; the cumulative effects of these transformations yield fresh ecological conditions, legacies that are passed on to subsequent generations (e.g. Crumley 1994; Dupouey et al. 2002; Balée 2006; Balée & Erickson 2006).

This dissertation is concerned with the role of human activity within a particular ecosystem: the high-altitude savannah grasslands of central Kenya's Laikipia Plateau. Over the last three or four thousand years, perhaps until the twentieth century advent of industrialised agriculture, pastoralism has been the dominant mode of food production in eastern Africa (Marshall 1990; Marshall & Hildebrand 2002; Lane 2004). The following chapter will explore how herding has become implicated in regional eco-dynamics and how this integration has shaped the socio-cultural development of pastoralist communities and cultures. The extent and nature of historical continuity between the earliest herders and modern groups like the Maasai is shrouded in ambiguity, largely due to methodological shortfalls that hinder its examination. It is this issue of how to approach the archaeology of pastoralism that is at the centre of my research agenda. I will argue that an understanding of how the practice of herding has impacted savannah ecosystems can act as a substitute for the scant archaeological record that survives at ephemeral settlement sites. At the same time, I will try to show how these ecological impacts are determined through herders' negotiations of dynamic social and natural landscapes, and the reflexive dialogue between the two. By exploring these inputs and how their effects persist as visible features of the modern

1.1 'Historical Ecology' is capitalised here when in reference to the discipline or academic movement, as opposed to that which is studied, implied by lower-case 'historical ecology' landscape, my research project aims to contribute to discussions of how contemporary pastoralist identities in Kenya came into being, and how eastern African herding has shaped and been shaped by the savannah.

1.1 Herders and the savannah

The term *savannah* is derived from the Spanish *sabana* (or *zabana*, originally), itself probably an adaptation of an Arawak term encountered by European explorers in the Caribbean, and used to describe the grassy, palm-studded plains they found on the islands (Harris 1980). The label has since been applied to around an eighth of the earth's land surface (Scholes & Archer 1997) and encompasses an immense variety of physical landscapes as well as innumerable compositions of floral and faunal communities. In terms of physical makeup, savannahs are characterised by a (near-) continuous layer of grasses with a discontinuous layer of trees or shrubs (Harris 1980; Skarpe 1992; Scholes & Archer 1997; Ratnam et al. 2011). While there is clear room for variation within this definition – it might equally describe the heavily-wooded savannahs seen in much of eastern Africa and the open semiarid steppe grassland of the Sahel – it is this broad vegetation-based criterion that I default to during this dissertation. It has also been proposed, however, that African savannahs exist as a consequence of fire and the impact of large herbivores rather than particular climatic conditions (Skarpe 1992); this latter point will become increasingly pertinent throughout the proceeding chapters.

In Africa, savannah environments cover some 13.5 million km^2 (Scholes & Archer 1997; Riggio et al. 2013), around half the continent, and host by some margin the world's highest densities of grazing animals (Cumming 1982). The pre-eminent subsistence regime practiced in these biomes is pastoralism, which in Kenya alone supports some eight million people (Davies 2007). These communities have long been blamed for the degradation and desertification of savannah landscapes (cf. Dodd 1994), and since the colonial period have regularly been subject to mass-displacement in favour of policies favouring agrarian development (e.g. Homewood 1995; Hughes 2006) or the preservation of so-called 'natural' environments, frequently as a resource with which to encourage tourism (e.g. Brockington 1999).

The assumption that herding has a detrimental influence on savannah ecologies has been disputed in recent years. It is now widely acknowledged, at least among the academic community, that while the presence of these groups has indeed tangibly affected the environment, this has often been as active and positive ecological *participants* rather than as necessarily destructive forces. For example, numerous studies (Stelfox 1986; Blackmore et al. 1990; Young et al. 1995; Augustine 2003; Muchiru et al. 2009; Veblen & Young 2010; Riginos et al. 2012; Donihue et al. 2013) have shown how the concentrated deposits of livestock dung that accumulate at herder settlements create, on abandonment, nutrient-rich patches that foster levels of biodiversity far above that of the surrounding 'natural' savannah. The rich grasses that flourish in these 'glades' become preferred grazing for both wild and domestic herds, the continued presence of which limits the re-colonisation of these areas by shrub and tree species and provides further nutrient deposition in the form of dung. Consequently, glades formed on the sites of abandoned pastoralist settlements can endure as distinctive features in the savannah for centuries. To illustrate the potential scale of the effect that herders have had on the savannah landscape a study in Amboseli in southern Kenya in the 1970s found that within an area of 157 km^2 nine new settlements were established over the course of a year. Each settlement can be given an approximate size of 0.13 km^2; even given a resettlement rate of 68 percent - the frequency with which new sites were established at previously occupied locations – over the course of a century this amounts to some 23 per cent of the entire area (c. 36 km^2) being directly impacted (Muchiru et al. 2009). Pastoralists have been consistently active in eastern Africa for at least 4000 years (Marshall & Hildebrand 2002), clearly long enough that their potential role in shaping the modern incarnation of the savannah should not be underestimated. As yet, though, the true nature and extent of human intervention remains poorly understood.

1.2 The archaeology of mobile pastoralism

The term 'mobile pastoralism' essentially describes a food production system based around the keeping of livestock and involving a degree of movement between distinct grazing areas, often on a seasonal basis (Dahl & Hjort 1976; Dyson-Hudson & Dyson-Hudson 1980; Khasanov 1984). This definition, though, does little to illustrate the socio-cultural and economic diversity found among herder societies, even between multiple groups occupying the same ecological zones (Bonte & Galaty 1991). In fact, there are issues raised by assigning the label based on purely economic criteria; many groups that self-identify as pastoralist do not actually keep any herds. For example, around Mt Kilimanjaro, on the border between Tanzania and Kenya, there are communities engaged in farming, who keep no livestock, but identify as Maasai – perhaps the archetypal African herders – based on historical connections to Eastern Nilotic-speaking agro-pastoralists. Furthermore, they are accepted as such by their cattle-keeping counterparts (Spear 1993). At the opposite end of the spectrum, the Mukogodo Maasai of central Kenya are a product of the deliberate rejection – over a single generation – of hunter-gatherer lifeways and an appropriation of livestock and of pastoralist identity, following the re-location of 'historic' Maasai populations from the region by the colonial government (Cronk 2002).

Both of these communities share complexities of identity that would be difficult to reconstruct without historical records, oral or written. Beyond the last few centuries, however, we often rely on scant and scattered archaeological data from which to infer several millennia of pastoralist social development. This is particularly keenly felt in eastern Africa; while other parts of the continent have seen a diverse range of approaches to the archaeology of mobile pastoralism (e.g. Gabriel 1973; MacDonald 1999; Manning 2008; Sadr 2008; Sadr & Rodier 2012), besides a few exceptions (e.g. work by Robertshaw *et al.* 1990 at Ngamuriak), there has been general resignation that beyond bones, lithics and pottery there is little worth pursuing at sites in eastern Africa (Robertshaw 1978; Gifford 1978). This is due, in large part, to climatic regimes and environmental conditions hostile to the perishable, temporary construction traditions that prevail in the region. Though ethnography has shown material culture to be fundamental to the negotiation of contemporary herder identities (e.g. Grillo 2012), in instances where material accumulations at archaeological sites are significant, complex interpretation becomes problematic without sound spatial frameworks (Cribb 1991). How societies organise space has frequently been shown to be reflective of – and perhaps contribute to the formation of – socio-cultural, ritual and political structures (e.g. Kent 1987; Fisher & Strickland 1989; Robin 2006; Fleisher & Wynne-Jones 2012), yet – unfortunately – we frequently lack the means to identify and interpret spatial information in the archaeological record of mobile societies.

Even distinguishing which sites were occupied by pastoralists rather than hunter-gatherers can be challenging; in eastern Africa, exchange relationships frequently develop where the two economies exist in proximity (e.g. Kratz 1980; Blackburn 1982; Galaty 1982; Cronk 2004), and in the archaeological record pastoralist ceramics often appear alongside mixed assemblages of wild and domestic faunal remains (Ambrose 1998; Gifford-Gonzalez 1998; Marean 1992). However, the keeping of livestock requires the provision of fenced enclosures for security, in which animals are kept overnight (Marshall 2000; Shahack-Gross 2003) and concentrations of dung accumulate (Western & Dunne 1979; Gifford 1978; Gifford-Gonzalez 2010). These features are not present at hunter-gatherer settlements (Yellen 1984; Mutundu 1999). The observation – or not – of enclosure deposits at archaeological sites would therefore appear to hold the key to hunter-herder differentiation, a straightforward distinction were it not for the rapidity with which the organic component of dung degrades in an open-air context, such that its identification becomes complicated (Shahack-Gross et al. 2003). The capacity to identify enclosures is no less important for addressing questions beyond simple economics, such as with regard to understanding the conception and ritualisation of settlement space. That the precise position of corrals in relation to other components of settlements – houses, for instance – should be shown by numerous ethnographic studies to be linked with culturally-specific notions of kinship, marriage and cosmology (e.g. Århem 1991; Huffman 2001; Herbich & Dietler 2007) lends further weight to the need to be able to recognise them in the archaeological record (see also Chang & Koster 1986).

There have been significant methodological steps taken in this regard. Where the organic component of dung does survive, for example in cave contexts (Brochier et al. 1992), it has been possible to make positive identifications, such as through lipid biomarkers (Evershed et al. 1997), studies of dung-associated mites (Schelvis 1992) or the observation of organic fibres in micromorphological thin section (Macphail et al. 1997). Other studies have looked to mineralogical indicators such as phytolith concentrations (Brochier et al. 1992) and dung spherulites (Courty et al. 1991; Brochier et al. 1992; Macphail et al. 1997). In explicit response to the paucity of available intra-site spatial information (cf. Gifford 1977; Robertshaw 1978), Shahack-Gross and various collaborators (Shahack-Gross et al. 2003; 2004) have looked at how these advances can be expanded so as to be able to recognise other elements of pastoralist settlements. Based on observations made of sediments within abandoned Maasai settlements of ethnographically-known layout, their work defined a taphonomic sequence for the degradation of dung deposits in enclosures, such that degraded dung could be recognised in the archaeological record (Shahack-Gross et al. 2003; Shahack-Gross 2011). In addition, geoarchaeological signatures were defined for other features of these settlements, such as hearths and gateways (Shahack-Gross et al. 2004), and distinctions made between cattle and caprine enclosures based on soil stable isotope values (Shahack-Gross et al. 2008). While there has been some success in the application of the approach to an archaeological context, by Shahack-Gross herself at the site of Sugenya, southwest Kenya (Shahack-Gross et al. 2008), wider implementation has been limited. Consequently, a successful and comprehensive spatial archaeology of an ephemeral pastoralist settlement in eastern Africa remains elusive.

Although studies like these are clearly useful, I would argue that the core issues of how herders experience the landscapes they inhabit and, crucially, how this experience influences both social trajectories and the impacts they exert on their environments, have gone largely unaddressed. The focus on sites and discrete assemblages seems somehow incongruous with pastoralist realities of mobility and engagement with broad landscapes. The realities of travelling, in search of pasture, water and trading partners in response to either base economic necessity or encultured and historical notions of territoriality, kinship or rites of passage, are fundamentally different from those of sedentary farming communities where quotidian experience is limited to single place and perhaps a more restricted sphere of social interaction (e.g. Bollig & Schulte 1999; Adriansen 2005; Adriansen 2008). Galaty (2013), for example, has used four case studies from across Africa – the Fulbe, the Nuer, the Maasai and the Tswana – to demonstrate how mobility patterns that are clearly structured by local ecological and climatic conditions are also influenced by a hierarchy of social and economic institutions, such as age-sets, trade with farmers and hunters, and political alliances and conflicts. Equally, these institutions and relationships are facilitated by that mobility.

Archaeology has, I would suggest, largely failed to tackle the importance of these dynamics and the centrality of movement to the functioning and historical development of herding in eastern Africa. The reliance on radiocarbon dating for the construction of chronologies is arguably one of the major obstacles here. While undeniably important in situating a given site within regional timeframes, there is clearly a disjuncture between the decadal (at best) timescales and site-specific information dealt with in radiocarbon chronologies and the seasonal or even finer temporal frameworks within which pastoralist mobility is structured. A few key works, such as Foley's (1981) study of 'off-site archaeology' in southwestern Kenya, have drawn attention to how mobile communities generate archaeological landscapes that, if processes of deposition and taphonomy can be properly understood, might be decoded so as to illuminate patterns and functions of mobility (see also Cribb 1991). While undeniably successful in its demonstration of the shortfalls of single-site investigations in the context of mobile societies, and in highlighting the potential for ecological adaption in human behaviour, Foley's approach is clearly a product of its time, concerned as it is with the search for 'process' and stressing of ecology as the principal driving factor of cultural evolution. Archaeological thinking has obviously moved on, with the emergence of Historical Ecology, for instance, ensuring that unilinear interpretations of human-environment interaction are no longer sustainable.

Some studies have built on Foley's ideas to great effect in exploring pastoralist landscapes (e.g. Causey 2008). However, the fact remains that individual settlements, however ephemeral, provide our best chance of accessing the requisite data for the reconstruction of pastoralist lifeways. Furthermore, ethnoarchaeology has shown how institutions negotiated through mobility (e.g. kinship networks, age-sets) can be materially manifest within settlements and artefacts, even if it is only through mobility and connection that these manifestations retain any meaning (Grillo 2012). Given that ecological legacies such as anthropogenic glades frequently provide the only spatial context available at pastoralist sites, it is vital that we develop a comprehensive understanding of these features, their formation and internal variation. A truly useful archaeology of pastoralist sites must therefore be based on an awareness of the dynamic interface between culture and environment that is central and specific to the daily lives of herders, in terms of how economic needs are addressed and the historicity of the strategies employed. Such an understanding, however, requires the drawing together of distinct data sources.

1.3 An 'archaeo-ecology' of pastoralism

This dissertation addresses what I perceive to be an unnecessary segregation of two perspectives on the sites of past herder settlements: mobility and landscape ecology. The integration of these two dimensions can contribute significantly towards an archaeology of pastoralist experience. Numerous ecological projects have observed how these sites affect the wider and enduring ecological profile of the savannah environment. The changes effected might be a function of soil nutrient imbalances created by dung accumulations within enclosures (e.g. Augustine 2003) or clearance of woody vegetation stimulating shifts in broader patterns of plant community composition (e.g. Muchiru et al. 2009), but the emphasis in these studies is on effect rather than cause. An understanding of the activities or processes that create the conditions by which these ecological changes occur is, quite reasonably perhaps, not of particular concern. In contrast, archaeologically-motivated projects like those undertaken by Shahack-Gross *et al.* (e.g. 2003; 2004) have generally focussed on the direct residues of human presence, limited though these usually are. I argue here that a consideration of how the inhabitants engaged with the wider landscape and of the post-abandonment ecology of herder settlements can help fill in gaps in the traditional archaeological record. Moreover, I argue that such an approach, aligned to that central mediating dynamic of mobility and ecology, might nurture an archaeology of pastoralism that better comprehends that which is so blurred in the daily experience of herders: the nature-culture divide.

1.3.1 Archaeology and historical ecology in Laikipia

Between 2002 and 2010, a sustained programme of fieldwork was undertaken on the Laikipia Plateau, an area of high-altitude (c.2000 m.a.s.l.) savannah in central Kenya. The work, undertaken under the auspices of the British Institute in Eastern Africa (BIEA) and subsequently within the 'Historical Ecologies of East African Landscapes' (HEEAL) project, utilised an explicitly multidisciplinary approach to define the environmental history of the plateau and explore how that history was and continues to be shaped by human occupation (Lane 2005; 2010). Besides rigorous archaeological and paleoenvironmental investigations, the agenda drew on records from the colonial and post-colonial eras to assess changes in land-use policy, wildlife distributions and land cover, with the intention of disentangling the complex historical interplay of anthropic and natural pressures that have contributed to the present environmental and social conditions on the plateau.

My work revisits a key location identified during the BIEA/HEEAL fieldwork. The site of Maili Sita, located at the foot of the Lolldaiga Hills, has been subject to several seasons of excavation and survey, including a comprehensive programme of environmental sampling. This work suggested intensive settlement from around the sixteenth century AD. Broad and intensive as they have been, investigations at Maili Sita have been unable to clearly define the nature of occupation. The most recent interpretation, based on a number of indicators to be discussed in detail later, suggests a series of short-term occupations – as might be expected for pastoralists engaged in seasonal mobility – and associate the site with the Laikipiak, a now-dissipated section of the modern Maasai, who occupied the plateau until the nineteenth century (Lane 2011). This attribution, however, is circumstantial at best; reliable ethno-historical data relating to the Maasai only reaches back around 200 years, with the preceding centuries clouded by vague and often contradictory linguistic reconstructions and oral traditions relating to the presence of economically- and culturally-diverse groups across the region (Sutton 1993). Earlier work at Maili Sita and other sites from this period has hinted at the mixing and merging of these communities, with iron producers, cultivators, hunters and herders interacting and negotiating their positions across a range of environments (Lane 2005; 2011; 2013; Iles & Lane 2015). Somewhere along the line these populations began to divide and coalesce into the distinct cultural identities held by the Maasai and their counterparts today; my research at Maili Sita contributes towards unravelling these processes with respect to the important cultural intersection of the Laikipia Plateau.

Drawing on a range of approaches from the diverse spheres of geoarchaeology, isotope analysis and remote sensing, this dissertation assesses how human presence has impacted the landscape of Maili Sita. I consider the relationship between the archaeological and ecological records at the site, neither of which, I argue, can be sufficiently understood without reference to the other. This builds upon the wider objectives of the HEEAL project (Lane 2010), which showed how social and natural environments are entangled at a regional and supra-regional scale. I propose that this 'entanglement' (after Lane 2016) can be observed and must also be explored at a smaller scale, at the level of the individual site, but that such understandings are inextricable from the wider physical and social landscapes through which herders move. Using this approach, I offer a reappraisal of human occupation at Maili Sita, positioning the site within a social landscape characterised by ethnic interaction and cultural fluidity, and a physical landscape that cannot be understood without reference to this human history.

1.3.2 Research Design

The broad research questions I will ask are:

- How was mobility and herd management structured at Maili Sita?
- What are the ecological legacies of human presence at the site?
- How might the interface between economic strategies and site formation processes inform an alternative or more complex interpretation of the occupation(s)?
- What are the implications of this interpretation for regional social and ecological histories?

My approach to answering these questions first considers data generated during the investigations directed by Paul Lane, most particularly the soil survey undertaken by Robert Payton and colleagues in 2004. As described previously, fieldwork at Maili Sita and in Laikipia more widely was undertaken over a number of years. A number of different teams and specialists were involved, and much of the raw data had thus far afforded only preliminary analysis. Prior to my own consideration of this existing data, and my subsequent collection and analysis of additional samples and material, I collated and organised as much of this information as possible. For instance, Maili Sita was surveyed during both the initial fieldwork in 2004 and again in 2010 by different teams using different equipment.

As a consequence, the two datasets generated could not be directly integrated, and much of my attention in the early stages of this research project was directed towards building a coherent GIS. Disjuncture between the map projections used by various contributors meant transposing the locations of excavation and survey units and other features based on excavation diaries and context sheets, among other sources. A number of these initial transpositions were adjusted upon visiting Maili Sita myself.

The major existing datasets to which I was given access were the excavation records – a near-complete set of context sheets for the 2004 and 2010 excavations – the soil data from Payton's survey, and the aforementioned array of GIS data pertaining to topographic survey, vegetation distribution, surface finds and key landscape features, as well as wider landscape survey conducted in 2004 and later used by Michael Causey in his PhD dissertation (2008). In addition, I was provided with data relating to: fungal spore and pollen analysis of a single 2004 unit profile (though not the raw data); pottery from the 2010 excavations, which gave context-specific sherd-counts, specifying the numbers and vague descriptions of diagnostic features, though no typological interpretations; faunal data from the 2010 excavations – the 2004 data could not be located; lists of samples (e.g. charcoal); various unpublished reports and written records, including excavation diaries; and the results of two radiocarbon dates relating to the main site and a close-by iron smelting location. Additional information relating to iron smelting and regional landscape survey was available through various publications by Louise Iles, who worked on the former during her MSc (Iles 2006; Iles & Martinon-Torres 2009; Iles & Lane 2015) and Michael Causey's work on the archaeological landscape of Laikipia during his MPhil and PhD (Causey 2005; 2008; Causey & Lane 2010). The archaeological material collected, from which these various datasets were derived, is stored mostly in the archaeology department at the National Museum of Kenya (NMK), and the stores of the British Institute in Eastern Africa (BIEA), both in Nairobi. Unfortunately, I was unable to locate all of the ceramic assemblage or any of the 2004 faunal material, which appears to have been lost in the intervening years. Furthermore, a number of the original analysts could not be contacted, for various reasons, and the extent of these issues only became clear during the research process.

As will be discussed in chapter four of this dissertation, these earlier investigations hinted at the significance of Maili Sita as an open-air pastoralist settlement in an under-investigated region and period, yet have been unable to clearly define the nature of occupation nor position the site within broader ethno-historical narratives. My principal interest lying in the historical ecology of the region, my not having the resources to undertake further excavation (on a useful scale) and given that much of the finds analysis from earlier investigations had already been conducted, I decided to focus on the soil and vegetation ecology at the site. Payton's team undertook soil survey along various transects in and around Maili Sita, the results of which are discussed in an unpublished BIEA report (Lane 2005). This report contains the results of various studies at Maili Sita and in Laikipia more widely, and I identified areas where these could be more closely integrated, most clearly with respect to the archaeological excavations and environmental surveys. My first objective was therefore to re-examine the raw geochemical and compositional data, and make comparisons with the other datasets within the context of the GIS that I compiled. This preliminary evaluation is described in chapter four, and provided the foundation for my own investigations and original data collection. This stage also involved the purchase and evaluation of high-resolution, multi-spectral satellite imagery (Worldview-2), which I built into the GIS and compared with Payton's data in order to evaluate visible correspondences between soil and vegetation distributions and possible anthropogenic geochemical enhancement. This integration of relatively-coarse ecological data – Payton's survey was fairly low-resolution, with samples taken at intervals of 40 to 100 metres – archaeological records and geographical context, provided the foundation for the design of my own data collection.

Knowing that even the extensive field research instigated by Paul Lane had been unable to fully comprehend the nature of occupation at Maili Sita and its social-historical and ecological implications, I sought to develop an approach in which particular assemblages could act as proxies for missing information. As described in detail in chapter five, the ratios of certain isotopes in biological material can be used to infer information about conditions during which that material was formed; in tooth enamel, for instance, stable carbon and oxygen isotopes can indicate diet and prevailing climatic conditions, respectively, during the period of enamel formation. In addition, strontium isotopes in enamel can indicate geological conditions, and thus inform speculation on where an organism originated or spent time. I undertook a pilot study considering these three isotopes in cattle teeth from Maili Sita, compared to modern reference specimens I collected from the local area and with known life histories. The rationale here was to reconstruct herd management strategies during occupation and, based on ethnographic observations of how different pastoralist site-types are associated with different herding activities, begin to construct an interpretative framework for other aspects of Maili Sita's archaeological record. Though this proved successful, my intention to expand the study was forestalled when the large 2010 faunal assemblage – to which I had been offered access – could not be located.

The principal element of original research in this dissertation, however, concerns a geoarchaeological and ecological investigation of the Maili Sita ridge, described in chapter six. As alluded to earlier, Payton's research, though low resolution, and in concert with my own consideration of satellite imagery, pointed to considerable anthropogenic influence on soil and vegetation in certain areas of the site. I undertook to greatly expand this investigation via a greatly higher-resolution programme of sampling and survey. In addition, while Payton's soil data focussed on quantifying geochemical residues that may have been impacted by occupation, I considered variables that would complement his findings by highlighting the factors that affected them. For instance, much of my focus has been on providing reliable indicators for the presence of livestock enclosures, principally through the effects of concentrated animal dung.

I visited Maili Sita three times between 2014 and 2016 in order to collect samples. The first trip was short (four days) and my primary intention was to gain a familiarity with the landscape of the Lolldaiga Hills and the Maili Sita site. I also spent time in NMK and at the BIEA, attempting to establish what material and samples were available. I selected three block samples taken from unit profiles during the 2010 excavations for export to the UK, where I prepared them for thin section manufacture (the final stage of slide preparation was outsourced to a dedicated facility) and undertook micromorphological and geochemical analysis (see chapter six). Through this I began linking data relating to soils at the site directly with excavation records. In 2015, I returned to the site and undertook comprehensive sampling of soils across the archaeological site and its surroundings, taking around 200 samples across three transects. These were shipped back to the UK where I undertook a series of physical, compositional and geochemical analyses. Finally, in 2016, I conducted an ecological survey of the site, using the same sample locations as for the above transect surveys to describe vegetation and instances of animal faeces across the site, from which to infer how variation in underlying sediments has affected plant colonisation and wildlife exploitation. While my 2014 and 2015 fieldwork took place in March, towards the end of the dry season, this survey was deliberately arranged for January and the transition between rainy and dry conditions in order that vegetation was in peak condition and plants at their most easily-identifiable.

This dissertation is therefore founded on a synthesis of previous research and new data. I have revisited previously analysed data, generated new data from existing sanples and undertaken extensive original sampling in the field in order to make the most of Maili Sita's considerable potential as an archaeo-ecological resource.

1.3.3 Dissertation Structure

I begin with a consideration of the broader context of pastoralism in eastern Africa. Chapter two outlines the history, so far as it is known, of livestock-based economies and pastoralist identities in the region, beginning with an overview of how concepts of 'ethnicity' have been constructed. It then discusses how many of the difficulties and inconsistencies in trying to interpret pastoralist archaeology in eastern Africa stem from the defiantly non-linear and osmotic manner by which languages, commodities, technologies and cultural traits have emerged, moved, developed and disappeared throughout the last 4000 years of eastern African herding. Chapter three looks closely at the ecological role of pastoralism, particularly the dynamics of glade formation and the impact of these features on soil, vegetation and wildlife. This is followed by examples of how ethnographers have observed and recorded the lives of contemporary herding communities and how their descriptions have influenced archaeologists seeking to reconstruct the undocumented past. Chapter four introduces the setting of my research project. Beginning with a description of the physical and social environment of the Laikipia Plateau, it then describes in detail the approaches and outcomes of previous investigations at Maili Sita before laying out my own agenda.

The middle section of this dissertation presents the original data collected during the research process. Chapter five discusses the potential of isotope analyses of faunal material from pastoralist sites towards illuminating the spatial and temporal dimensions of mobility by looking at grazing patterns, diet and seasonality. I outline the design and results of my pilot study at Maili Sita and compare my findings with ethnographies of herder settlements to assess the kind of occupation that might be expected for Maili Sita, thinking about use-of-space and consequent ecological residues at the site. Chapter six presents the results of extensive soil and vegetation survey and geoarchaeological analyses, alongside satellite imagery of the site and its environs, whereupon observations are made of anthropogenic inputs to current ecological conditions. Chapter seven presents a survey of the wider region using satellite imagery, situating the occupation of Maili Sita within a wider spatial, temporal and cultural milieu.

The third and final section considers the various implications of my findings. Chapter eight, the first of two core discussion chapters, reviews traditional histories and linguistic reconstructions in light of my own findings, and positions Maili Sita and the Laikipia region with broader ethno-historical narratives. Chapter nine considers this project's methodological contribution to the archaeology and ecology of pastoralism and, in light of my results, offers a critical assessment of how archaeologists and ecologists think about pastoralist settlement and its history. Finally, chapter ten concludes the dissertation with a reflexive summary of my findings and methodology, and considers the prospects for building on this research in the future.

2

Pastoralists in Eastern Africa

Figure 2.1. They live as they always have...look[ing] after this savage and mysterious land'. Photograph of a Maasai man and excerpt from accompanying text, obtained from Southworld.net (2013) in an article entitled 'Kenya - a journey into Maasai culture'

As with the rigidity of the nature-culture divide, another problematic western conception attributes African pastoralists with a kind of cultural stasis or immutability. Images of proud herdsmen gazing across the savannah have helped sell countless glossy coffee-table books, yet disregard the historicity of these communities. In eastern Africa, as with any other people in any other part of the world, such groups did not emerge fully formed, and explorations of their archaeological heritage have helped illuminate the complex and long-term processes by which pastoralist economies and identities have been forged, manipulated, dismantled and lost – that interaction rather than isolation has shaped the communities we see today.

This chapter outlines the history of pastoralism in eastern Africa, with an emphasis on how changing environments have fostered networks of cultural, economic and demographic exchange with fellow herders, hunter-gatherers and farming communities, categories that are not mutually exclusive. As explained in my introductory chapter, this dissertation is closely concerned with the origins of Maasai identities. However, as the following paragraphs will make clear, the complexities of that group's emergence and the difficulties we face in trying to understand it stem from the diverse-yet-entangled histories of a variety of distinct peoples, herders and others. The chapter is concluded, therefore, with an outline of the recent history of the Maasai, and an example of how 'being Maasai' remains a fluid and malleable concept. This case study is intended to highlight the disjuncture between how socio-political context influences pastoralist identity in ways that the cultural-stratigraphic sequencing that dominates many of archaeological investigations is ill-equipped to explore. I begin, though, with a brief and general discussion of the roles of ethnicity and cultural identity in Africa, and how the past and the present intersect and diverge in the construction of social landscapes and their representation in the archaeological record.

2.1 African identities

Ethnicity has been understood in current anthropological thinking as the 'self-perceived inclusion of those who hold in common a set of traditions not held by others with whom they are in contact' (De Vos 2006:4). While this may be a useful set of parameters with which to distinguish cultural groups in the ethnographic present, such a definition is synchronic, appearing to deny, or at least to underplay, the historical processes by which these traditions emerge, develop and disperse. Without this temporal dimension, the relevance of the concept of ethnicity to archaeologists seeking to understand diachronic historical processes is moot.

The question for archaeologists, then, regards how perceptions of shared identity are arrived at: 'how far back in time we may legitimately employ contemporary ethnic or cultural labels in our reconstructions?' (Stahl 1991:268). While the 'primordialist' view of ethnicity as somehow static and unchanging, expressed in the culture-historical linkage of material culture types with specific communities, fails to account for individual capacity to renegotiate and remodel identity, the 'constructivist' alternative – that ethnicity is subjective and lacks this *a priori* stability – has been criticised as 'throw[ing] the baby out with the bathwater' (Richard & MacDonald 2015:18). The dismantling in the 1980s of ethnic classifications envisioned as colonial inventions, imposed in advancement of the cause of indirect rule (e.g. Ranger & Hobsbawm 1983), has since been recognised as a well-intentioned denial of African agency (e.g. Ranger 1993; Spear 2000). Consequently, these ideas have given way to an acceptance that the coalescence of ethnic identities – as they are self-perceived rather than externally-imposed – is dialogic, as tied to past experiences and cultural legacies as it is to current social and political conditions (e.g. Peel 1989). From this perspective, present and future identities are and will be based on innumerable ancestral reformulations that crystallise once more in the unique context of a descendent community. The place and goal of archaeology, then, may not be to try and delimit and define cultural groups (MacEachern 1998) but rather to chart the processes that give rise to traditions and shape perceptions of shared identity.

Material culture has been central to archaeologists' explorations of identity since the aforementioned culture-histories of the early twentieth century. More recent ethnoarchaeological studies, many of which have been undertaken in Africa, have shown the kinds of correlations between artefacts and peoples identified by these studies and used to construct historical chronologies to be frequently and fundamentally misleading. Associations between material assemblages and language groups, for example, have been commonly used to trace ethno-histories across great swathes of the African continent (de Maret 2005). With respect to pastoralism, some concession might be made towards the fact that material culture and linguistic evidence is often the full-extent of the archaeological record. This, however, does not render such approaches any less problematic; Hodder (1982) and others (e.g. Wiessner 1983; Larick 1986; Grillo 2012) have drawn attention to the way social information is woven into the material culture of mobile societies in Africa, and shown that style can be both a subconscious expression of culture and a conscious definition of identity, yet other observers have shown how style can transcend nominal 'ethnic' boundaries (Dietler & Herbich 1994; Gosselain 2000). Similarly, nuanced archaeo-linguistic reconstructions have shown how language is adopted and adapted in response to socio-political conditions with occasionally little regard for historical precedent or arbitrary geographical boundaries (e.g. Schoenbrun 1998; Blench 2006). This is not to say that such approaches are entirely flawed; Blench (2015:146) makes the important point that 'ponderous literature' seeking to emphasise the subjectivity and unknowability of ethnicity can be disingenuous, and that language, for instance, can and does constitute a distinct social divide.

In short, archaeology's relationship with ethnicity in the deep past verges on the paradoxical; while accepting that we cannot 'know' how people in the past defined themselves, we rely on physical manifestations of those definitions in order to construct our narratives. Certainly, the archaeology of pastoralism in Africa has, in seeking to describe how domestication spread through the continent, often relied heavily on ethno-linguistic and artefactual groupings in lieu of complex and comprehensive archaeological data with which to interrogate such assumptions. The remainder of this chapter considers this history, as it is currently 'known', while keeping the points raised in this initial section firmly in mind.

2.2 Conceptualisations of pastoralism

Prior to venturing a detailed discussion of the history of pastoralism, it is worth considering the connotations of various terms and concepts alluded to in my introductory chapter and referred to throughout this dissertation. Globally, and within eastern Africa itself, pastoralism is a broad church, neither a single phenomenon or a defined mode of production (Bonte & Galaty, 1991). At least as varied in its manifestations as farming, not only does the relative importance of livestock in a given economic system – whether based around cattle, camels, or smallstock – vary considerably even between communities that may share a common ethnic identity, there are considerable differences in how that stock is managed. For instance, African pastoralists are generally perceived to be highly mobile, moving around the landscape in encultured response to environmental and social impositions, yet while movement may on some level be central to the functioning of all pastoralist systems, the range of mobility strategies employed by herders is broad.

There have been numerous attempts to categorise forms of pastoralism according to degrees of mobility and the relative economic importance of livestock (e.g. Khasanov 1984; Binford 1980; Ingold 1980), the usefulness of which has been questioned. The critique is valid in so much as these appellations are overly reductive and reliant on ethnographic analogy (Bernbeck 2008), yet as with other such analogies they retain some use as heuristic indicators of the range of practices this economic strategy can encompass (Wylie 1985). There is, for instance, an important distinction between *nomadism* and *transhumance*. Ingold (1987:188) defines nomadism as involving free horizontal movement within a single ecological zone, while transhumance denotes structured shifts between zones, such as in the exploitation of seasonally-available resources. However, building on the work of Gulliver (1955) among the Turkana, Ingold is careful to point out that these are not mutually exclusive categories. For the Turkana, quotidian nomadism is practiced within a seasonal programme of transhumance between mountain and plains pastures (Gulliver 1955).

Though the term 'nomadic' is originally derived from the ancient Greek verb *nemo*, meaning to graze livestock (Liddell et al. 1958), it has come to be associated with any kind of residential mobility. Wenrich and Barnard (2008) describe four basic categories of mobility: 1) an entire group or community travels opportunistically from resource to resource; 2) parts of different groups travel to and from specific resource locations; 3) different parts of a single group travel between resource locations and a single central base; 4) an entire group moves between locations according to a structured and fixed pattern. The first three broadly correspond, respectively, with Khasanov's (1984) descriptions of *pastoral nomadism proper*, *semi-nomadic pastoralism* and *semi-sedentary pastoralism*, while the last is analogous with transhumance. However, these are again not exclusive or exhaustive categories; among eastern African herders like the Maasai and Samburu, for instance, some members of the community stay within the main homestead, engaging in daily short-distance journeys between local pastures, water sources, markets etc., while others, typically young men, travel much further afield between outlying pastures, returning intermittently with produce or to participate in community events (e.g. Spencer 1965; Århem 1985; Hodgson 2000).

Not only can the level of mobility employed by a pastoral society not be assumed, neither can actual involvement in stock-keeping. To use the example of the Maasai once more, though in many ways the archetypal African 'people of cattle', the possession of livestock is not necessarily a prerequisite for assuming Maasai identity. The Arusha Maasai, on the Kenya-Tanzania border, appear to have exclusively practiced farming since the Maasai expansion of the nineteenth century and provide important access to cultivated resources for their stock-keeping counterparts (Spear 1993); as Anderson (1993:128) notes, this may symbolise an essentially-pastoralist Maasai hegemony 'to which all could aspire, but not in practice a cultural reality'. Further illustration of this point is provided by the Samburu, who if they lose their animals to disease or raiding, can temporarily join neighbouring Dorobo hunter-gatherers until they can regain possession of livestock (Spencer 1965; Hodder 1982). It is therefore inconsistent with the actualities of African pastoralism to rely on a definition along the lines of that given by Krader (1959:499) – 'those who are dependent chiefly on their herds of domestic stock for subsistence'. Instead, as Homewood (2008:1), echoing Anderson (1993), puts it, a pastoralist might be 'one for whom [stock-keeping] is an ideal'.

This point, that pastoralism and pastoralists are adaptable, able to manipulate and adapt their economic strategies to the extent of abandoning stock-keeping altogether, is crucial to understanding the history of herding in eastern Africa. Importantly, it is a point that is missed or underplayed by studies that focus on synchronic moments in the historical trajectory of a community, and therefore default to categorising their subject according to narrowly-defined types. As alluded to in my introduction, the archaeology of pastoralism has been guilty of such perspectives. The nature of herder mobility is such that settlements may only be occupied for a short period and thus represent a single moment in the life of a community. Consequently, and in contrast to the diachronic perspectives available at deeply stratified urban sites, for instance, where change and variability can be observed, investigations of open-air pastoralist sites can often do little more than describe socio-economic functioning as a static phenomenon (e.g. Lynch & Robbins 1979 see also discussion in Chang & Koster 1986). There are exceptions, of course; deep deposits at Gogo Falls in southwestern Kenya evidence long-term economic variability, with demonstrable fluctuation in the relative importance of wild versus domestic fauna (Robertshaw 1991; Marshall & Stewart 1994). Even this example, however, is only able to deal with variability at a very coarse timescale – dated occupation horizons at Gogo Falls span several millennia (Robertshaw 1991) – and the kinds of short-term, seasonal-scale variation hinted at ethnographically and shown to be central to the pastoralist experience (e.g. Spencer 1965; Dahl and Hjort 1976) may be beyond the reach of archaeology and the error margins of dating techniques. Clearly, then, in many situations this preoccupation with the momentary is difficult, if not impossible, to avoid; rather, it is vital to be aware of these limitations when interpreting the implications of an archaeological record.

Occupation of the site of Maili Sita, the focus of this dissertation, predates the emergence of the specialist and idealised forms of pastoralism still practiced by the Maasai and their ilk. As I will go on to discuss, it seems likely that this earlier period, in the middle of the last millennium, that the foundations were laid for pastoralist cultures and identities we see in the region today. Before attempting to understand the mechanics of this influential period, it seems prudent to examine its origins and development over the preceding millennia. This narrative, as ever, is not without its complexities and contradictions.

2.3 Eastern African pastoralism: Origins and spread

Cattle are now generally thought to have been domesticated from an indigenous African wild progenitor in the eastern Sahara some nine or ten thousand years ago, independent of the similar processes that occurred in the Near East and Asia (e.g. Loftus et al. 1994; Wendorf & Schild 1994; Bradley et al. 1996; Hanotte et al. 2002). This was followed some seven thousand years ago by the introduction of smallstock from western Eurasia (Close 2002). These early forms of animal husbandry were seemingly developed as a supplement to foraging among hunter-gatherer populations concentrated within dry lake basins or around massifs, for whom it may have acted as an additional, predictable food source (Marshall & Hildebrand 2002). Though the late Pleistocene and early Holocene saw much wetter conditions than today, the earliest sites are located in areas adjacent to wetlands (Smith 2005); an increasingly erratic and drying climate from around 5000 BC (Butzer et al. 1972; Stager et al. 1997) prompted movement beyond these narrow confines.

From this ‘cradle’ in the eastern Sahara, then, pastoralism has spread to all corners of the African continent. Yet the process of this spread was not gradual and steady, but rather proceeded in ‘fits and starts’ (Wright 2013). It is thought that increasing aridity encouraged the westward spread of herding between 5000 and 3000 BC, with groups maintaining a generalised economy inclusive of hunting, fishing and gathering (Marshall & Hildebrand 2002), but with an ever-decreasing reliance on plant resources (Barich 1987). The growing cultural and economic importance of cattle is illustrated by the development of a widespread ‘cattle-burial cult’, with cattle bones and iconography incorporated into a mortuary complex observed with minor variation across the eastern and central Sahara in the centuries after 4400 BC (Paris 2000; di Lernia 2006).

Besides threatening the meagre resources already available in the northeastern Sahara, increasing aridity caused a southward movement of the so-called ‘tsetse fly barrier’, wherein humid conditions favourable to disease vectors posed a threat to livestock. The reduced impact of epizootics is often cited as a key factor in the continued southward expansion of herding across eastern Africa (e.g. Gifford-Gonzalez 1998), though we currently lack material evidence with which to examine the idea (D. Wright, pers. comm. 2015; but see Chritz et al. 2015). It is possible, instead or in addition, that areas like Sudan and the Ethiopian lowlands that had previously been well-suited to pastoralism were rendered inhospitable by these drier conditions, effectively forcing southward migration (Lane 2004). This seems to have been the case across the northern and central Sahara, which by 2500 BC had become too dry to support herds, prompting a second and final wave of southward movement in the more favourable conditions of Sahelian West Africa and the grasslands of what is now South Sudan and northern Kenya (Smith 1984; Gifford-Gonzalez 1998).

Herders, then, are thought to have reached eastern Africa by the late-third millennium BC (Barthelme 1985) at which point incursions were made into the lowlands around Lake Turkana. The earliest secure dates for domesticates in the region have been obtained from the site of Dongodien (Marshall et al. 1984). An origin for these immigrant communities in Sudan, Ethiopia and possibly Somalia (Bower 1991), is supported by historical linguistic evidence linking them with proto-Southern Cushitic speakers (Ehret 1998), though the reliability of such data given the timescales involved has been questioned (Bower 1991). However, there are similarities in the subsistence practices noted at sites like Dongodien (Marshall et al. 1984; Barthelme 1985) and those observed at sites in South Sudan, like Kadero (Gautier 1984). It is probable, though, that rather than pastoralism being introduced simply via the migration of existing stock-keepers, local foraging communities began to accumulate livestock and were assimilated into herding economies through mechanisms of exchange (Barthelme 1985; Lane 2004), or perhaps even early instances of raiding and theft (Ambrose 1984). It may be that contact and exchange with local hunter-gatherers was employed by pastoralists moving into new areas as a means of mitigating against the effects of disease and drought, allowing them to fall back on wild resources if required (Gifford-Gonzalez 1998). As described earlier, a comparable pattern has been observed amongst contemporary groups with various involvements in day-to-day stock keeping, with apparently-fluid social identities based on subsistence practices being manipulated depending on the availability of particular resources (e.g. Cronk 2002; Spear 1993).

An interesting phenomenon associated with the emergence of pastoral production in northern Kenya is the construction of megalithic architecture – a practice most commonly discussed in the context of agrarian societies (Hildebrand et al. 2011) – in the form of 'pillar sites', comprised of platforms and standing megaliths, often in association with mortuary contexts (Hildebrand et al. 2011; Hildebrand & Grillo 2012; Grillo & Hildebrand 2013). Some have claimed an astronomical alignment for these sites indicative of sophisticated cosmology (Lynch & Robbins 1978). Though this interpretation has since been refuted (e.g. Soper 1982), the broader notion that the pillar sites express growing social cohesion and the ability to harness labour (Hildebrand & Grillo 2012; Grillo & Hildebrand 2013) presents them as powerful depictions of the social implications of the arrival of herders. Indeed, there is arguably continuity between the 'pillar sites' in Turkana and the kinds of earlier constructions associated with the aforementioned Saharan 'cattle cult' (di Lernia 2006). A compelling, if still hypothetical, explanation concerns the role of such monuments in mediating interactions at socio-economic frontiers (Hildebrand & Grillo 2012; c.f. Lane 2004), as emblems and focal points of novel social institutions through which distinct communities are unified. While it is curious that monuments on this scale are not found in eastern Africa beyond the confines of the Lake Turkana basin, nor are they constructed after c.2100 BC (Hildebrand & Grillo 2012), the construction of stone cairns, often linked to mortuary practices, is a feature common in ethnographic records of herders like the Maasai and Samburu (Lane et al. 2007; Davies 2013b).

Following its establishment in northern Kenya, there was an interruption in the southward spread of herding, perhaps due to arid conditions further south restricting groups to the vicinity of Lake Turkana and the wetter conditions of the southern Ethiopian highlands, or to increased contact with wild animal populations such as wildebeest and buffalo, which carry diseases like Malignant Catarrhal and East Coast Fevers (Marshall & Hildebrand 2002). The earliest evidence of domesticated livestock in the Central Rift Valley is found in association with hunter-gatherer occupation at Enkapune Ya Muto rockshelter, c.2000 BC (Marean 1992). Notably, these levels indicate very low densities of domestic caprines alongside abundant wild fauna. This may indicate that conditions here, while suited to browsing livestock, remained too dry for cattle, which do not appear at the site until c. 1440 BC (Marean 1992; Ambrose 1998). Smallstock, on the other hand, are much more resilient to environmental stress, and in times of drought are frequently sought by contemporary pastoralists seeking to rebuild their herds (e.g. Spencer 1965; Dahl & Hjort 1976).

2.4 The Pastoral Neolithic and the emergence of specialisation

The appearance of domesticate remains at Enkapune Ya Muto heralds the beginning of the period loosely termed the Pastoral Neolithic (PN) (e.g. Bower 1991; Collett & Robertshaw 1983b). The terminology has its detractors, who argue that it is reductive, and unduly emphasises the importance of herding with respect to other subsistence practices, that its inherent dependence on rigid artefact typologies (c.f. Wandibba 1977) neglects to consider the contribution of exchange relationships (Karega-Munene 1996). The phrasing is thought to promote a clear distinction between PN groups and their contemporary 'Eburran' hunter-gatherer counterparts when, in fact, the reality seems to have been something of a 'grey area' (Wright 2007:29).

While the PN nominally begins with the appearance of caprines at Enkapune Ya Muto, the proceeding centuries appear to have witnessed little change in the economic importance of wild resources in central and southern Kenya (Lane 2004). There are sporadic instances of domesticates observed in association with wild fauna at sites across the region, such as at Usenge 3 and Gogo Falls, on the northeast shores of Lake Victoria (Lane, Ashley, et al. 2007 Karega-Munene 2002; Marshall & Stewart 1994). Both date to the mid second millennium BC and, as at Enkapune Ya Muto, it is caprines rather than cattle that predominate. However, the introduction of livestock took place at a 'trickle' (Bower 1991:74), and it is not until the turn of the first millennium BC that faunal assemblages begin to yield greater proportions of domesticates relative to wild species. This delay could be a function of the same climatic and/or epizootic factors that restricted earlier herders to the environs of Lake Turkana (c.f. Ambrose 1984; Gifford-Gonzalez 1998) though Wright (2013:65) notes that cultural barriers – dietary taboos, for instance – might also prevent divergence from an existing subsistence regime. It also echoes discussion of delayed- versus immediate-return economies (e.g. Ingold 1980), wherein hunter-gatherers engaged in immediate-return subsistence economies struggle to integrate the delayed-return production of stock-keeping and cultivation. This may be due, amongst other things, to issues of labour requirements, access to pasture and egalitarian levelling mechanisms at odds with the capitalistic connotations of possessing livestock or agricultural land (Marshall 2000). A noteworthy ethnographic account of the effects such integration can have is offered by Brooks et al. (1984), with respect to the !Kung San of southern Africa, for whom the adoption of even limited food production resulted in major social reconfiguration.

Sites dating to the early PN – the 'trickle' phase of the second millennium BC – or relevant levels at sites with long occupation histories, such as Enkapune Ya Muto and Hyrax Hill in the central Rift (Marean 1992; Sutton 1998) and Seronera in northern Tanzania (Bower 1973), are often associated with Nderit ware (Gifford-Gonzalez 1998). These ceramics are strongly associated with groups engaged in herding around Lake Turkana yet faunal representation at these sites is heavily weighted towards wild animals. This lends substance to the argument that such occupations represent autochthonous hunter-gatherers who participated in exchange relationships with the northern groups, and that ceramics and livestock (or livestock products, i.e. meat, milk and hides) may have been obtained in exchange for wild resources (Gifford-Gonzalez 1998; Ambrose 1998). Nderit also appears at Gogo Falls, a nominally pastoralist site, albeit one with a faunal assemblage weighted equally towards wild species (Marshall & Stewart 1995); it has been mooted that the site represents herders having lost their livestock, perhaps through disease (Robertshaw 1990). However, recent stable isotope data has shown that the area may have been at the entrance to a key 'grassy corridor', a gap in the epizootic barrier that allowed herders to move into southern Africa (Chritz et al. 2015). As such, a mixed subsistence economy may have been a choice rather than a necessity. As discussed earlier, with climatic conditions being less favourable to husbandry, the ability to obtain wild resources, whether independently or via trade, may still have been vital to these earliest migrants.

After 1000 BC, however, the 'trickle' becomes a 'splash' (Bower 1991; Wright 2013), with domesticates beginning to outnumber wild fauna in assemblages from sites in the Rift Valley, central and southern highlands and around Lake Victoria (Bower 1991). This is reflected in historical linguistic data pointing to the marginalisation of the remaining Khoisan-speaking hunter-gatherers in favour of Southern Cushitic-speaking herders originating in southern Ethiopia and Southern Nilotes from South Sudan (Ehret 1998). The drying trend towards the semi-arid conditions seen across the eastern African savannah today was initiated during the third millennium BC (Wright et al. 2015), but not until the first millennium BC do conditions in central and southern Kenya reach their present state of suitability for herding, with rainfall sufficient to maintain grazing resources while not enough to render epizootics a significant obstacle. Indeed, Marshall's (1990) influential paper proposed that it was exactly these climatic developments that prompted the southerly influx of herders. However, the possibilities that cattle on the borders of the tsetse-barrier may have developed disease resistance (Gifford-Gonzalez 2000) or that the use of medicinal plants to treat such conditions (Gradé et al. 2009; van der Merwe et al. 2001) facilitated movement into affected territory (Wright 2013), dictate that while the improving climate may well have been a major driver, its primacy remains unproven.

Two material traditions have been recognised among the sites of stock-keeping populations of the early-PN, based on varying constellations of material culture with distinct geographical distributions: the Savannah Pastoral Neolithic (SPN) and the Elmenteitan (Collett & Robertshaw 1983b; Robertshaw 1988; Marshall 1990b; Gifford-Gonzalez 1998; Marshall & Hildebrand 2002; Lane 2004). It has been suggested that the two traditions can be associated with distinct linguistic communities, the SPN with Southern Cushites and the Elmenteitan with Southern Nilotes (Ambrose 1982). This, however, implies a degree of wholesale and isolated southerly migration from two points of origin; whether or not this idea is sustainable will be returned to in later chapters. While faunal ratios certainly became heavily weighted toward domesticates, the lithic assemblages from sites of both categories show continuity with earlier Later Stone Age (LSA) assemblages, as indeed do contemporaneous hunter-gatherer sites of the 'Eburran 5' tradition (Ambrose 1984) such as Crescent Island Causeway (Gifford-Gonzalez & Kimengich 1984) and levels RBL2.1 and RBL1 of Enkapune Ya Muto (Ambrose 1984). This has encouraged the theory that husbandry took root mainly through the acquisition of livestock from a small number of northern pastoralists by autochthonous hunter-gatherers (Bower 1991).

Table 2.1. Pastoral Neolithic ceramic traditions, dates and key sites (Laikipia sites in bold). Information drawn from Siiriainen 1984; Causey 2010; Lane 2013

Tradition	Dates (approx.)	Key Sites
Nderit	2500-500 BC	Dongodien, GaJi2, Jarigole, **Sukuta Farm, Kisima Farm**
Illeret	2500-500 BC	Illeret, North Horr
Turkwel	200-1000 AD	Lopy, Apeget
Narosura	800 BC-400 AD	Narosura, Prolonged Drift, Crescent Island Causeway, **LHS-10/11**
Maringishu	300 AD - ?	Maringishu, Hyrax Hill, **Kisima Farm**
Akira	100-800 AD	Seronera, GvJm44, **Kisima Farm, Sukuta Farm**

SPN sites tend to be situated in areas of high-altitude open-habitat, like the Rift Valley floor around Lakes Nakuru, Naivasha and Elmenteita, and further south in the Loita Plains and the Serengeti (Lane 2013). In terms of ecological and topographical setting, these sites occupy locations comparable with those preferred by modern groups like the Maasai (Western & Dunne 1979). Material culture assemblages include obsidian, often from local sources in the central Rift (Merrick & Brown 1984), and, as I have mentioned, show technological continuity with the local LSA (Ambrose 1998). Ceramic wares associated with the SPN tradition include Nderit, which is observed from Lake Turkana (Barthelme 1985) to northern Tanzania (Bower 1973); indeed, this spread and early dates led Gifford-Gonzalez (1998:186) to propose that Nderit sites be considered a distinct category. Later SPN styles include Narosera, Maringishu and Akira; the first two are largely restricted to the Central Rift – though Narosera may be present further south at Lemek (Robertshaw 1990) and has been observed as surface material in Laikipia (site LHS-10/11; Causey 2010) – while Akira is observed from northern Uganda (Robbins et al. 1977) and northern and central Kenya (Bower 1991; Siiriäinen 1977; 1984; Robertshaw 1990) to the Serengeti (Bower 1973). This breadth of distribution, alongside available radiocarbon dates pointing to manufacture during the first millennium AD (Wandibba 1980) and faunal assemblages indicating a partial return to greater wild resource exploitation, have fostered the notion that Akira relates to a final phase of SPN expansion (Bower 1991, in Lane 2013) and interaction with hunter-gatherer groups, who may have produced the pottery as a trade good (Robertshaw 1990).

Sites linked with the Elmenteitan tradition occupy a broader range of settings than do those of the contemporaneous SPN. Rockshelters, such as the later levels at Enkapune Ya Muto (Ambrose 1998), as well as open-air locations, have yielded Elmenteitan material. Geographical distribution is more limited, being largely restricted to southwestern Kenya from the Mau Escarpment close to the eponymous Lake Elmenteita down to the Mara Plains and the eastern shores of Lake Victoria (Robertshaw 1988). Elmenteitan material has, however, been observed in assemblages from the Laikipia Plateau (Siiriainen 1984).

As with the SPN, Elmenteitan faunal assemblages are overwhelmingly domestic, even though the sites themselves are frequently located in areas with abundant wild resources (Marshall 1990b). There are, though, contrasts between the composition of assemblages from open-air and more sheltered occupations; Ngamuriak, one of the largest and most intensively studied sites (see Robertshaw et al. 1990), exhibits roughly equal proportions of cattle and smallstock (Marshall 1990a), while contemporaneous levels at Enkapune Ya Muto rockshelter, for instance, are dominated by the latter. This variation, and that these Elmenteitan rockshelter occupations are also located in different ecological zones, frequently at much lower elevations along the foot of the Mau Escarpment, has led Robertshaw (1988:64) to speculate whether this indicates a degree of seasonality, wherein more resilient smallstock were brought to graze the less hospitable pastures of the Rift Valley. This fits well with stable isotope data from Masai Gorge and Enkapune Ya Muto that supports a pattern of seasonal movement of browsing livestock between altitudinal zones (Balasse & Ambrose 2005); it also echoes ethnographic observations made of the Turkana, wherein cattle are subject to seasonal transhumance while small stock management is more 'truly nomadic', able to exploit peripheral, marginal pastures (Gulliver 1955:29).

An apparently tripartite size distribution for Elmenteitan sites points to changing dynamics of settlement during this period. While some size variation may be explained by lateral 'creeping' due to the local relocation of corrals to prevent excessive accumulations of dung (Robertshaw 1990), structural variations in midden distributions as well as the aforementioned open-air-versus-rockshelter distinctions, presuppose a link between site form and function. Such a link has been well-documented among modern eastern African pastoral communities (Mbae 1990). This kind of variability in the past has been taken to imply a level of social complexity (Robertshaw 1990; Bower 1991). There certainly seem to be differences in economic investment at larger versus smaller sites; evidence of substantial construction in the form of post holes and fireplaces has been observed at Narosera (Odner 1972) and Ngamuriak itself has provided the only reliable evidence of a PN house floor excavated in eastern Africa (Robertshaw 1990). While the difficulties of identifying residues of construction and spatial arrangement at pastoralist settlement sites are widely recognised (Robertshaw 1978; Gifford 1978; Shahack-Gross et al. 2003; Shahack-Gross et al. 2004) and thus a lack of evidence for such features elsewhere is hardly proof of non-existence, the supposition that these sites may have been of a higher status (Robertshaw 1990:296-7) is not perhaps unreasonable. Further weight to this interpretation may be derived from faunal data; though not enough such material is yet available to make definitive claims, the assemblages from Sugenya (Simons 2005) and Ngamuriak (Marshall 1990b) suggest that their occupants lived in a certain degree of comfort; herd off-take patterns at both sites reflect ethnographic observations of modern eastern African herder groups in unstressed environments (Dahl & Hjort 1976), and point to a dairy- rather than meat-based diet (Simons 2005). Conversely, more highly fragmented bone assemblages at smaller, peripheral sites like Oldorotua 1 suggest a greater requirement to maximise the meat taken from a carcass and gain access to marrow, perhaps due to economic marginalisation (Simons 2005).

Along with the dense accumulations of dung at sites like Sugenya (Simons 2005; Shahack-Gross et al. 2008) suggestive of intensive and sustained corralling of livestock, these points may be taken as pointing to a form of 'tethered nomadism' (Bower 1991:70, after Ingold 1987), wherein mobility patterns are structured around a central point of reference. It may be that the largest sites – Sugenya and Oldorotua 3 – which are significantly larger than almost anything seen today among more mobile communities, provided bases from which low-level mobility incorporating the outlying minor sites was based.

The PN, then, saw the emergence of many of the traits associated with contemporary herders in eastern Africa, such as economic specialisation, seasonal mobility, and exchange relationships with neighbouring groups. The emergence of pastoralism in the region followed 'multiple trajectories' (Lane 2013:133); as well as the demic migration implied by linguistic data (Ehret 1998) and evidenced by, for example, the genetic dissemination of lactose tolerance (Tishkoff et al. 2007; Ranciaro et al. 2014), there was economic appropriation of herding practices by autochthonous hunter-gatherer and, in certain places, -fisher populations. The period also witnessed a consolidation of the pastoralist ideology that, while arguably traceable back to the Saharan 'cattle cult' (di Lernia 2006), was later to be so powerfully expressed by the Maasai and others groups in the region (Sutton 1993). This point may be well illustrated with reference to agriculture; while no clear evidence for cultivation has been found at PN sites, it has been suggested that adzes and other ground stone tools could have been agricultural implements, and that many sites occupy locations ecologically suited to farming (Robertshaw & Collett 1983). However, no PN sites have been located in the most amenable areas, such as the Eastern Highlands, adjacent to the central Rift, leading Robertshaw and Collet (1983:296) to speculate that ideological reasons prevented diversification away from a livestock-oriented economy. There was, though, a change during the proceeding Pastoral Iron Age (PIA) that, besides the strengthening of a number of pastoralist institutions, saw a partial withdrawal from some of the more rigid forms of specialisation seen at sites like Narosura, where faunal representation is over 93 percent domestic (Minimum Number of Individuals, MNI = 132; Gramly 1974). Instead, greater mobility and wild resource use (Bower 1991), albeit likely through contact with hunter-gatherer groups rather than a dual hunting-herding economy (Robertshaw 1990; see Ingold 1980 on the sociological contradictions of such a combination), coincided with emergent agriculturalist populations and, later, the adoption of iron technologies (Collett & Robertshaw 1983a). It is in this period that the Eastern Nilotic Maa language, from which the dialects spoken by the modern Maasai and Samburu, among other groups, are derived appears in linguistic reconstructions for the Central Rift Valley. Unfortunately, however, archaeological investigations of sites dating to the PIA have been few and far between.

2.5 The Pastoral Iron Age (PIA)

Much like the initial adoption of livestock-based economies in central and southern Kenya, the transition between the PN and the advent of the PIA during the early- to mid-first millennium AD seems not to have been one of rapid, wholesale change, but rather a gradual and patchy socio-economic reorientation. The late-PN period between AD 100-700 coincides with an expansion of farming economies, associated with the Bantu-speaking, iron-using communities that emerged on the northern shores of Lake Victoria in the latter part of the first millennium BC (Lane 2004). These groups are commonly associated with Urewe ceramics (Stewart 1993; Clist 1987; Van Grunderbeek 1992) though the actual evidence for such links is markedly thin and even contradictory (Karega-Munene 2002; see also Amin 2015). For instance, Gogo Falls has yielded Urewe in association with domesticated fauna but not cultivated crops (Robertshaw 1991). Rather than being an ethnic marker for migrant farmers, Ashley (2010) and others (e.g. Lane 2004; Lane, Ashley et al. 2007) suggest that Urewe production might be a response (and a contributor) to changing social relations that appear to have developed around this time. Bower (1991) has noted that during this period, in which wild fauna return to dominate faunal assemblages and the wide-ranging, lightweight Akira ceramics appear alongside fewer stone tools, mobility seems to have been emphasised. Taylor et al. (2005) have observed a return to arid conditions, at least in central Kenya, in the early first millennium AD, and it seems possible that this undermined the large-scale herding that emerged in the PN, encouraging diversified economies in the form of iron-facilitated farming around the lake and hunting in the drier interior. The style and function of Urewe may therefore be symptomatic of new systems of contact and exchange between economic groups as they negotiated these changing conditions.

2.5.1 'Old pastoralism' and the Sirikwa

By AD 700-900, however, there are indications of further substantial socio-economic change, emblematic of which may be the adoption of iron technology by herders in the Central Rift. Among the earliest evidence of this comes from the 'main site' at Deloraine Farm, in the form of extensive iron working remains (mainly tuyeres) alongside a domestic faunal assemblage, implements for cereal processing (grindstones), and a diminished stone tool complex (Ambrose et al. 1984; Sutton 1993a). Of additional interest is the observation that ceramics at Deloraine appear to exhibit stylistic continuity with Elmenteitan wares (Ambrose et al. 1984). Unfortunately, there are very few other sites dated to this period and the spatial and temporal extent of the early PIA is poorly understood.

Some scholars (e.g. Ehret 1971; Vossen 1982; Sommer and Vossen 1993) suggest that the last centuries of the first millennium AD saw the aforementioned first appearance of Maa in the Rift Valley. Under this model, Eastern Nilotic groups that emerged some six thousand years ago in South Sudan (Ehret 1974), are thought to have moved south from western Turkana as part of a wider spread of the Ongamo-Maa language group, perhaps facilitated by iron technology acquired through interaction with Eastern Cushites established in the lowlands on the opposite side of the lake; indeed, Ehret (1982:35) suggests that these exchanges encouraged shared social institutions like endogamous blacksmith 'castes' and ritual circumcision. While a split saw speakers of Ongamo continuing southwards towards Mount Kilimanjaro, Maa seems to have remained in the Central Rift (Sommer and Vossen 1993).

The extent to which these early Maa-speakers were in contact with Southern Nilotic (Elmenteitan) agro-pastoralists already present in the region, as well as the Cushites with whom they had demonstrable interaction and cultural exchange, is unclear. It may be that integration was almost total, that early-Maa populations along with southward-moving Cushite communities were absorbed by the Southern Nilotes, forming the basis for what Lamphear (1986) has called the 'old pastoralism'. In Lamphear's (1986) view, these emergent 'old pastoralists' included the Sirikwa, a culture (if not a single people) that emerged around the twelfth century in the Central Rift and Western Highlands and best known for its distinctive settlements, the so-called 'Sirikwa holes'. These are characterised by a shallow central depression, c.10 m in diameter and up to 1.0 m deep, sometimes encircled by a low stone wall or wooden fence, that was used as a cattle kraal, and around which up to three habitation structures are arranged (Sutton 1973). Over 200 sites have been recorded across a range of environmental zones (Davies 2013a), often in clusters of between five and fifty 'holes', usually situated on sloping ground, with a single downhill-facing gateway and evidence of relatively substantial gate-post and fencing arrangements, beyond which dung middens accumulate (Sutton 1987). Lanet ware, named after the type-site in the Central Rift – the main feature of which is notably *not* a 'Sirikwa hole' but rather two large (c.300 m diameter) ringed earthworks, dating to the early second millennium AD (Posnansky 1967) – is characteristic of Sirikwa sites across their spatial and temporal spread (Lane 2013).

Recent reviews of the material assemblages from Sirikwa sites have questioned the extent that they can be attributed cultural homogeneity – they certainly exhibit a much greater degree of economic differentiation than was previously assumed (Kyule 1997; Sutton 1993c; c.f. Sutton 1973). The entirely domestic faunal assemblage at the Hyrax Hill site, in the Central Rift, depicts a pastoral specialism resonant of modern groups (Sutton 1987; Kyule 1997), while grinding stones and a 'complex kitchen' recovered at Chemagel, in the Western Highlands, are said to portray an economy much more geared towards agriculture (Sutton 1987:16). Such emphasis on cultivation may point to the incorporation of Bantu farmers in the Sirikwa umbrella-culture (Sutton 1987). Within the individual sites, though, there is no evidence for socioeconomic diversification or stratification; Davies (2013) draws parallels between a kinship-based heterarchy that seems to have characterised Sirikwa society and that which may have been instituted among specialised agriculturalists in Pokot/Marakwet (Davies 2010). This co-occurrence of economically-distinct specialist producers with shared social institutions may have encouraged exchange by way of agricultural surplus in return for cattle, a prestige commodity, stimulating further specialisation and intensity within wide regional networks (Håkansson 1994; Davies 2015 see also Comaroff & Comaroff 1990).

The relationship between the Sirikwa and modern populations remains unclear. Some commentators have described a link with contemporary Kalenjin communities, such as the Okiek and Marakwet, on the basis of perceived similarities in material culture (Sutton 1987). Indeed, a link with the Kalenjin would corroborate Lamphear's (1986) suggestion that the Sirikwa were not exclusively Maa-speakers or Southern Nilotes, but were a mixed community of Nilotes and Cushites. However, Sutton (1987) has argued that it is unlikely the Sirikwa at Hyrax Hill produced their own pottery, but rather may have obtained it through some form of exchange relationship with non- or semi-Sirikwa ceramic-producers. Such a relationship would bear comparison with more recently observed symbiotic arrangements between forager and stock-keeping groups, such as those between the Maasai and Okiek (Blackburn 1974), Samburu and Dorobo (Clarfield 1989) and Gabbra and Waata (Kassam 2006). Though in apparent decline from around the fifteenth century, Sirikwa culture seems to have lasted into the eighteenth century (Sutton 1987), albeit based on potentially-problematic radiocarbon dates. Should this timeframe be accurate, the decline of the Sirikwa would coincide closely with the emergence of the Maasai as a distinct entity (Waller 1979; Anderson 2016). That is not to suggest that there was direct continuity between the Sirikwa and the modern Maasai or that the Maasai were responsible for the disappearance of the Sirikwa, but as will be discussed below, there was certainly a shift towards the kinds of pastoral specialisation and social institutions associated with the Maasai – a move towards 'Maasai-ization' (Sutton 1993c) – over the second half of the last millennium.

2.6 Maasai

It is worth taking a moment to highlight this distinction between Maa-speakers and the Maasai, before thinking about what has come to constitute 'Maasai-ness' and how this concept might have developed. Maa speakers can be classified into two major dialects; a form known as North Maa is spoken by the Samburu and Il Chamus, while the Maasai themselves speak variants of South Maa (Sommer and Vossen 1993). A possible third variant, central Maa, is spoken by the Kore, who now live near Lamu Island on the coast but identify themselves as descendants of the Laikipiak (Romero Curtin 1985), the inhabitants of the Laikipia Plateau prior to their defeat and dispersal during the nineteenth-century Iloikop wars (Sobania 1993). Maasai are notionally a distinct people, albeit one that is singularly difficult to define on purely ethnic or economic terms. As Galaty (1982:3) has it, 'for Maasai [people], the notion of "Maasai" is a pre-eminently natural category since it represents an aspect of reality as concrete as geographical features, as biologically distinct as cattle, and as unique in practice as species of wild animals', yet to an outside observer the appellation can appear fluid and inclusive. This etic perception, though, may in fact be more accurate as to the origins and history of this enigmatic society.

2.6.1 Expansion

The nineteenth century AD saw the peak of a second Maa language expansion, at which point it was spoken widely between southern Ethiopia and central Tanzania, a territory of some 60,000 square miles (Galaty 1991) encompassing an array of geographical, ecological and economic zones, as well as self-identified non-Maasai populations (Sommer and Vossen 1993). Based on the linguistic divergences of extant Maa dialects, this second expansion into the Central Rift occurred around 1600 (Ehret 1984), yet Maasai traditional history does not 'begin' until the end of the eighteenth century (Lamprey and Waller 1990).

The events of the intervening centuries remain unclear. There has been a persistent idea that the period saw a widening of the gulf between the increasingly pastoralist Ilmaasai and the agricultural or agro-pastoralist Iloikop, forebears of the modern Arusha, Il

Chamus and Samburu, as well as the now-extinct Iloogolala and Laikipiak (Jacobs 1965; Lamphear 1986). The ethnic dichotomy between the Maasai and the Iloikop has since been dismantled (Waller 1979; Lamprey & Waller 1990; Galaty 1993); instead, a more convincing narrative, presented by Galaty (1993; variants in Berntsen 1979 and Waller 1979), portrays a period of centrifugal movement by various Maa-speakers out of a Rift Valley core, wherein groups displayed greater cultural affinity with this centre than with their immediate neighbours. This proposed pattern of 'frontier expansion, internal segmentation and external amalgamation' (Galaty 1993: 68), which is supported by linguistic evidence (e.g. Vossen 1988), goes some way towards explaining the spread and development of the well-defined Maasai sections and their distinction from Maa-speaking non-Maasai groups like the Samburu. However, it is unlikely that the finer details of this complex period of shifting identities and economies can ever be fully understood (Lamprey & Waller 1990). It is not until the late eighteenth century that these distinctions become fully embedded and we are able to trace these groups' development with any degree of reliability.

2.6.2 Drought, Conflict and Consolidation

In contrast to the dynastic chronologies of the Great Lakes region (see Sutton 1993b), the oral traditions of the acephalous communities of the Rift Valley and its environs are framed around the succession of age sets (Anderson 2016). Males are born into a particular age set, which for the Maasai are common across the 'federation', the sixteen politically-autonomous sections that identify as 'Maasai' (Jacobs 1965; Galaty 1993). They will belong to these age sets for the rest of their lives and the association constitutes a fundamental part of their identity. The system works on approximately fourteen-year cycles (twelve years for the Il Chamus, Spencer 1998), with members of an age set entering and graduating from *murran*-hood together (Spencer 1965; 1993). As *il-murran* (pl., sometimes *moran*), young men endure a period of forced withdrawal from society during which they live together and forge strong agnatic links. It has been suggested that these broad horizontal networks may, in the past, have been more important than family ties, facilitating the distribution of individual herds between agnates so as to ameliorate the risks of stock-loss due to localised drought, disease or conflict (Spear 1993:12). In addition, the absence of potentially disruptive young men strengthens the cohesion of the core familial unit, under the gerontocratic domination of the eldest male (Spencer 1993), another tenet of 'Maasai-ness'.

For other groups, such as the Turkana, the generational categorisation of men is much less formal (Gulliver 1958). Prior to the early- to mid-nineteenth century there appears not to have been any formal age set system in Turkana society beyond that of father-son. Lamphear (1993:93-4) argues that formalisation around this time may have served a more specific, primarily military, purpose, facilitating the mobilisation of military force while reinforcing the status of elders as the Turkana sought territorial and economic expansion. Interestingly, Maa-speakers and the Turkana share an Eastern Nilotic linguistic heritage, yet age set organisation is a ubiquitous feature of Cushitic groups such as the Rendille, Gabbra and Borana (e.g. Fratkin 1986; Stiles 1992); this coincidence combines with linguistic evidence (e.g. Ehret 1982) to suggest significant contact with Cushitic herders prior to the splintering of Maa into its modern sub-communities, such as Maasai, Samburu, Il-Chamus, and Parakuyo. Further, the origins of the current age set cycles employed by these groups can be traced to a common temporal origin around the 1830s, the effective beginning of Maasai traditional history (Anderson 2016). This period coincides with what appears to have been the most severe drought in eastern Africa for 750 years (ibid.) with complete desiccation of Lake Baringo (Kiage & Liu 2009; Bessems et al. 2008) as well as Lakes Chibwera and Kanyamukali in Uganda (Bessems et al. 2008) and a significant low-stand in Lake Naivasha (Verschuren 2004) during the first decades of the eighteenth century. Oral histories from across the region record a major famine around this time (e.g. Webster 1979; Tiki et al. 2013). This coincidence of paleoenvironmental records alongside indications of dramatic social impact and upheaval have led Sobania and Waller (1989, cited in Anderson 2016) to propose that these potentially destructive events instigated a wholesale 'remaking of identity'. It is not clear, however, whether these post-catastrophic identities were entirely new or replicated those that existed in the eighteenth century and before.

Anderson (2016) argues for a reframing of regional history during the nineteenth century, the most prominent events of which, at least from a Maasai perspective, were the inter-sectional Iloikop wars. These were fought in three phases between the 1830s and 1870s, the first of which may have been linked to the alleviation of the drought during the 1830s, with environmental recovery triggering a battle for resources. Aggravated by the Rinderpest epidemics of the late-nineteenth century, the wars culminated with the effective-destruction of the Laikipiak by Purko Maasai, who seem to have banded together with Kisongo, Kaputiei and Loitai sections (Galaty 1993). To refer back to Galaty's (1993) model of spiral expansion, these southern Maasai sections may have shared closer affiliation with the core Maasai federation centred on the Rift Valley, while relative outliers like the Laikipiak were geographically and socially isolated and thus particularly vulnerable during periods of ecological stress. Interestingly, the cultivating Il Chamus seem to have participated directly in Maasai age set initiations prior to the 1860s; the Dwati/Twati and Nyangusi age sets feature coevally in both groups' listings before this point (Anderson 2016). Laikipiak refugees are thought to have sought sanctuary with the Il Chamus around this time, in response to growing hostility from the Purko-Kisongo alliance. Chamus traditions are vivid in their recollection of an attack on their villages in the 1870s, a consequence of affiliation with the Laikipiak which must surely have hastened their divergence from the core Maasai (ibid.).

2.6.3 The Colonial Period

Eastern African pastoralism since the arrival of British colonialism has been popularly defined by its specialism, with the acquisition and accumulation of cattle the ultimate goal and symbol of prosperity. There has presumably always been an affinity towards livestock among Maa speakers, and it seems plausible that without livestock there would have been no means and little incentive for their ancestors to have left their eastern Sudanic homeland. However, the strength and rigidity of the economic and social divisions to have emerged since the early twentieth century seems to have been amplified. An interesting explanation for the perpetuation of the hunter-farmer-herder trinity, in spite of the apparent fluidity with which individuals and goods can move between them, is proposed by Galaty (1982). His concept of 'synthesis through exclusion' views the three as diametrically opposed in terms of the values they uphold, but it is this opposition that reproduces and redefines the boundaries between them, allowing for networks of communication and exchange that do not jeopardise the integrity of each group's identity.

The relative peace instituted during the colonial period may have served to cement these divisions further, somewhat perversely perhaps, by alleviating the hostile conditions that had fostered much of the ethnic malleability of the nineteenth century and before. The substantial reductions in livestock across the region caused by Rinderpest and other epidemics (Mack 1970; Waller 2004), estimated at as much as 80 per cent of the total Maasai herd (Waller 1988; Anderson 2002), negated the resource struggles that had previously led to outbreaks of violence. There was also wide variety in the relationships that different groups maintained with the colonial government; the Samburu, for instance, allied themselves with the British in return receiving protection from the Turkana, who were very much excluded from the colonial state (Spencer 1965). For the 'core' Maasai of the Purko-Kisongo alliance, the early twentieth century saw those that had not already moved onto the Laikipia Plateau following the Iloikop wars were removed there from the Rift Valley, to the newly-formed 'Northern Maasai Reserve' (Hughes 2006). In 1911, however, the plateau itself was deemed prime for European settlement and a controversial agreement[1] saw the Maasai relocated once more to the Southern Reserve, south of Nairobi. These reserves and the people contained within were given defined boundaries, such that processes of migration and assimilation that had previously been informal and opportunistic became subject to legal and bureaucratic ratification (Waller 1993). In consequence, it was necessary, perhaps for the first time, for there to be an accepted definition of 'Maasai-ness', yet even this was open to manipulation. The final section of this chapter considers the case of the Mukogodo, whose manipulation and appropriation of 'Maasai-ness' in the early-twentieth century is a prime example of the ambiguity of African cultural identities (sensu Richard & MacDonald 2015). Moreover, the situation of Mukogodo territory neighbouring Maili Sita offers further illustration of the Laikipia Plateau as a cultural frontier across which new identities are formulated (sensu Kopytoff 1987).

2.7 Mukogodo Maasai

The Mukogodo Maasai – the fullest account of whose recent history is given by Cronk (2002; 2004) live around the Mukogodo Hills in the northeast of the Laikipia Plateau, bordered to the south by large private ranches – of which Lolldaiga Hills is one – and to the north and east by the Mukogodo Forest. Much of their territory is today comprised of community-owned group ranches. Prior to the aforementioned relocation treaties between the British colonial government and the Maasai in 1911 which saw Laikipia emptied – to a greater or lesser extent (c.f. Vaughn 2005 on the presence of 'outlaws' into the 1930s) – of African pastoralists, the Mukogodo were hunter-gatherers. Though linguistic links with the autochthonous Khoisan-speaking groups that occupied eastern Africa before the southward spread of pastoralism have been identified (Ehret 1974), until the mid-twentieth century the Mukogodo spoke Yaaku, an Eastern Cushitic language related to Oromo. The relationship between the Mukogodo and their pastoralist neighbours – presumably the Laikipiak in the nineteenth century before their defeat and replacement by the Purko, and perhaps the Il-Tatua before them (discussed further in chapter four) – typified that which exists more widely between hunters and herders: in this case, the Dorobo and the Maasai (see also Hodder 1982 on the Lonkewan Dorobo and the Samburu).

Besides its usage as an ethnic label, 'Maasai' is a designation of status, at least in the eyes

2.1. The extent to which the Maasai 'agreed' to this relocation has been questioned; the agreement was signed by the Maasai *laibon*, Lenana, on his deathbed (Hughes 2006).

of those who fall within or are covetous of such a designation (Cronk 2002). The same applies to 'Dorobo', or 'Il-Torrobo' in Maa. While the etymology of the word is unclear – it has been linked with the Maa word for 'short', *dorop* (Huntingford 1929:335), the Southern Nilotic *darabe:da*, meaning "forest" (di Stefano 1990:55), and to a combination of the Maa for 'bees', *lotorok*, and "cattle pen", *bo* (Cronk 2002:32) – it is generally applied to those who do not possess cattle and live off wild resources, encompassing numerous Kalenjin-, Maa- and Kikuyu-speaking groups across the region. The term has broadly pejorative connotations; for the Maasai, the Dorobo have a mythological association with an original fall from grace, having shot an arrow through the cord between heaven and earth down which cattle were sent (Hollis 1905 in Cronk 2002:32). While there is certainly a general association with non-pastoralists, the epithet is somewhat inconsistent in it application; cattle are not a restricted commodity beyond the expense of procurement and it is possible for Dorobo to acquire livestock and thus raise themselves, within a generation or so, to the 'rank' of Maasai. Equally, it has been noted that the Samburu, who maintain a comparable system of subsistence hierarchy to the Maasai, can temporarily 'become' Dorobo should their herds be depleted due to disease or other malefactors (Spencer 1973). However, the label can be difficult to shake, such that groups that have kept livestock for several generations are still referred to as Dorobo (Waller 1985).

To return to the Mukogodo, in the process of establishing reserves for the various groups they assumed control over, British colonial administrators mistook 'Dorobo' for an ethnic label rather than a general term for those without livestock, and the Mukogodo were accorded a special status as 'true Dorobo' (Cronk 2002). Consequently, the Dorobo reserve was located in and around the Mukogodo Forest, north of the land that had been allocated for European settlement. In response to the programme of deportation in place across Laikipia, pastoral groups such as the Mumonyot Maasai began to intermarry and forge bonds with the Mukogodo, on the basis that if claiming Dorobo identity was insufficient to allow people to stay, livestock could be left with Mukogodo affines and returned to later. Cronk (2002:36-7) describes how no marriages between Mukogodo and non-Mukogodo were remembered before 1900, yet in the first decades of the twentieth century there was a sharp rise in the numbers of Mukogodo women marrying non-Mukogodo, stock-owning men. Through a process of bridewealth payments, Mukogodo began to accumulate livestock and assimilate Maasai values and cultural traits. By the 1920s, this reached such an extent that the Yaaku language previously spoken by the Mukogodo was abandoned in favour of Maa, and today is spoken very infrequently by only a few of the oldest members of Mukogodo society. Indeed, the label 'Mukogodo Maasai' is today generally accepted as a tribal identity across Kenya, with growing political representation (Cronk 2004).

While the relevance of this example to understandings of pre-colonial identities in Laikipia may not be immediately apparent, it does show, with respect to the speed and totality with which hunter-gatherer values and the Yaaku language were abandoned, how easily identities and behaviours can be manipulated in response to external pressures. Indeed, as an example of socio-economic assimilation the case of the Mukogodo may be a useful ethnographic analogue for explanations of the earlier spread of specialised herding and the expansion of the Maasai, albeit one significantly influenced and facilitated by the machinations of a colonial power. Interestingly, the Mukogodo appear to have previous form for willingness towards cultural adaptation; oral traditions from the sixteenth and seventeenth centuries AD suggest intermarriage and exchange relationships between the Mukogodo and Wardai Daaya pastoralists, Oromo Cushitic speakers originating in southern Ethiopia. Notably, it was at this time that the Mukogodo adopted Yaaku (Lemoosa, 2005:10).

The Mukogodo are a clear counterpoint to the ethnocentric, primordialist perspective that human societies display an innate affinity with others of their own ethnic group and a corresponding antipathy with outsiders (e.g. Geertz 1963). As Cronk (2002:38) recognises, though, neither does their situation conform to the opposing, instrumentalist position, that ethnicity is merely a tool by which social interaction is orchestrated; the Mukogodo would surely not have been granted their special status that allowed them to stay in Laikipia without the Yaaku language that so clearly distinguished them from Maa-speakers (ibid:39). However, this was a language that was discarded, seemingly-deliberately, over a matter of decades or less; Heine (cited in Cronk 2002:39) claims that a formal decision to adopt Maa was taken at a single public meeting in the 1930s. What is clear though, is that the Mukogodo appear to have been, and continue to be, well-aware of the power of ethnicity and its use in negotiating and manipulating changing social environments, by either referencing and reinforcing prior identities or though the capacity to adopt new ones. The Mukogodo certainly seem to have mastered both. In recent years there have even been motions towards a Yaaku revival (Carrier 2011); in an apparent response to heightened global awareness and discussion of indigenous rights, there has been a movement to revive the Yaaku language and reconstruct a non-Maasai identity. Recently, a museum of Yaaku culture has even been constructed in the Kurikuri Group Ranch, next to the Mukogodo Forest Reserve. A cynical view of these developments might cite the growth of land claims around the Mukogodo Forest as evidence of something mercenary. An alternative perspective would be that in the modern climate of rural marginalisation, this represents an ingenious way of ensuring the relative prosperity of a community through ready adaptation to socio-economic conditions and opportunities as they present themselves, something which this chapter hopefully shows to have extensive historical precedent in eastern Africa.

2.8 Summary

Sadr (2008:185) offers an interesting analogy for the adoption of herding in southern Africa by way of the spread of horses through North America in the seventeenth and eighteenth centuries; it is thought that horses and riding skills were acquired by Pueblo Indians forced into Spanish service in New Mexico (Haines 1959 cited in Sadr 2008). These people escaped and initiated a culture of raiding and trading amongst Native American groups that saw horses spread across the continent in under 200 years, with very little input from the group that first introduced them. The southward expansion of herding out of northern Kenya may have followed a similar trajectory, with relatively small groups of Nilotic and Cushitic pastoralists encountering hunter-gatherer communities as well as each other. Raiding and exchange, developing core-periphery relationships, climatic variation and the mobility required to exploit marginal environments generated new social landscapes that fostered new forms of community and material expression, a process that has continued ever since.

The latter half of the last millennium saw the formulation of the pastoral identities that feature so strongly in cultural mosaic of eastern Africa today, most acutely since the early nineteenth century and the emergence of distinct 'tribal' groupings. Although tribalism now holds a strong influence over the modern socio-political landscape (Bratton & Kimenyi 2008), the history of many of these now-distinct entities is one of entanglement and osmosis. This history has not always been peaceful, as illustrated by the scale and impact of the Iloikop wars, and though recent trajectories have at times been shaped as much by environmental forces – such as disease epidemics – as by human agency, the impacts of twentieth century colonialism have been keenly felt. The complexity of these processes demonstrates what little we know about the formative events of previous millennia, but serves to help define an appropriate course for archaeology. It is impossible to understand the archaeological record at pastoralist sites in the region purely by attempting to trace the origins of a single group, if, indeed, it is possible to identify a single group at all. Instead, the history of eastern African herding demands to be understood with reference to landscapes, as the product of interacting communities, shifting boundaries (both ethnic and territorial) and complex ecologies. The challenge remains, however, as to how we can understand the development of these landscapes, and human presence therein.

3

Ecologies and ethno-archaeologies of herding

Figure 3.1. Patches of dung on the sites of livestock corrals in the Lolldaiga Hills, with new grass coming through (O. Boles)

The previous chapter reviewed current thinking around the history of eastern African pastoralism, or perhaps more accurately, *pastoralists*; given the multilinear paths by which different groups adopted stock-keeping and the diverse manifestations of animal husbandry observed today, a single, catch-all '-ism' may be misrepresentative. This next chapter focusses on the legacies of herding economies, in terms of how these groups impact the savannah environments they inhabit. I begin with a general consideration of how, in recent years, deterministic positions emphasising environment as the principal and immutable driver of cultural differentiation have given way to conceptualisations wherein societies and landscapes are shaped by long-term human-environment *interaction*. This frames a discussion of how ecologists have explored the role of pastoralists within savannah ecosystems, primarily through the effects of abandoned livestock enclosures on soil, vegetation and wildlife.

The second half of the chapter critiques these discussions for their inadequate consideration of historicity of herding and monolithic view of how pastoralist settlements function; case studies with particular relevance to the research locale of this dissertation demonstrate the variety of herder lifeways and settlement patterns present in a relatively small portion of eastern Africa's pastoral territories, even between groups that share similar characteristics. Finally, I highlight how recent archaeological projects, partly inspired by the ecologists' recognition of identifiers for pastoralist settlement in the landscape, have used ethnographic observation in developing these ideas in order to access fine-grained, socially-relevant spatial information.

3.1 Anthropogenic landscapes and the 'pristine myth'

The idea that most, if not all, environments on Earth have been directly or indirectly affected by human activity is one of the foundations of historical ecology (Crumley 1994; Balée 1998; 2006). The concept of the Anthropocene (Crutzen & Stoemer 2000) – the idea that the industrial era, c.1850 AD, heralded the dawn of a distinct geological epoch wherein the total impact humanity exerts on global ecodynamics outweighs the effects of 'natural' climatological and geological change – and its growing prominence outside academia, highlights many of the key issues, yet remains somewhat vague in its practical application. Some have proposed a start-date that is both more specific and more recent; Steffen et al. (2015) cite drastic socio-economic and demographic change since 1950, termed the 'Great Acceleration'. Others are even more precise, arguing that 11:29 am (GMT) on the 16th March 1945, the moment of detonation of the Trinity atom bomb, the first test of a nuclear weapon, in the desert of New Mexico, provides a useful stratigraphic boundary (Zalasiewicz et al. 2015), similar to that of the meteorite striking the Yucatan peninsula that marks the boundary between the Cretaceous and Paleogene periods (Schulte et al. 2010). Nevertheless, there is general agreement that the Anthropocene is a post-industrial phenomenon.

This industrial-centrism has been widely critiqued and has detracted somewhat from the efforts of many scholars in highlighting longer term trajectories of anthropogenic environmental impact and landscape manipulation, both deliberate and incidental. Strong arguments have been made that the emergence of agriculture in Eurasia some eight thousand years ago, with its associated forest clearance, instigated an anomalous trend of rising atmospheric CO_2 concentrations that contributed significantly to global temperature increases (Ruddiman 2003; Kaplan et al. 2010), and should therefore be considered the 'start' of the Anthropocene (Ruddiman 2013). These arguments bear comparison with notions of the 'pristine myth', given its famous moniker by Denevan (1992) but conceptualised by many others at the time (e.g. Bowden 1992; Gómez-Pompa & Kaus 1992 Simms 1992; Turner & Butzer 1992). Much of the initial discussion focussed on the state of the American landscape at the point of the Columbian encounter, and the suggestion that early European explorers were presented with a pristine natural environment in which indigenous populations lived with no perceptible impact. This idea of harmony and the 'Noble Savage' has been forcefully discredited by examples of pre-Columbian landscape modification; for example, the impacts of induced fires on the oak-chestnut woodlands of the Appalachian mountains (Delcourt & Delcourt 1997; 1998). Similar observations have been made in other parts of the world, such as in the islands of Melanesia, where the maintenance of rainforest species compositions previously thought to be 'natural' is in fact reliant on human intervention via selective clearance (Bayliss-Smith et al. 2003). Again, in southwest Australia (Kost 2013), thousands of years of controlled burning by the Noongar people have shaped forest makeup. In this case, intervention in the indigenous broadcast fire regime since European colonisation has had the effect of reducing biodiversity and increasing the severity of bush fires (see also Gammage 2011). A final example from a West African context, concerns the forest 'islands' found across Guinea; these features, previously thought to be the last remnants of 'old growth' forest, are located within previously occupied areas. The establishment of these forests is now thought to have been a direct consequence of deliberate transplanting, cultivation and protection of select species by past populations (Fairhead & Leach 1996). Interestingly, one of the key tree species found in these forest groves is *Canarium schweinfurthii* (ibid.), of the same genus as the *C. indicum* noted as a key indicator species for areas of past settlement by Bayliss-Smith et al. (2003) in their work in the Solomon Islands.

Perhaps the greatest depth of research into the enduring ecological legacies of human presence in purportedly 'natural' environments has concerned the Amazon basin. I would argue that the kinds of questions that Amazonist scholars have addressed are of particular relevance to this dissertation and that it is worth offering a detailed consideration of the kinds of information being generated in this region.

3.1.1 Human-environment interaction in Amazonia

Besides an increasingly rich array of archaeological data, contributions from geographers, ethnographers and botanists have recognised the role of pre-Columbian societies in shaping the ecological profile of the Amazon basin (e.g. Roosevelt 2013; Lins et al. 2015; Balée & Nolan 2016). Arroyo-Kalin (2016) proposes that these contributions can be arranged into three general topics: landscape engineering, the transformation of vegetation compositions and the formation of anthropogenic soils. The first, though of great importance to understanding the human history of the basin, is perhaps of less relevance to my own work and as such will not be discussed in depth here. The latter two, though, bear comparison with circumstances in eastern Africa and are worth looking at in more detail.

There are now extensive records detailing the manipulation of plant biodiversity by indigenous communities in Amazonia (e.g. Balee 1989; Clement 2006), wherein certain species are encouraged or discouraged within and transported between particular locales. While this has the effect of decreasing local alpha diversity (diversity within a single 'plot'), beta (regional/inter-plot) and gamma (super-regional, i.e. the Amazon basin) diversity becomes increasingly heterogeneous (Huston 1994; Balee 2006). Ethnographic observations of Kayapó communities in Brazil demonstrate the extent to which certain patches of forest that might on first inspection appear natural, contain plants of which 85% are said to have been deliberately planted or otherwise encouraged; indeed, in one of these plots, 138 of 140 species identified were considered useful by local communities (Posey 1985). Swidden cultivation has also played a major role in developing the heterogeneity of the plant mosaics, through mechanisms such as the selective timing of fire events with particular periods in the growth cycle in order to emphasise the succession of certain species, or the mineralisation of plant matter via burning, improving the nutrient content of the generally thin and nutrient-poor forest topsoil (Arroyo-Kalin 2012). Vegetation patterns reflective of human disturbance are observable in something approaching fifteen percent of the Amazon rainforest (Balee 1989). Given the relative sparseness of population in the region, figures like this indicate the considerable time-depth attached to these transformative processes.

It is not only plants communities that are manipulated. *Azteca sp.* ants are known to repel *saúva* leaf-cutting ants, which can be damaging to desirable plant species; the Kayapó will remove portions of *Azteca* colonies and transport them to areas where leaf-cutters are prevalent as a form of biological insecticide (Posey 1985). Perhaps the most significant observation from an archaeological perspective, though, concerns the recognition and understanding of anthrosols, soils that have developed as a consequence of human action (Limbrey 1975). In Amazonia, the best known of these are Amazonian Dark Earths (ADEs): *terras pretas* and *terras mulatas*. The former describes areas of dark-coloured soil, generally in association with scatters of ceramics, which mark the location of pre-Colombian settlements, while the latter are lighter-coloured deposits, generally found adjacent to *terras pretas*, and evidence intensive burning activity such as swidden agriculture. These expanses, generally located atop non-flooding *terra firme* in the vicinity of river channels, range from small oval patches to stretches of several kilometres along bluffs above waterways (Arroyo-Kalin 2014). ADEs are estimated to cover around 0.1-0.3 percent of the Amazon basin, an area of up to 18,000 square kilometres (Sombroek et al. 2003:130). Recognition of the extent of human occupation in the region supports claims that prior to the arrival of Europeans, the Amazon supported dense, complex, sedentary communities (Heckenberger 2003; Arroyo-Kalin 2014), totalling upwards of five million people (Denevan 1992).

ADEs show significant chemical-enhancement due to the concentrated inputs of household waste – organic matter, bone, excrement and burning residues – altering local pedogenic processes by raising soil pH and encouraging nutrient-rich stable organo-mineral complexes. This results in greater cation exchange capacity as well as higher concentrations of organic carbon, calcium, phosphorus and potassium, among other elements (Arroyo-Kalin 2008; 2014). In addition to the illumination of the likely extent of pre-Columbian habitation in the Amazon basin, research into ADEs has shown that these additions to the soil profile, and consequent divergent pedogenic pathways, significantly improve the fertility of the nutrient-poor, acidic rainforest soils. It is in part by this mechanism that the levels of biodiversity recorded by Balee (1989) and others (e.g. Clement et al. 2003; Junqueira et al. 2010) are facilitated, either through useful plant species being deliberately propagated atop these nutrient-rich soils or through subtler modifications of natural patterns of vegetation succession. As fertile or biodiverse 'islands', these sites become assets, or 'landesque capital', valued by subsequent communities whose lifeways are directly influenced by these legacy features of long-term human occupation (Arroyo-Kalin 2016). Continued use of the land ensures the perpetuation of the processes by which these anthrosols are created and reworked. Consequently, ADEs have been key to the realisation that the Amazon landscape was managed by pre-Columbian societies in a manner apparently more sustainable than modern practices, to the extent that human presence actually increased the overall biodiversity and ecological health of the river basin (Clement & Junqueira 2010).

3.2 Pastoralist ecologies

A similar perspective has been developed with respect to pastoralist interventions in African savannah landscapes, whereby daily cycles of livestock dispersal for grazing in the wider landscape and nightly contractions for corralling within settlements lead to the redistribution of plant nutrients and seeds contained in dung and encourage ecological heterogeneity. These processes are key to understanding the role of herding in shaping these environments and to tracking mobile communities for the purposes of archaeology.

3.2.1 Savannahs

Savannahs are defined as tropical or near-tropical environments characterised by a continuous grass-dominated herbaceous understory with discontinuous woody vegetation or shrub coverage (Scholes & Archer 1997). The degree of tree or shrub cover within this broad categorisation can vary significantly, such that the term 'savannah' can be applied to both grassy woodlands and sparsely wooded grasslands, with local plant community compositions determined by a range of climatic, edaphic and biological factors (Ratnam et al. 2011). There is increasing global concern with the process of 'savannization' (Borhidi 1988), by which the degraded environments produced by forest clearance and logging are seen to be visibly comparable to savannahs but with much diminished functional ecology. Not the least important aspect of this diminution is the difficulty with which these environments can respond to ongoing disturbance, such as the brush fires to which they are particularly susceptible (Barlow & Peres 2008). Issues of degradation, however, are not limited to the pseudo-savannahs left behind by loggers; the ecological dynamics of true savannahs have been among the least understood of the world's terrestrial biomes (Huntley & Walker 1982), a situation particularly problematic with respect to the position of these environments' human inhabitants, the majority of which practice some form of mobile pastoralism.

In few places is human engagement with savannah environments more pronounced than eastern Africa, where some eight million people are thought to be engaged in or directly reliant on herding (Davies 2007). In recent decades there has been a swell in research directed at understanding the herder-savannah dynamic. Numerous projects have investigated the impacts that pastoralist activity and the presence of livestock has on wildlife (e.g. Homewood & Rodgers 1991; Mizutani 1999; de Leeuw et al. 2001; Augustine 2004; Young et al. 2005; Morris et al. 2009; Odadi et al. 2011; Bhola et al. 2012; Mizutani et al. 2012), vegetation (e.g. Stelfox 1986; Young et al. 1995; Reid & Ellis 1995; Veblen & Young 2010; Porensky & Veblen 2011; Riginos et al. 2012; Donihue et al. 2013) and soils (e.g. Blackmore et al. 1990; Turner 1998b; Shahack-Gross et al. 2003; Augustine 2003a; Muchiru et al. 2009). While these investigations have been largely concerned with relatively short-term interactions and consequences – such as vegetation succession patterns in the first months and years following the abandonment of livestock enclosures (e.g. Muchiru et al. 2009; Porensky & Veblen 2011) – a number draw attention to the longer term legacy effects of pastoralist presence (e.g. Stelfox 1986; Blackmore et al. 1990; Reid & Ellis 1995; Young et al. 1995; Shahack-Gross et al. 2003; Donihue et al. 2013). These studies have shown that the relationship between herders and the savannah is not only complex, but that it is in many ways symbiotic. Moreover, it is a relationship that over the millennia of herding in Africa, has exerted a significant influence on the ecological development of the modern landscape. The following paragraphs will explore the details of this in greater depth, with a focus on the formation, perpetuation and implications of anthropogenic glades.

3.2.2 Glades

As described earlier, levels of tree and shrub coverage can vary considerably within the 'savannah' categorisation (Ratnam et al. 2011). In eastern Africa, these variations occur at a local level, such that the landscape has a mosaic ecology with biological communities of distinct composition showing variously abrupt or diffuse boundaries (Young et al. 1995). This heterogeneity is perhaps the fundamental driver of savannah ecodynamics, whereby differential exploitation of the landscape by plant and animal species, as well as human societies, encourages and perpetuates ecological re-negotiation. Glades – grass-dominated and heavily-grazed clearings embedded in more heavily-wooded or otherwise differently-vegetated settings – are one such manifestation of this.

A basic requirement of pastoralism in Africa is that livestock must be enclosed overnight for protection from predators and raiding by neighbouring herders (Western & Dunne 1979). For many groups, like the Maasai, this involves bringing the animals into the village, wherein domestic structures surround a central corral, known as the *boma* (Kiswahili) or *enkang* (pl. *enkangiti*, Maa) (Mbae 1990). The establishment of these settlements involves the clearing of woody vegetation and the construction of thornbrush fences and wattle-and-daub buildings (ibid.) The sites are occupied on a temporary basis, and the accumulation of dung within the enclosures dictates that on abandonment, soils are characterised by high nutrient levels, fostering re-colonisation by rich grasses (Reid & Ellis 1995; Augustine 2003a; Veblen 2013). Wild herbivores are attracted to these re-colonised areas, as are subsequent herders. Continued deposition and concentration of dung from wild and domestic grazers, whose presence also serves to discourage regrowth by shrubs and trees, perpetuates these features in the landscape (Stelfox 1986; Blackmore et al. 1990; Augustine 2003a; Muchiru et al. 2008). This is, of course, a simplistic summary of the herder-savannah dynamic as it is understood by ecologists, and it is worth breaking down the key ideas and observations on which this perspective is based. In keeping with the concerns raised earlier in this dissertation that a successful archaeology of pastoralism needs to be ontologically specific, constructed around and addressing the particular features of the pastoralist experience, I now turn to the practical considerations herders address when founding their settlements.

3.2.3 Settlement location: environmental factors

One of the most important factors for pastoralists in deciding where to establish a settlement is the availability of water. Dahl and Hjort's (1976) seminal study of modern herding practices in eastern Africa indicates that the zebu crossbred cattle ubiquitous in teh region today can require at least 35-45 litres daily, depending on climatic conditions (e.g. air temperature), lactation patterns and the moisture content of ingested plants (Dahl & Hjort 1976). In arid lowland areas, cattle must drink at least every two or three days depending on breed, and up to every fourth day in highland conditions. Sheep and goats require more frequent access to water than do cattle. Though daily intake is much less (c.0-1 litre) such that water might be brought to the herd rather than the other way round, in arid environments smallstock are usually kept closer to water sources. In wet season conditions, sheep and goat can go without drinking for up to three months if fed on green pasture with high leaf-moisture content (Dahl & Hjort, 1976).

Given that cattle can be driven at speeds of approximately 3-4 miles per hour (though some studies have suggested speeds as low as 1-2 mph, e.g. Van Raay 1975:110), during a ten-hour day and allowing for around seven hours grazing, the maximum distance that settlements might be located from a water source would be 10-12 miles (Dahl & Hjort 1976). There are, however, additional factors to consider, such as topography and access to pasture; the best grazing conditions are often found away from water sources, and camps might therefore be located so as to optimise access to both. For instance, it has been noted that pastoralist grazing orbits are elliptical (Figure 3.2), as herders try to maximise available resources and minimise competition with other herds (ibid; Spencer 1973). It is worth noting that the breeds of cattle kept by eastern African herders have changed since the colonial period, with many herders adopting a crossbreed of indigenous and imported types. For instance, a Red Poll-Boran crossbreed is common across highland Kenya, particularly in large commercial herds (Mizutani et al. 2012), and is desirable both for the higher milk-yields associated with the imported stock and the resilience to aridity of Zebu cattle (Trail et al. 1984). Estimates such as water requirements and limits of

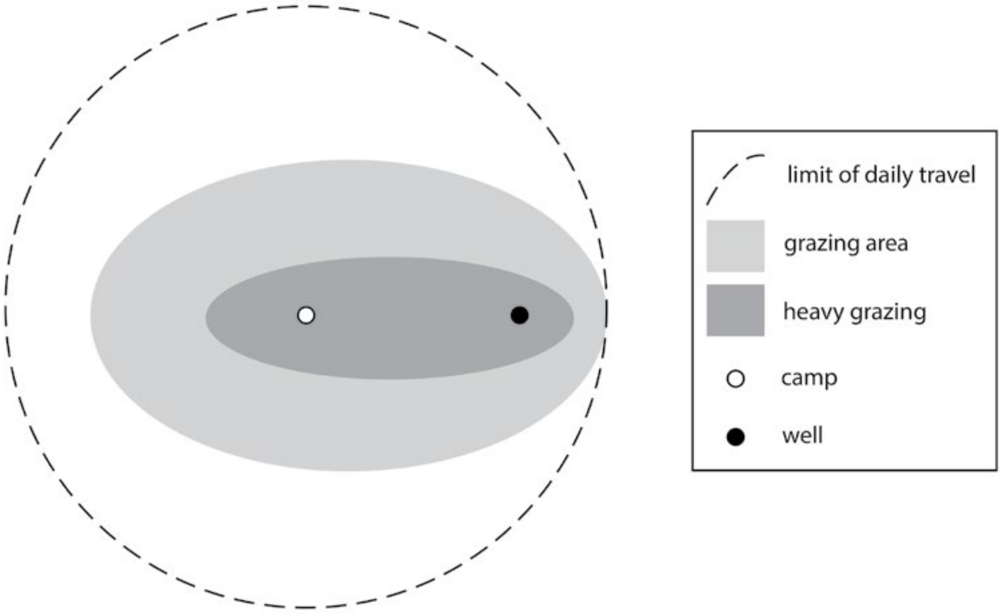


Figure 3.2. Elliptical cattle grazing pattern, based on need for access to water and pasture

daily travel, alongside ultimate productivity, based on observation of modern herds may therefore bear little relation to conditions in the past, a point that must be considered when interpreting settlement patterns.

There is also a need to avoid placing unnecessary strains on livestock that can counterbalance the benefits of immediate access to water or pasture (Western & Dunne 1979). For instance, heavily-wooded, swamp and riverine environments harbour disease vectors such as the trypanosomiasis-carrying tsetse fly. As Porter (1965:410) states, "the necessary habitat [for tsetse fly] involves heat, moisture and shade, all in close proximity, and accordingly moist lowlands and drier plains of [dense vegetation] near perennial streams are commonly infested". Moreover, excessive rain can create problems of waterlogging, such that certain areas become hazardous, particularly to young livestock. For example, waterlogging prevents the Karamojong of northern Uganda from grazing much of the western part of their territory during the wet season (Dyson-Hudson & Dyson-Hudson 1970).

For the Maasai, topography is another important consideration in determining settlement location. The convex upper portion of hill slopes is preferred over concave footslopes, partly because the accumulation of deep sandy/silty soils resulting from erosion run-off are more susceptible to the aforementioned waterlogging. Indeed, following a severe rain event, the run-off itself can be destructive; Western and Dunne (1979) note that up to 20 centimetres of deposits can accumulate on footslopes following a single heavy rainfall; while events of this magnitude are unusual, they suggest that as little as two centimetres might be enough to inflict structural damage on a boma. The same authors, whose 1979 study of the environmental determinants of Maasai settlement location in Amboseli, in southern Kenya, remains the most detailed and widely-cited investigation of its kind, propose that the maximum gradient of slope chosen for settlement is 0.08. The Maasai themselves state that, a) steeper slopes encourage the cattle to charge downhill when startled, breaking fences, and b) that these are covered by a layer of stones that hinders construction and is uncomfortable for the cattle. The latter point is borne out by particle size analysis of hillslope soils (ibid.). Other studies have pointed out that some degree of slope may be desirable, in order that run-off might wash away excess dung and urine that might pose health risks, thus prolonging the potential use-life of the compound (Mbae 1990).

Soil colour is also a determinant, with reddish hues being associated with better drainage and therefore preferred over lighter, greyer sediments. Western and Dunne (1979) state that red soils are found most often at the tops of hills, while the unoccupied pediment slope soils are significantly lighter, a consequence of the anaerobic conditions created by frequent saturation. In the latter, soils become gleyed, whereby waterlogging causes iron compounds to be reduced, and soils less red (Rapp & Hill 2006). The Maasai themselves offered the explanation that the lighter coloured soils are colder at night and thus uncomfortable for the cattle, risking of lower milk production; this is perhaps a consequence of these soils' higher reflectivity and reduced heat absorbance over the course of the day. This and the earlier point about stony soils are notable for the manner by which these communities vocalise the importance of comfort for the livestock over themselves.

Maasai settlements are rarely located close to dense vegetation cover, due to risks from dangerous wild animals and disease-carrying insects. However, a certain amount of nearby tree cover is desirable as a source of wood, both for the construction of houses, fences and firewood (Andersen 1977). Western and Dunne (1979:92-3) put the ideal figure at between two and eight per cent. Local tree species seem also to be taken into consideration, though not viewed as essential, with *Acacia mellifera* identified by the Maasai as useful for fencing due to its network of thorns, while the straight, sturdy branches of *Acacia tortillis* are preferred for house support poles. In areas where appropriate tree cover is scarce, as on the Athi Plains, northeast of Amboseli, groups like the Kaputei Maasai will transport house poles with them (ibid.). To reiterate, the findings of Western and Dunne's study pertain to a single Maasai population in southern Kenya, and there is clearly potential for variance in other groups, regions and time periods. However, in the absence of other studies, as an account of general expectations their work is invaluable.

3.2.4 Impacts of settlement: soils, vegetation and wildlife

Settlements are occupied for different periods and at different times depending on local environmental conditions and socio-cultural frameworks; the influence of the latter will be discussed later. In areas with particularly dramatic seasonal variability or lacking perennial water sources, such as Amboseli (Western & Dunne 1979), a site might be occupied for only part of the year. Under the bimodal rainfall regime of eastern Africa this might tend towards twice-yearly habitation. In other parts of the region, such as Ngorongoro in northern Tanzania, where higher altitudes and mountainous topography see higher rainfall than lowland areas, extended settlement is possible (Århem 1985). After a maximum of four years or so, however, issues of waterlogging and health problems linked to accumulated dung force movement to new, often neighbouring, locations (Århem 1985; Western & Dunne 1979). Indeed, it has been suggested that dung deposits can reach several metres deep prior to abandonment (Muchiru et al. 2009).

3.2.4.1 Soils

On abandonment, then, the major residue of occupation is a layer of dung overlying the mineral soil, with no plants remaining (Muchiru 2009), except for any shade trees deliberately conserved by the community (cf. Mbae 1990). Significant differences in soil carbon (C), phosphorus (P) and nitrogen (N), sodium (Na) and potassium (K) have been noted on the sites of old *bomas* – hereafter referred to as 'glades' – compared to surrounding areas, as a direct consequence of massive inputs of dung and urine (e.g. Stelfox 1986; Reid & Ellis 1995; Blackmore et al. 1990; Augustine 2003a; Muchiru et al. 2009; Veblen 2012). Frequently this takes the form of enrichment, which can register as high as >20 times that of natural levels (Augustine 2003a). Also noted are elevations in soil pH (Young et al. 1995; Augustine 2003a; Muchiru et al. 2009; Blackmore et al. 1990), organic C (Blackmore et al. 1990) and moisture retention (Reid & Ellis 1995). Low soil N and P, in particular, are known to limit grassland productivity in eastern Africa (Turner 1998a), yet within glades, where these elements are concentrated, biomass can exceed that of the surrounding area within five years of abandonment (Western & Dunne 1979); after twenty years, it can be double (Muchiru 2009). However, though nutrient enrichment might be applicable as a broad-brush term for alterations of soil chemical composition inside glades, there are regional inconsistencies. While elevated-P is frequently cited as evidence of enclosure deposits (David 1971; Augustine 2002) such a pattern is not universally observed; Young et al. (1995:102) describe a significant drop in P, as well as manganese (Mn) and magnesium (Mg), within glades in comparison to background levels. Notably, this study was conducted at the same area – Mpala Research Centre, in central Kenya – as that by Augustine (2003), in which glade-soil P concentrations were recorded to be more than double those of bushland soils.

3.2.4.2 Vegetation

The precise nature of plant re-colonisation at these sites can vary significantly, such that grass-dominated patches are not the only biological indicator of past boma locations. The reasons behind this variation are likely related to a combination of local ecology – i.e. the relative abundances of various species – and the herding strategies employed. Blackmore et al. (1990), for example, show that in southern Africa, groves of *Acacia tortillis* – identified by the Kenyan Maasai to be an important construction material (Western & Dunne 1979) – are frequently found atop soils enriched in Ca, Mg, K and P, and can be reliably associated with iron age settlements (Blackmore et al. 1990). By contrast, functionally similar sites in Botswana display distinctive patterns of *Cenchrus ciliaris* grass (Denbow 1979). In Turkana, in the north of Kenya, *A. tortillis* is again noted as a marker of past herder activity; circular patches are observed to grow within old goat/sheep corrals, yet were not recorded in old cattle enclosures, presumably a function of seeds imported in the digestive systems of browsers (Reid & Ellis 1995). It seems possible that the *A. tortillis* patterning seen in southern Africa shares this origin, though elevated soil nutrients are cited as facilitating the distinctive vegetation pattern observed there (cf. Blackmore et al. 1990). In central and southern Kenya, where much of the more recent research into the ecological correlates of pastoralism has been focussed (e.g. Porensky et al. 2013; Riginos et al. 2012; Augustine 2003a; Veblen & Young 2010; Young et al. 1995; Veblen 2013), less arid conditions favour grazing over browsing livestock. In these more productive landscapes, grasses are dominant on the sites of former corrals for the first 60 years after abandonment (Muchiru et al. 2009), with, for example, *Cynodon plechtostachyus* – a species otherwise effectively restricted to fertile alluvial areas (Edwards & Bogdan 1951) – widely reported as becoming rapidly established atop abandoned boma sites, which it dominates for several years (e.g. Augustine 2003b; Muchiru et al. 2009; Veblen 2012). Indeed, the strength of the association between this species and former corrals has earnt it the name 'manyatta grass' among the Maasai, who consider it a key forage species (Muchiru et al. 2009). *C. plechtostachyus* is often succeeded by *Pennisetum stramineum* after 20 years or so (Veblen 2012). Meanwhile, woody species such as *A. tortillis* establish themselves quickly but incrementally, and over the course of a century can reach numbers exceeding those beyond the human-affected area. It may be only once these initial coloniser trees begin to die, however, that vegetation begins to return to background levels (Muchiru et al. 2009). This pattern has been noted in areas of varying rainfall and soil type across eastern Africa (Veblen 2012; Muchiru et al. 2009; Treydte et al. 2006), although it is not ubiquitous; *A. tortillis* is not observed within glades in the Maasai Mara, southeastern Kenya, falling as it does beyond the limit of that species' ecological range (Muchiru et al. 2009).

3.2.4.3 Wild animals and glades

A large part of the persistence of glades in the savannah landscape can be attributed to the changes they effect on wild animal distributions and behaviour. The rich pasture available within glades attracts grazing ungulates, thereby perpetuating nutrient turnover (Augustine 2004). For medium-size wild grazers, like Grant's gazelle and impala, densities of dung observed within glades can reach ten times those outside (Young et al. 1995). These animals have been observed to preferentially forage *P. stramineum*, releasing *C. plechtostachyus* from competitive suppression (Veblen & Young 2010). In addition, small browsing species, like dik-dik, impala, and warthog, feed on tree shoots, suppressing certain species' recruitment (Augustine 2004; Treydte et al. 2006).

It is also thought that glades offer reduced risk from predators to all but the largest herbivores. In Riginos and Grace's (2008) study of wild herbivore foraging behaviour, six of the most common species (zebra, Grant's gazelle, hartebeest, giraffe, eland and steinbuck) exhibited strong preferences towards grazing within glades. Indeed, the authors note a positive correlation between vegetation density and body size; predation appears to be of less concern for elephants, which, in contrast to the much smaller Grant's gazelle, show no preference for areas with low tree and shrub coverage (Riginos & Grace 2008). In some cases, the desire for glade grasses among wild animal populations has moved beyond preference and become a requirement; phosphorus concentrations in non-glade grasses at locations in central Kenya have been shown to fall below the levels required by pregnant and lactating cattle (McDowell 1985) and impala (Augustine 2004), while these levels are exceeded within glades.

3.2.4.4 Edge effects

The ecological impacts of settlements extend beyond glade perimeters. At active Maasai homesteads, demand for construction materials and firewood, which themselves can vary in size from 50-100 m in diameter (Western & Dunne 1979; Mbae 1990; Muchiru et al. 2009) can have a visible impact over 200 metres beyond the settlement edge (Western & Dunne 1979; Muchiru et al. 2009). Wild animals help to preserve these peripheral impact zones, contributing to the role of glades as biodiversity 'hotspots'. Zebra, for instance, appear to favour the boundary between glade and background, the first 25 metres or so beyond the perimeter (Young et al. 1995). This mirrors the distribution of *P. stramineum*, which grows most readily in this area (ibid.). While *P. stramineum* is more competitive in terms of succession than *C. plechtostachyus* (Veblen 2008) and grows taller, such as can inhibit visibility at ground level, it may be less tolerant of grazing. (Riginos & Grace 2008). In this case, then, zebra contribute to the suppression of a species that, due to its height, provides a less hospitable environment for smaller grazers. By extension, this encourages the propogation of another grass species, *C. plechtostachyus*, that is favoured by other grazing animals, both wild and domestic (Veblen 2012).

The impacts these features exert on the ecological profile of the savannah are not limited to the c. 200 m 'impact zone'. The concept of the ecological 'edge' is similar to that of a biotone, the transitional zone between two adjacent patches of distinct land cover. These boundaries, and the flow of organisms and energy between them is central to the functioning of the heterogeneous savannah landscape (Cadenasso et al. 2003). Studies of the relative isolation of glades in a savannah environment – again conducted in Laikipia, partly at Mpala Research Centre (more of which later) – showed that tree densities were elevated where two glades were found less than 100 m apart, compared to areas surrounding isolated glades (defined as >250 m apart; Porensky 2011). This can perhaps be explained by a much reduced herbivore presence, as much as half, around isolated glades. It has also been suggested that this might be an effect of pruning, with trees harvested for firewood and construction materials experiencing accelerated growth. This pattern has been noted for *Acacia drepanolobium*, the dominant tree species across the arid uplands of eastern Africa, used extensively for such purposes (Okello et al. 2001). Moreover, the indirect legacy effects – the persistent influence of an ecological process after that process has ceased – of glade formation are not restricted to vegetation and large mammal distributions, but have also been observed to impact bird life (Morris et al. 2009) and arboreal fauna such as geckos (Donihue et al. 2013).

Moving still further into the landscape, to consider the regional-scale ecological impact of mobile herding and anthropogenic glades, it follows that if domestic herds are feeding in particular areas yet being corralled – and defecating – in others, there should be a long-range and long-term redistribution of soil nutrients around the savannah (Augustine 2003a). Studies into the effects of this are limited, but it has been suggested that grazing has a particular impact on distributions of nitrogen (N) and phosphorous (P), both closely linked to grassland productivity (Turner 1998a). It has been proposed that while N becomes highly concentrated within bomas during use, 70 percent is lost during the 18 months following abandonment. While some of this occurs via leaching, the majority is thought to be volatilised and redistributed through rainfall (Augustine 2003a). Augustine (2003:147) raises the concern, though, that the replacement of volatilised N in this way can be dependent on prevailing winds, whereby equable replacement is contingent on locally normalised precipitation. N is therefore rarely redistributed evenly. P, on the other hand, is better retained within glade sites, with persistent nutrient pools forming at some expense to the surrounding landscape. While this can have the effect of reducing rangeland productivity in a wider sense (Turner 1998a), the greater nutrient availability of glade 'hotspots' can be beneficial to both wild and domestic animals, creating systems of positive feedback centred on glade sites (Augustine & McNaughton 2003).

3.2.5 Summary

It is increasingly clear that herding makes an important contribution to the ecodynamics of savannah environments, and does so at a range of scales and trophic levels. These range from the immediate and tangible impact of dung accumulation and soil nutrient enrichment within *bomas* to subtler influences over the grazing habits of wild herbivores and vegetation mosaics across wide areas. Given the long history of African pastoralism, these mechanisms are likely to be deeply embedded – such as in the earlier example of pregnant impala – yet they are far from static. As changing economic, social and political conditions affect the lives of herders, so do these changes filter down to impact the ecological functioning of the savannah.

3.3 Herder settlements: demography, function and form

If herding and the settlements of its practitioners are accepted as exerting a demonstrable influence on landscape ecologies, and if we are to fully understand that dynamic, we must be careful not to assume that its effects are universal or that herding is a monolithic entity, either today or over its lengthy history in eastern Africa. The majority of research relating to such interactions, however, seems to assume that herder settlements and behaviours are indeed uniform, and focusses on livestock enclosures as the primary driver of glade formation (Augustine 2003a; Muchiru et al. 2009; Veblen 2012). Little attention has been given to more specific effects driven by other elements of settlements, or how the encultured practices of the people that live there shape local ecologies (but see Causey 2008; Weissbrod 2010).

The second part of this chapter looks at variability in the demography, function and spatial arrangement of pastoralist settlements, which can vary considerably according to cultural, political and economic conditions. What is more, patterns of landscape exploitation around these settlements do not adhere to constant, predictable rules, and, as I hope to have communicated in chapter two, pastoralist economies are sufficiently varied that observations made of the ethnographic present may have little relation to the archaeological past. This goes for ethnoarchaeology as well as for more traditional cultural ethnography. In examining the long-term history of herding and its contribution to savannah ecologies and in order to undertake meaningful archaeological investigations of settlements, there is a clear need to move beyond simplistic models of what constitutes 'normal' pastoralist behaviour, just as the first part of this chapter discussed the need to challenge simplistic perceptions of the 'pristine' versus the 'anthropogenic'. Thus, the following paragraphs describe the basic economies, settlement patterns and community dynamics of three pastoral groups active in eastern Africa today, groups who, as will become clear in later chapters, have a particular relevance to this dissertation: the Maasai, Samburu and Rendille.

3.3.1 Maasai

As discussed in the previous chapter, the Maasai are nominally a collection of semi-nomadic pastoralists, with an economy and ideology focussed on cattle. While sheep and goats are also kept, cattle function not only as a source of food (mainly milk rather than meat) but as the principal measure of wealth and medium of exchange. Social organisation is ostensibly heterarchic within a clan-based structure, though is effectively gerontocratic and patriarchal, with cattle controlled by elder men and maintained through the linear progression of the age-set system (Jacobs 1965; Galaty 1982; Bekure et al. 1991; Spear & Waller 1993). Smallstock are also kept, largely as an expendable supply of meat – cattle being much less readily given up for consumption – or as commodity for trade. Furthermore, with sheep and goat requiring less grazing and water, they are often vital during times of environmental stress or conflict, and can provide a foundation on which to rebuild diminished herds (Dahl & Hjort 1976; King et al. 1984; Ryan et al. 2000).

The basic Maasai settlement unit is the *enkang* (pl. *enkangiti*), the semi-permanent homestead. Up to 80 m in diameter, these can hold between 50 and 80 people (Jacobs 1965; Mbae 1990), though nineteenth century accounts suggest that these may have been considerably larger in the past (e.g. Thompson 1887). *Enkangiti* are arranged according to a spatial grammar structured by Maasai cosmology and expressing fluid notions of gender, kinship and privacy (Århem 1991; Hodgson 2000; Spencer 2003). Settlements are comprised of a broadly circular arrangement of houses surrounding a central area in which cattle are corralled overnight, with the whole site encircled by a fence made of *Acacia* branches. Smallstock enclosures are located next to the houses around the perimeter fence, while young animals are sometimes kept within the houses themselves. Houses are generally oval or oblong, average around six by three metres in plan, and are constructed from a wooden frame of saplings plastered with a mixture of mud and dung. A fireplace consisting of three stones arranged in a triangle is placed in the centre of the main room (Andersen 1977; Mbae 1990; Århem 1991). The area surrounding the hearth is kept clean by daily sweeping, and refuse dumped on the inside of the perimeter fence. This might include bone, potsherds, and hearth ash, and can form an arc along the fence-line as it accumulates. A second rubbish dump, containing the excess dung from the calf stall and live embers from the hearth is located outside the *enkang*, some three to five metres from the entrance (Mbae 1990). Houses are clustered according to family units, each unit with its own gateway into the homestead. Maasai are polygamous, and a man's first wife will build a house – women do the building (Hodgson 2000) – closest to the gate, the second wife on the opposite side, and subsequent wives alternately either side of those (Mbae 1990; Hodgson 2000). The number of houses within an *enkang* varies; Hodgson (2000:171) recorded an average of 3.8 houses per homestead in Emariete, Tanzania, in 1992 while Århem (1991:58) records upwards of eleven in 1984. Bekure et al. (1991) notes a similar decline in household size over recent decades. Wealthier households may keep up to 400 head of cattle, and 200 small stock, while poorer families may have 50-60 of each (ibid.). These may be split into sub-herds of up to 100 for daily grazing activities, the maximum considered controllable by a single herder (Dahl & Hjort 1976). Again, it is important to remember that early colonial records suggest that Maasai settlements used to be somewhat larger (e.g. Thompson 1887; Merker 1910), and present household and herd sizes observed more recently may not accurately reflect earlier patterns.

The Maasai occupy a vast area of eastern Africa, encompassing numerous ecological and

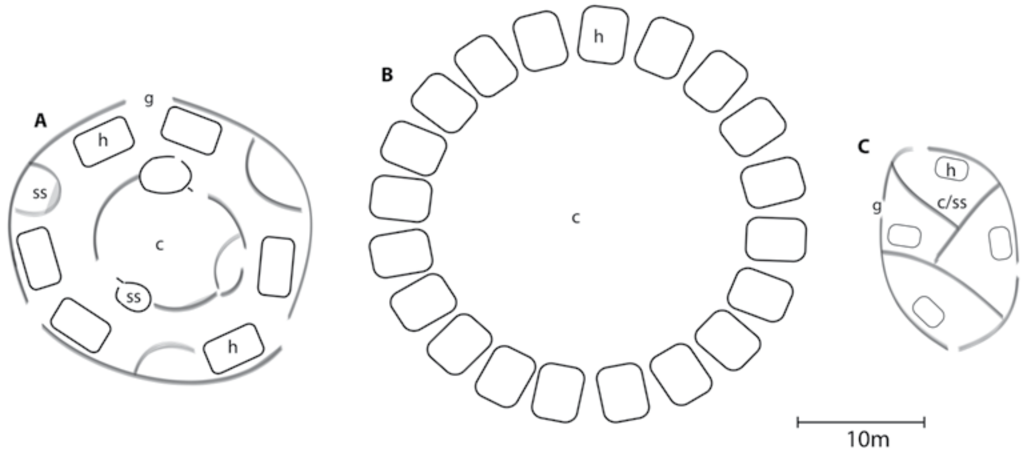


Figure 3.3. Maasai settlements: A: enkang, B: manyatta, C: seasonal camp. ss - smallstock enclosure, c - cattle, g - gateway, h - house. Based on sketches in Mbae 1990 and Arhem 1991.

climatic zones. Consequently, their settlement patterns are adapted to suit local conditions. Compared with pastoral groups in more arid or otherwise marginal environments (e.g. the Turkana; McCabe 1994; McCabe et al. 1999), the Maasai are relatively sedentary, though, as already mentioned, there is considerable variability across the multiple biomes of Maasailand. For example, in the relatively dry conditions of the Amboseli basin, settlement use is highly seasonal. The northern part provides extensive wet-season pastures, with settlements occupied for shorter periods and more dispersed to minimise competition, while the dry season sees greater aggregation in the southern part of the basin, with access to standing low-quality grazing in swamp and woodland areas (Western & Dunne 1979; Bekure 1991). A similar form of transhumance is employed by the Maasai of the Ngorongoro region of northern Tanzania, who move seasonally between the lowland plains and the volcanic highlands (Århem 1985). By contrast, the more hospitable conditions of the Loita-Mara region, west of the Rift Valley, host more permanent settlements; *enkangiti* are located close to perennial watercourses, and occupied all year round by women, children and elders, while temporary camps are established across the wider landscapes, which young men use to exploit more distant pastures as conditions dictate (Lamprey and Waller 1990). Grazing around the main enkang is often reserved for juvenile animals and pregnant heifers, an area known as *olopololi*. Herding duties within this reserved area are generally undertaken by young and experienced herding. *Olopololi* can be quite extensive, up to five kilometres radially from the settlement (Western & Dunne 1979:94), though this size is flexible depending on the conditions and season. Bekure et al. (1991:59-61) make the important observation that *ololopoli* can be managed cooperatively amongst a 'neighbourhood' of nearby settlements linked through kinship ties, and administrated by a council of elders.

The period a settlement is occupied also varies regionally, and can be anything from two to twenty years (Western & Dunne 1979; Århem 1985; Bekure et al. 1991; Shahack-Gross et al. 2003). Sites are generally abandoned due to the accumulation of dung and its associated health risks. This frequently leads to a new *boma* (enclosure) being established adjacent to the existing one (Mbae 1990). However, if there is insufficient space or excessive disease concerns, a new location might be sought. It has been observed that dung within abandoned settlements is burned to reduce the possibility of disease transmission (e.g. Western & Dunne 1979; Mbae 1990), though this is not a universal activity (e.g. Shahack-Gross et al. 2003). Western and Dunne (1979:95) have suggested that reoccupation of previously-used locations occurs on a 20- to 25-year cycle. Settlements tend to be located towards the top of gentle slopes, in areas with good drainage and away from densely wooded areas, as a measure against tsetse fly and wild animals (ibid.).

While herding strategies are generally centered on *enkangiti* as central nodes for wider landscape exploitation, temporary camps are used to take advantage of remote pastures. Located up to 35 km from the primary homestead, these camps might be sited so as to exploit fresh grazing during the wet season, sparing pastures closer to the *enkang*, or as dry season refuges. They could therefore be located in low-lying plains or highland areas, respectively (Mbae 1990). Camps are often comprised of herds and herders from various homesteads, perhaps linked by distant kinship ties, and are much smaller, of lighter construction and with multiple smaller stock pens rather than the large communal byres associated with *enkangiti* (Mbae, 1990). The extent to which seasonal camps are used varies across Maasai territory; in areas with more extreme variation in pasture availability regular seasonal transhumance might be practiced; for example, this pattern is noted for the Kisongo Maasai of Amboseli (Western, 1973). In areas like the Maasai Mara, with less resource-stress, *enkangiti* are occupied year-round (Lamprey & Reid 2004; Coast 2002), and the use of these outposts might be restricted to periods of extreme drought.

A third type of settlement is the *manyatta,* constructed at particular locations as foci for the *il-moran*, the young, male warrior age-set. Though they nominally live in these villages, the *il-moran* are effectively itinerant and move across large territories, such that the *manyatta* are frequently deserted (Spencer, 2003). The most important role of the *manyatta* is as the focal point for the elaborate ceremonies marking the graduation of *il-moran* into elderhood. Age-set designations are common across wide regions and ceremonies which draw people from across these territories for a period of feasting and initiation rites. The spatial arrangement of the *manyatta* reflects this; houses are again located around the perimeter and, though evenly spaced, the circle is divided into the clan groups and moieties that characterise Maasai social order (Århem 1991). Cattle are kept in a single central enclosure, which is also the focal point of ceremonies, while small stock are kept beyond the perimeter. *Manyatta* sites are often re-used, though the interval between age-set graduations can be as much as seven years (Spencer 2003). Among the most important functions of the age-set system is the fostering and institutionalisation of ties of kinship and inter-dependence, crucial to being able live in marginal environments. For instance, complex systems of gift-giving and 'risk-pooling' (Aktipis et al. 2011) allow livestock to be redistributed and herds to be rebuilt where certain members of an age-set or kinship group lose animals to drought, disease or raiding.

A final notable form of Maasai site from an ethnoarchaeological perspective is the *ol-pul* (pl. *il-puli*) meat-feasting location. These sites are established up to a kilometre from the main homestead and used for the preparation and consumption of meat; barring the heads of animals which are sometimes taken to the *enkang* to be boiled for broth, all meat consumption takes place at these outlying locations. *Il-puli* are comprised of a central hearth and pile of firewood, around which people sit in a semi-circle. Bones accumulate where they are dropped, with larger pieces broken to access marrow. A sleeping area might be located a few metres from the hearth, where young men remain to guard the meat against wild animals (Mbae 1990).

3.3.2 Samburu

Similarities between the Maasai and their fellow Maa-speakers, the Samburu, extends beyond the linguistics; the two groups share a socio-political structure based around age-set succession and gerontocracy, an economic and cultural focus on cattle and a vocal, if flexible, disdain for hunting and farming (Spencer 1965). However, elements of settlement choices and herding strategies do differ and are worth explicating.

The Samburu occupy an area of around 11,000 square miles between the southeastern shores of Lake Turkana and the Ewaso N'giro river, just north of Isiolo. Neighbouring groups include their closest allies, the Rendille, to the north (and interspersed), Boran to the east, and Turkana and Pokot to the northwest and west, with whom they have a much more hostile relationship (McCabe 2004; Straight 2009). As with the Maasai, Samburu homesteads – also *nkang* – are comprised of 4-10 polygamous households, each of an average of seven people. Fifteen houses might be considered a large settlement, with six or seven being more common (Spencer 1973). These households are essentially independent, and individual elders are able to leave following a season of inhabitation, so as to join other villages within their clan group, which can be widely dispersed.

Settlements are generally 30-40 metres in diameter, though can be larger or smaller depending on social or ecological conditions; Spencer's (1965) classic ethnography of the Samburu notes how in times of environmental stress, when pasture is limited, settlements are likely to be smaller and more dispersed, while periods of abundance might see larger and lengthier aggregations. Smaller settlements are considered economically advantageous; cattle are unable to graze as widely as camels, for example (see section on Rendille, below), such that available grazing around the settlement can become denuded and relocation required. This is logistically easier for smaller communities, for obvious reasons. Furthermore, cattle become more difficult to manage in larger numbers.

Each settlement contains an average of around 80 cattle, though this can be as low as 40 or as high as 150. In contrast to the Maasai, Samburu enclose cattle in a 'yard', known as *mboo*, around the thornbrush perimeter fence of the *enkang*, with small stock – often around 100 head – kept in the centre. As with the Maasai, cattle are afforded far greater importance and prestige than smallstock, though this likely underrates the economic role of the latter as a source of meat and trade goods, as well as an important reserve in times of strife. House construction techniques vary; in the arid lowlands where greater mobility is required, houses are constructed using a frame of flexible wooden poles covered with mats or hides (or tarpaulin, today). In highland areas, houses more closely resemble those of the Maasai, with a wooden frame covered in mud and dung (Grillo 2012). There has not been an ethnoarchaeological study made of Samburu activity areas and refuse patterns as to avail comparison with Mbae's (1990) account for the Maasai, and so the finer dynamics of this are not available (but see Grillo 2012 on Samburu material culture).

Rainfall in Samburu territory is less predictable than that of the more southerly areas occupied by the Maasai, and this is reflected in settlement patterns and mobility. Seasonal or otherwise outlying camps are a feature of Samburu herd management, with young men able to endure considerable hardship, bringing the surplus herd – those animals not required for subsistence (ie. milk) provision at the *nkang* – to richer but more distant pastures. These camps generally lack house structures, with *lmurran* (the young male equivalent of the Maasai *il-moran*) choosing to sleep in the open and be ready for frequent movement. Grillo (2012:73) emphasises how the *lmurran* can spend the entire year in these camps, in contrast to their Maasai counterparts who congregate in the *manyatta* in large militaristic forces. Indeed, the Samburu area would perhaps be unlikely to support the kinds of dense populations associated with these warrior villages (Spencer 1965:xxvi). In

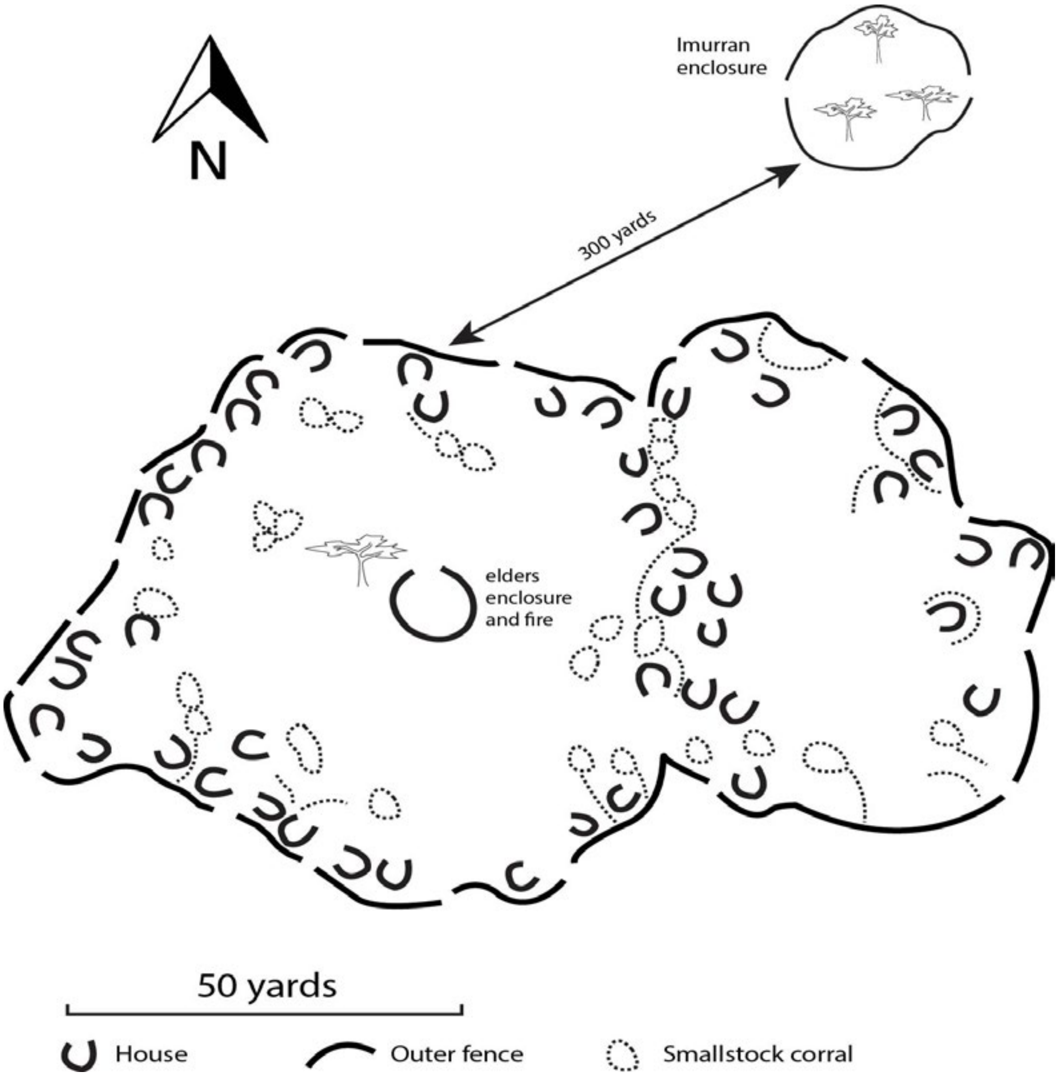


Figure 3.4. Samburu lorora, redrawn from Spencer 1965:92

his comparative ethnography, Spencer (1973:22) speculates that the relationship between Samburu settlements and outlying camps, used to negotiate the most difficult periods of the dry season with less emphasis on the separation of the elder-dominated settlement from the young male herders, is less formalised than that enacted by the Rendille and, arguably, the Maasai. Camps are often fairly close to the *nkang* and are often visited by the herd-owning elders to reinforce the link with the main community.

The Samburu do celebrate circumcisions and age-set graduations by way of regional gatherings, however, and these take place at specially-constructed sites known as *lorora* (Figure 3.4). These are structured differently from the *manyatta* where the Maasai *eunoto* ceremonies take place. Each family with a son taking part builds a house, clustered together by clan group, with an adjacent calf enclosure shared by four or five families, with cattle kept nearby. A great number of cattle are slaughtered and consumed within the *lorora* during these events. More usually meat is consumed at peripheral feasting sites comparable to the Maasai *ol-pul*. Following the ceremonies, some *lorora* are burned, while others are left to decay naturally (Spencer 1965; Grillo 2012).

3.3.3 Rendille

The Rendille are Eastern Cushitic-speaking pastoralists who occupy an area to the north of that held by the Samburu, between Lake Turkana and Mt Marsabit. The northeast of the region is generally below 1000 m.a.s.l. and very arid, and the Rendille therefore rely more heavily on camels and smallstock than cattle (Spencer 1973). Relations with the Samburu are generally positive, in part due to the lack of competition resulting from divergent stock choices. The two groups live in very close proximity in the slightly higher and more temperate southern part of Rendille territory, where a bridge culture has emerged: the cattle- and camel-keeping Ariaal. Both the Rendille and Ariaal share traditions like age-set succession and segmentary, clan-based descent with the Samburu (Fratkin 1991; Sun 2005), though linguistically they are most closely related to the Somali (Schlee 2014). According to Schlee (1985; 2014; contra Kassam 2006), and along with the Gabbra, Garre, Sakuye and at least part of the Somali, prior to around AD 1500 the Rendille were part of the Proto-Rendille-Somali (PRS) complex of camel-keepers with a common Somaloid language and a shared ritual calendar.

Camels have a similar role in Rendille society as do cattle for their Samburu neighbours. However, the herds are generally considerably smaller, with an average of 1.4 camels per capita (Roth & Fratkin 1991). While the greater milk yield of camels – up to a multiple of four – may preclude the need for ever more animals, camels also have a longer gestation period and seemingly a higher rate of disease, such that herd sizes increase very slowly (Spencer 1973:11-13). Susceptibility to disease may be another reason why the Rendille do not compete with the Samburu for the richer, highland pastures; the thick bush found in these areas harbours sleeping sickness-carrying tsetse fly, to which camels have a particularly low resistance. Camels are therefore maintained for milk and as transport animals. Small stock, which have much shorter pregnancies and can be more readily replaced, provide a source of meat, and are kept in relatively high numbers, up to 10 per capita (Roth & Fratkin 1991).

As with the groups already discussed, the Rendille operate a system whereby a main settlement, known as the *goob*, is linked to outlying herding camps, *forr*. Camels can travel significantly further and for longer without water than cattle and small stock, up to three months during the wet season if fed on green pasture (Dahl & Hjort 1976), so potential grazing territories are greatly expanded, and camps can be located up to 200 km from the *goob* (Sato 1984). In fact, while cattle herding is generally planned around the capacity of the livestock, the effective grazing area of camels is limited by the requirements and capacities of the herders (Spencer 1973) In contrast to the elliptical grazing patterns of cattle, camel grazing strategies might be conceived as forming a series of circular areas around the camps, which are moved continuously with the herds (Dahl & Hjort 1976; Spencer 1965).

The main settlements are much larger than those of the Maasai and Samburu (Figure 3.5). Though sometimes dispersing to smaller units during the driest months, these can contain as many as 100 houses and measured over two hundred metres across. Spencer (1973:20) speculates that the decision to aggregate on such a scale could be defensive, which echoes McCabe's (2004) ideas on the social ecology of pastoralism, and might be expected given the hostility between the Rendille and neighbouring groups like the Turkana and Boran

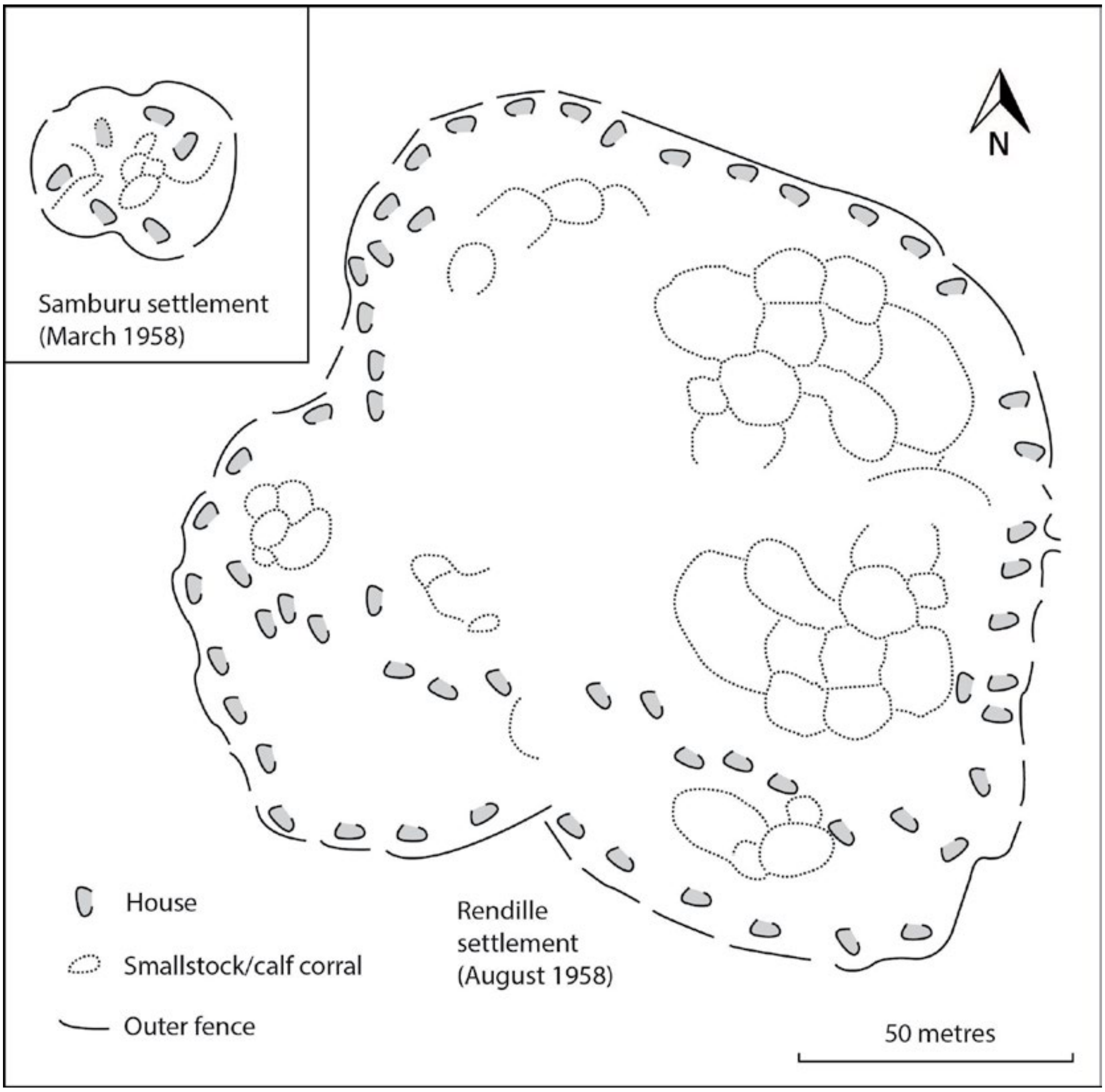


Figure 3.5. Comparative sketch of Rendille and Samburu Settlement, redrawn from Spencer 1973:21. Note the double line of houses along the southern side, added by later arrivals.

(Schlee 2014). It could equally be due to camels being more docile in large numbers. A persuasive alternative, though, is that the strength of consensus opinion made possible by large gatherings aids community cohesion in an essentially heterarchical society. Given the greater inter-dependence within Rendille society, necessitated by the harsh environment, these large settlements may help forge the close and wide ranging bonds that facilitate it. The above plan of a settlement evidences the flexibility and inclusivity of Rendille society, showing a second ring of houses along its southern edge that were created later when a second group joined and was incorporated into the community (Spencer 1973:21). As with the Maasai and Samburu, each male stock owner has their own gateway and each married woman her own house. Unlike the polygamous Maa-speakers, however, the Rendille are essentially monogamous and there should ideally be an equal number of gateways and houses. These encircle groups of livestock enclosures, mainly for the small stock that remain at the *goob* while the camel herd spends most of the year at the outlying *forr* camps. At the centre of the *goob* is the *naabo*, a fenced off area in which elder men congregate to discuss issues and make decisions affecting the life of the community, around which the rest of the settlement is constructed (Sato 1984; Segal-Klein 2016). Rendille houses are lighter constructions than those of the Maasai and Samburu; larger buildings employ two parallel semi-circular frames with subordinate ribs attached to form the main dome-like structure, while a single frame is used in building smaller houses. The roof is traditionally sealed using woven plant-fibre matting (see description and illustrations in Schlee 1985:178-9).

Sun (2005) notes that outlying camps differ in their layout and social composition depending on whether they hold cattle or camels. Firstly, cattle camps tend to be open, with little emphasis on fencing other than by way of small enclosures for young animals, as adult cattle are said to graze at night and return to the camp – and their offspring – independently. Camels do not do this and therefore require the construction of a substantial perimeter fence, built using acacia branches and up to two metres high. Second, while cattle camps are subdivided with further fencing, in order to accommodate herds belonging to different clan-groups, camel camps are comprised of members of a single clan or sub-clan and are thus open internally, though again young animals are corralled within a further internal pen. A final point of interest is that Rendille congregate in larger groups during the rainy season, during which time larger, multi-clan cattle camps are more common. Smaller, single-clan constructions prevalent during the dry season, perhaps due to the reduced availability of milk to sustain human populations.

Schwartz (1979:165) draws an interesting link between camel herd size and settlement location. Based on the notion that camels were vital for water transportation and therefore

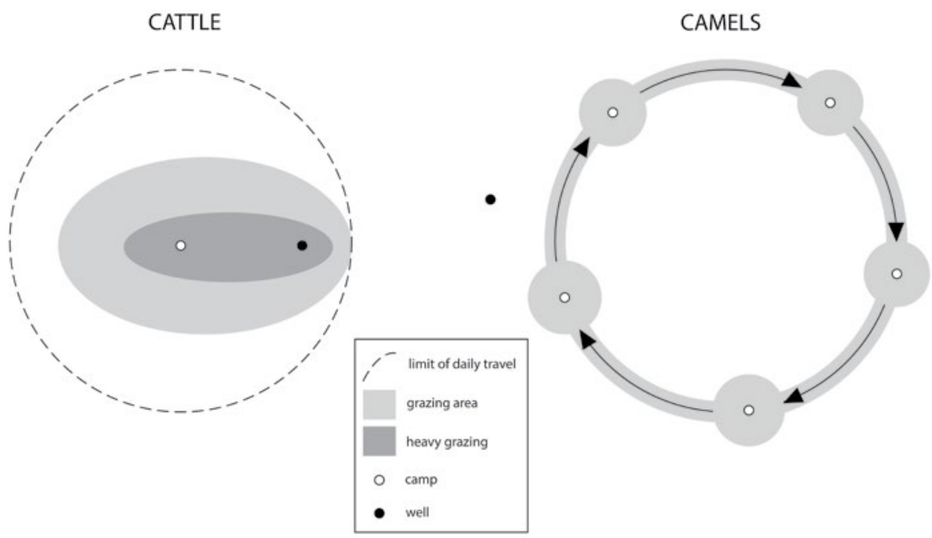


Figure 3.6. Comparison of grazing/settlement patterns between cattle and camel herders: oval daily orbit versus series of short-term camps, based on descriptions in Spencer 1973

a prime determinant of Rendille settlement patterns, he hypothesised and found that settlements with fewer camels would be situated closer to water sources; of a sample of 31 settlements, all with less than three camels per household were found to be located within 2.5 kilometres of a water source, while half of those with more than six camels located more than eight kilometres away.

3.3.4 Summary

Today, the three groups considered above share a combination of language (Maasai and Samburu), territory (Samburu and Rendille) and cultural practices such as age-set organisation (all three). Furthermore, while the Rendille focus on camels sets them apart, the two Maa-speaking groups practice very similar forms of cattle-oriented pastoralism. Indeed, the distinction between Maasai and Samburu is one that might only be said to exist because the members of those communities continue to redefine and perpetuate it. That said, Samburu do think of themselves as Iloikop, and thus closely related to the Maasai. There are, however, subtle differences in how these two groups choose to construct and administrate their settlements that may be important to the self-definition of community identity, and reflect socio-political circumstances. For instance, the Samburu preference for keeping cattle in the 'yard' around the inside of the perimeter could indicate less of a concern with security against raiding than that of the Maasai, whose ring of houses acts as a second line of defence around the central corral. Other elements of site structure and function are linked to practical economic concerns driven by ecology and the herd management practices required to negotiate specific local conditions; the problem remains how such cultural and ecological drivers can be inferred from the apparently-meagre physical traces that these settlements and patterns of landscape-use leave behind.

3.4 Ethnoarchaeological Approaches to Pastoralist Sites

The ways in which the spatial structure of settlements can be reflective of socio-cultural, political and ritual conditions, have been most extensively-documented with respect to contemporary agricultural (Robin 2006; Artursson et al. 2010) and, in particular, hunter-gatherer communities (e.g. Yellen 1977; Gifford & Behrensmeyer 1977; Binford 1978; Kent 1987; Simms 1988; Fisher & Strickland 1989; Gamble & Boismier 1991). The latter, in common with pastoralists, are frequently mobile, and their sites are observed to share certain traits and features with those of stock-keeping communities (Cribb 1991; Banning & Kohler-Rollefson 1992). For instance, building materials and construction techniques are likely to be rather less substantial than in contexts where durability is of greater concern and energy more willingly expended on site construction (Kent 1992). A similar correlation links the amount of material culture associated with a settlement and the length of its occupation; pottery in particular has been more closely associated with agricultural groups than with mobile herders or hunters (see discussion in Eerkens 2008), encapsulated in Sahlins' (1972:11) notion that accumulated material culture can somehow be 'oppressive' to these groups, limiting the mobility so relied-upon. Consequently, there has been resignation to the idea that mobile communities can be difficult to trace archaeologically (Gifford 1978; Robertshaw 1978; see also David 1971; but see MacDonald 1999; Sadr 2008), pessimism that can be traced back to Childe's (1936:81) concession that, "pastoralists are not likely to leave many vestiges of their presence…tents need not even leave deep post-holes where they once stood". Unfortunately, this has meant that many of the questions raised by ethnographic studies, relating to how the spatial structuring of settlements and camps both reflects and reinforces the aforementioned socio-cultural and political conditions of life in pastoralist communities, have been left unanswered.

More recently, however, there has been a reappraisal of how ethnoarchaeology can inform on some of these issues. Since Chang and Koster's (Chang & Koster 1986) influential call for an archaeology of pastoralism that looks 'beyond bones', there have been concerted efforts to re-evaluate the place of material culture in herder society, to better understand the decisions behind settlement foundation, and to recognise the finer-grained impacts and residues of pastoralist presence in the landscape as a means of identifying and defining sites. To consider some examples from eastern Africa, Grillo (2012) argues that rather than being simply a hindrance to Samburu mobility, ceramic technologies facilitate the exploitation of certain resources such that marginal environments can be negotiated; in effect, pottery *enables* mobility. By a similar token, Dietler and Herbich (1994) have documented how micro-variability in ceramic style among Kenyan Luo communities reflect networks of personal interaction between potters, arguing that pots are crucial to the negotiation and articulation of cultural identity (see also Larick 1986 on Samburu spear points and Hodder 1982 on personal adornment among the Il-Chamus). The same authors (Herbich & Dietler 2007) offer a persuasive argument for the organisation of pastoralist settlements being just as embedded in cultural conditions as either farmers or hunters, a point implicit in countless descriptions of herder villages where the houses of various community members – the wives of the patriarch, for example – are arranged according to encultured notions of seniority (e.g. Evans-Pritchard 1940; Spencer 1973; Mbae 1990).

As well as how houses are arranged in relation to other buildings and gateways, pastoralist settlement ethnoarchaeologies are most frequently concerned with the position of corrals. Yellen (1984) has argued that the relative position of enclosures to the houses among Dobe !Kung hunter-gatherers in southern Africa is indicative of their commitment to pastoralism; the Dobe acquired goats for the first time in the late 1960s, at which point corrals were located outside of the main camp-circle, yet by the time significant herds of both goats and cattle had been accumulated in the 1980s, enclosures were positioned much more centrally. While the positioning of corrals in the middle of settlements has clear practical advantages, in terms of protecting stock from raiding and predation, many have argued that such positioning also reflects the importance of livestock – particularly cattle – in African pastoralist worldviews. One such theoretical construction is the Central Cattle Pattern (CCP), developed by Kuper (1980) to explain the settlement organisation of Bantu villages in southern Africa, and subsequently applied by Huffman (1982; 1993; 2001) in the interpretation of Iron Age sites. While the concept has been useful as an illustration of the symbolism embedded in settlement patterns, it has been heavily critiqued for not taking into account the range of similar patterns observed among non-Bantu societies across Africa, exaggerating the relevance of a single idealised and rigid model of how these patterns are understood (e.g. Lane 1994; Badenhorst 2009). However, and while conceptualisations of space are clearly open to negotiation and reformation by individuals (Moore 1986), from an archaeological perspective it has proven very difficult to investigate even the kinds of relatively simplistic spatial questions raised by the CCP, due in large part to the issues of preservation mentioned earlier.

3.4.1 Geo-ethnoarchaeology and enduring indicators

A series of papers by Shahack-Gross and colleagues (Shahack-Gross et al. 2003; Shahack-Gross et al. 2004; Shahack-Gross et al. 2008; Shahack-Gross 2011) sought to define the taphonomic sequences and potential enduring residues of the individual elements of pastoralist settlements; specifically, the study took inspiration from the idea of persistent anthropogenic savannah glades and aimed to delineate intra-glade distributions of anthropogenic settlements. Abandoned Maasai villages of known age in southern Kenya were mapped with the help of former inhabitants, with special reference to house locations, corrals, refuse areas and gateways. These were then sampled for mineralogical and micromorphological analyses. The study considered villages that had been abandoned between one and forty years previously, and focussed initially on how to unequivocally identify corrals in the archaeological record. This was encouraged in part by the idea that the presence of livestock enclosures at a settlement is the only reliable indicator of pastoralist production (Chang & Koster 1986), differentiating communities actively engaged in husbandry from hunter-gatherer or agricultural economies able to obtain animal products through exchange relationships with herders. Such a distinction is impossible to uphold based on the presence or absence of domesticate faunal remains. As described in chapter two, the origins and development of food production in eastern Africa over the last four thousand years, particularly in arid environments not suited to cultivation, are defined by interactions between autochthonous hunter-gatherers and incoming stock-keepers and a fluidity of socio-economic identity; it is therefore imperative that such distinctions be made if we are to grasp the historical dynamics of this development.

As discussed earlier with regard to anthropogenic glade formation, and though ethnographic records suggest that other refuse is sometimes found within corrals, often linked to ritualised disposal (e.g. Mbae 1990), dung is the major accumulating deposit. However, being composed mainly of organic matter, dung degrades rapidly and is often not easily or firmly identifiable several years after deposition. Though in African savannah environments dung can be visible in, for instance, aerial photographs for some 15-years following abandonment, appearing as darker organic-stained patches of soil (e.g. Gifford 1978; Lamprey and Reid 1990; see also Robbins 1973; Cribb 1991; Banning and Kohler-Rollefson 1992) post-depositional processes of chemical decomposition and bioturbation usually leave little trace at archaeological timescales. There are some exceptions to this, such as in Botswana, where dung can become vitrified due to natural super-heating by lightning strikes or bush fires (Thy et al. 1995) or by deliberate burning by humans (Huffman et al. 2013). Strangely, while similar deposits have been observed in southern India (Johansen 2004), the phenomenon has not been documented elsewhere in Africa, although the burning of dung is commonly recorded ethnographically (e.g. Evans-Pritchard 1940; Western & Dunne 1979; Mbae 1990). Though relatively rare in the archaeological record, desiccated (di Lernia 2001), waterlogged (Rasmussen 1993) or temperate environments with consistent soil moisture levels (Macphail et al. 2004), might preserve the form of individual faecal pellets. Indeed, dung can be reliably recognised in conditions amenable to the preservation of organic residues via analyses of lipid biomarkers (Evershed et al. 1997) or faecal parasites (Schelvis 1992) provide reliable potential indicators. In Africa, and other semi-arid, open-air environments (e.g. Lancelotti & Madella 2012), however, durable, inorganic markers must be sought.

3.4.1.1 Soil micromorphology

Soil micromorphology is one such avenue. It has been observed that the trampling of dung within corrals and stables causes the horizontal alignment of organic fibres (Macphail et al. 1997; Macphail et al. 2004), though again, without organic preservation this is difficult to identify in thin section. Shahack-Gross et al. (2003; 2004) proposed that while organic matter had all but disappeared in the oldest samples, dung could be partially identified by a texture notably finer than regional sediments due to the concentration of biogenic minerals found in dung (Brochier et al. 1992). However, an undulating microlaminated structure, caused by the residual alignment of opal phytoliths after organic fibres have degraded (see also Wattez et al. 1990; Albert et al. 2008) and visible in thin section, was thought to be a better indicator. Shahack-Gross et al. (2003; 2004) observed such a structure in the oldest enclosure sediments tested (c. 40 years old), by which point organic matter associated with habitation had long-since degraded. It is worth noting, though, that a subsequent study showed that where livestock diet is dominated by dicotyledonous plants, more likely as part of a browse-rich diet as might be consumed by caprines, such laminations may not be visible due to the plants fibres being much poorer in phytoliths (Shahack-Gross & Finkelstein 2008). It was hoped that similar evidence of compaction or trampling might be found within areas identified as former houses, as one might expect for a floor surface, though none could be discerned. A possible explanation might be in the difference in weights between cattle and humans (c. 200 kg vs. 60-70 kg; Shahack-Gross et al. 2004:1408), which seems to be supported by the lack of microlaminations observed in caprine enclosure sediments.

3.4.1.2 Spherulites

A second micromorphological marker of enclosure deposits at abandoned Maasai villages was the presence of densely-concentrated faecal spheulites. These calcium carbonate minerals form in the guts of herbivores (Brochier et al. 1992; Canti 1997; Canti 1999), and though very small, 5-15 μm in diameter, are easily identified in thin section by a 'pseuso-uniaxial extinction cross' related to an anisotropic mineral composition (see discussion in Canti 1997). High densities of spherulites have been observed in archaeological contexts across the world (various references in Canti 1999) and while previously thought to have been most common in caprine dung (Brochier et al. 1992), their presence has since been observed in the dung of cattle and other ruminants, as well as carnivores in very low concentrations (Canti 1999). It has, however, been established that spherulite formation is ultimately dependent on the grazing conditions to which an individual animal is subjected; a positive correlation has been noted with soil pH, both in terms of that on which an animal was originally feeding and that onto which dung is deposited. pH below 6.0 is considered the lower limit for spherulite production or preservation, while soils above pH 7.7 host considerably higher concentrations (ibid.). However, the details of formation and preservation have yet to be fully understood and inconsistencies have been recognised, wherein dung from animals subject to ostensibly identical grazing conditions can contain zero *and* high spherulite counts, with some authors arguing that an absence of spherulites cannot be considered evidence for the absence of dung (Lancelotti & Madella 2012). Furthermore, there is currently no basis on which to differentiate species (but see Cogdale 2015) and thus whether the presence of spherulites can be attributed to domestic or wild herbivores, clearly a concern with respect to the wildlife-rich savannahs of eastern Africa. Relative density, however, remains relevant, and the kind of concentrations observed by Shahack-Gross et al. (2003; 2004) in all enclosure deposits compared to samples both from other areas of the homesteads and regional controls, points to the usefulness of spherulite analysis in combination with additional proxies for recognising degraded dung.

3.4.1.3 Phytoliths

Shahack-Gross et al. (2003; 2004) take a similar approach to the possibility of differentiating activity areas within pastoralist settlements based on phytolith concentrations, reasoning that dung-rich sediments will yield significantly greater phytolith counts due to the degradation of organic matter. Subsequent papers proposed that a metre-thick layer of dung, not unusual within livestock pens, would degrade to leave a 2-3 cm layer of phytoliths, albeit in the context of an Iron Age monumental structure in Israel at depths beyond the reach of most intensive bioturbation and root action (Shahack-Gross et al. 2005; Albert et al. 2008). Concentrations in Maasai villages of all ages were shown to be highest within enclosures, where up to 20 million phytoliths were identified per gram of sediment tested, compared to a maximum of four million in regional control samples. Though somewhat less reliably, refuse pits and hearths also showed elevated phytolith densities, as, interestingly, did gateways; evidence of phytolith elevation in sediments taken from a gap in the perimeter fence of the 30-year study site were thought to be due to the twice-daily passage of livestock in and out of the settlement (Shahack-Gross *et al* 2004:1405). While the identification and recording of domestic areas and animal enclosures have long been major concerns in archaeologies of mobile settlements, the significance of the relative locations of these secondary features is now recognised (Robertshaw 1978; Fisher & Strickland 1989; Mbae 1990; Kent 1992). Phytoliths are composed of opal, which is stable in pH levels between 5 and 9 (Karkanas et al. 2000), and therefore likely to preserve for considerable periods in the alkaline soils of eastern Africa. Equally, that only a single sample could be linked to a gateway, and that only possible because the exact location of the gap in the fence was known, suggests that the methodology needs further refinement before it can be useful in identifying ephemeral features across archaeological timescales.

3.4.1.4 Mineralogy and geochemistry

The use of bulk phosphate analysis to identify enclosure deposits is long-established (Provan 1971; Conway 1983), yet it fails to differentiate between types of anthropogenic deposits. The decomposition of organic-rich dung deposits instigates the formation of authigenic minerals – formed *in situ* – the most common of which are calcium-phosphates (Brochier et al. 1992; Karkanas et al. 2000; Macphail et al. 2004; Shahack-Gross 2011). While soil phosphates are frequently derived from animal urine and faeces, plant ash and the decomposition of bone animal tissue, such as would be expected for domestic waste and the types of refuse associated food preparation areas, can cause similar elevations (e.g. Terry et al. 2004). Therefore, if phosphates are to be useful in addressing the kinds of questions required for the understanding of intra-site organisation, greater precision and, as ever, multi-proxy approaches are required. One technique advocated by Shahack-Gross et al. (2003) is the use of Fourier-Transform Infra-Red spectroscopy (FTIR) supported by X-Ray Diffraction (XRD), for the identification of mineral spectra associated with the residues of particular activities. Their study found that the rare mineral monohydrocalcite ($CaCO_3 . H_2O$), an unstable form of calcium carbonate ($CaCO_3$), was present and persistent in enclosure deposits, particularly those that held smallstock. Due to this bias towards caprine enclosures, as well as chemical similarities (i.e. $CaCO_3$), tentative links might be drawn with faecal spherulites, the implication being that the latter may be composed of monohydrocalcite (Shahack-Gross et al. 2003:454). Importantly, the authors observe that no monohydrocalcite was recorded in the 30-year old sites close to the river, yet was present in a 40-year-old settlement in an elevated position; they conclude that preservation may therefore require drier conditions, something also noted for spherulites. Unfortunately, FTIR requires specialist equipment and well-resourced reference collection for reliable mineral identifications, and therefore maybe beyond the scope of many archaeological projects where out-sourcing is not possible. However, this potential correlation between spherulites and monohydrocalcite may negate the need for FTIR in the context of pastoralist archaeology, the former being considerably easier to identify.

Table 3.1. Features identifiable using various analyses, after Shahack-Gross et al. *(2004:1048)*

Analysis	Corral	House	Hearth	Gate	Refuse	Fence
Micromorphology	✓		✓		✓	
Mineralogy	✓		✓		✓	
Phytolith density	✓			✓	✓	

3.4.2 Archaeological Applications

As outlined above, the geo-ethnoarchaeological study undertaken in southern Kenya defined a range of indicators for enclosure deposits which represent possible means by which to recognise degraded dung deposits, when used in combination. Importantly, the authors (Shahack-Gross et al. 2003:457) were able to support the claim made by Karkanas et al. (2000:926) with respect to cave-site deposits, that the majority of diagenesis of dung takes place soon after deposition and burial, but that following the complete degradation of organic material, residues become much more stable. For open-air sites such as those studied in southern Kenya, organic matter was seen to be negligible some thirty years after abandonment, from which it is hypothesised that signatures still visible after such time could be expected to endure across much longer timescales.

However, the approach has yet to be sufficiently tested in archaeological contexts,

Table 3.2. Analytical markers for various features of pastoralist settlement using techniques advocated by Shahack-Gross et al. *(2004)*

Analysis	Indicator	Cause	Implied feature
Micromorphology	Microlaminated soil Calcium crystals Spherulites	Trampled dung Ash Dung	Corral Hearth, corral, dump Corral
Mineralogy	Monohydrocalcite Calcite	Dung Ash	Corral (esp. smallstock) Hearth, corral, dump
Phytoliths	High density	Dung	Corral, gateway

particularly in the African setting for which it was designed. It was successfully applied in the Negev Highlands, southern Israel, where microlaminated phytolith layers were observed in conjunction with dung spherulites and phosphate nodules within contexts relating to first-millennium BC pastoralist communities (Shahack-Gross & Finkelstein 2008), confirming that under certain conditions – high aridity, in this case – the proposed indicators remain valid for several millennia. A further test of the methodology was undertaken at the site of Sugenya (Shahack-Gross et al. 2008), an Elmenteitan/Pastoral Neolithic site in southwest Kenya, again dating to the early first millennium BC (Simons 2004). As well as the known micromorphological and mineralogical markers, this study also looked at the potential of stable carbon and nitrogen isotope analyses for delineating dung-rich sediments. While the potential elevation of ^{15}N ratios in midden deposits, for example, had already been established (e.g. Commisso & Nelson 2006), based on the comparison of known-age enclosure sediments with archaeological samples that fulfilled other criteria for dung deposits, the Sugenya study showed that nitrogen enrichment could be used as an additional indicator of degraded dung. Interestingly, while carbon isotopes in isolation could not be used to identify enclosures, where such distinction was possible by other means, variability in ^{13}C ratios was shown to be related to whether cattle or caprines were corralled there. This pattern seems to be based on the relative prevalence of C_3 and C_4 plants in these animals' respective diets (Shahack-Gross et al. 2008). Microlaminations of opal phytoliths were observed in enclosure deposits, as were phosphate nodules and high phytolith densities. Spherulites, on the other hand, were not present and nor was there much evidence of calcite; this supports the notion discussed earlier that spherulite formation depends on local soil conditions where grazing takes place (Canti 1999). Even still, the authors were able to show that even in semi-arid savannah environments, some key markers for enclosure deposits can be preserved.

There are, however, several qualifications that might be raised regarding the wider application of their approach. Firstly, the preservation of the microlaminations noted as being the only definitive evidence for domestic enclosures, and arguably the lynchpin of the study, relies heavily on the enduring integrity of the soil structure. The potential for bioturbation, erosion, root action and other factors that might erase such features is less of an issue over ethnographic timescales, yet clearly becomes increasingly pertinent with age. The significance of these factors is also contingent on local ecological conditions. For instance, the descriptions and photographs of soil thin sections from Sugenya given in the published report (Shahack-Gross et al. 2008) do not seem to have been severely affected by bioturbation, except in near-surface sediments where the laminations appear truncated. There is also evidence of pedogenetic – soil forming – processes that may be less advanced were bioturbation a more serious inhibiting factor. While the details of soil and environmental conditions at Sugenya are not available, it is apparent that these may be more conducive to the long-term preservation of microstratigraphy than is the case at other visibly-similar locations. A further qualification concerns the preservation of phytoliths: opal is known to be soluble in alkaline conditions and therefore may not preserve in soils of above pH 8 over archaeological timescales. Given that the addition of ash raises the pH of soils (Demeyer et al. 2001), the common pastoralist practices of burning dung and the disposal of hearth ash in livestock enclosures (Western & Dunne 1979; Mbae 1990) would be detrimental to phytolith preservation. Third, the samples in which microlaminations are observed all relate to deposits at some 60 cm depth and thus below the level where environmental taphonomic factors would be most active. Savannah environments are not generally associated with soil accumulation, except perhaps through alluvial and colluvial processes; archaeological horizons at open-air sites – particularly when atop raised topography as preferred by many modern pastoralists (see above) – are therefore unlikely to be buried at the speed and to the depth necessary for such preservation. Only where the archaeological deposits themselves accumulate so rapidly and deeply that the lowermost sediments are shielded from taphonomic disruption might features like microstrata be expected to survive. Unfortunately, the fulfilment of this criterion is often precluded by mobility, with people moving on before deep deposits accumulate.

3.5 Summary

Ecologists and archaeologists studying pastoralist settlements have constructed their approaches to understanding the effects of these sites based on the same underlying principal; the notion that anthropogenic activities and deposits stimulate enduring changes to the savannah landscape has been used either to trace a typically-archaeological path back to the initial context of formation, or to understand and project the impact that these human inputs might have on current and future ecosystem function. This chapter aims to have highlighted the key points to be raised by each camp, in terms of what these residues or effects might be. The processes and consequences of glade formation demonstrate how pastoralism has become entangled within savannah ecologies, while the geo-ethnoarchaeological work of Shahack-Gross and colleagues has helped define an approach by which archaeologists might access the socio-cultural contexts behind this integration in the past and understand the historical development of the modern herding societies. However, when the potential contribution of methods like these is considered in light of the ethnographic descriptions of Maasai, Samburu and Rendille that form the heart of this chapter, we gain an indication of just how far short we fall. As David (1971) showed in his seminal paper looking at reconstructions of Fulani household compounds, even with very detailed information, it is very difficult to estimate apparently-fundamental measures like total population. Consequently, our interpretations of the archaeological record are likely to be fairly rudimentary, perhaps little more than confirmations of either the presence or absence of livestock.

By a similar token, ecological studies of the effects of herding remain largely uni-linear in the types of livestock management that they factor into their models, a situation not helped by the fact that a significant proportion of these studies have been undertaken at a single research centre in central Kenya, as will be discussed. A brief consideration of the ecological and cultural diversity that determines the strategies people follow highlights the implications such generalisations have for the validity of those models, particularly over longer time periods. For instance, the decision of the Rendille to focus on camels – now perhaps an ideological choice if previously one imposed by economic necessity – dictates a very different pattern of landscape exploitation and settlement patterning from that of Samburu cattle-keeping. Moreover, the keeping of smallstock within the settlement while large animals remain outside in the camps determines the content of the dung being deposited within; in the case of browsing caprines as opposed to grazing cattle, the former would entail a much higher concentration of seeds from trees and shrubs, with commensurate effects on vegetation succession on abandonment. As such, the historical development of savannah ecosystems could be understood very differently depending on the extent to which species diversity is attributed to natural processes over anthropogenic interventions.

The remainder of this dissertation is concerned with how these ideas might be used to construct an archaeo-ecology of pastoralist settlement that operates on two levels: my first concern will be how elements of both archaeological and ecological approaches, and the data-sources they draw upon, might combine to inform a reflexive approach to ephemeral sites – one that is designed to explore issues that are specific and central to the pastoralist experience, and that of the archaeologist, in terms of the unique problems and possibilities raised in such a pursuit. I thus hope to be able to comment on the history of herding economies in a poorly understood regional and temporal context. Essentially, this constitutes an archaeological agenda, with questions about the human past supported by an ecological perspective. My second concern reverses this, and attempts to use archaeological data as a means of understanding the historical processes that have shaped current ecological conditions. The next chapter sets the scene, so to speak, by describing the particular setting of my study: the Laikipia Plateau.

4

Laikipia, Lolldaiga and Maili Sita

Figure 4.1. Lolldaiga Hills Ranch, view west from Maili Sita (O. Boles)

This chapter describes the setting of my research project. Beginning with an outline of the geographical, social and economic landscape of the Laikipia Plateau and a focussed evaluation of its archaeology and recent history, briefly alluded to in chapter two, my focus then narrows to the site of Maili Sita. My research seeks to build on previous investigations in the area and better situate Maili Sita within a broader milieu of pastoralist interaction and economic change, as well as the wider sphere of research interest into the historical ecology of rural landscapes in eastern Africa (e.g. Hakansson 2004; Lane 2009; Stump 2010; Lane 2010; Davies 2010; Lane 2011; Marchant & Lane 2014; Reid 2015). Having established this context, I return to the research questions defined in my introductory chapter and my approach to answering them.

4.1 Laikipia

4.1.1 Topography and Geology

The modern administrative district of Laikipia lies atop an eponymous equatorial highland plateau of over 9,000 km2, close to the geographical centre of Kenya. Bounded to the south by Mount Kenya and the Aberdare range and a steep escarpment into the Great Rift Valley to the west, the plateau grades more gently into the Leroghi (sometimes *Leroki*) Plateau to the northwest and the low-lying arid plains of Samburu beyond and to the east. Altitude varies considerably, between 1500 m.a.s.l. at the lower-lying northern end,

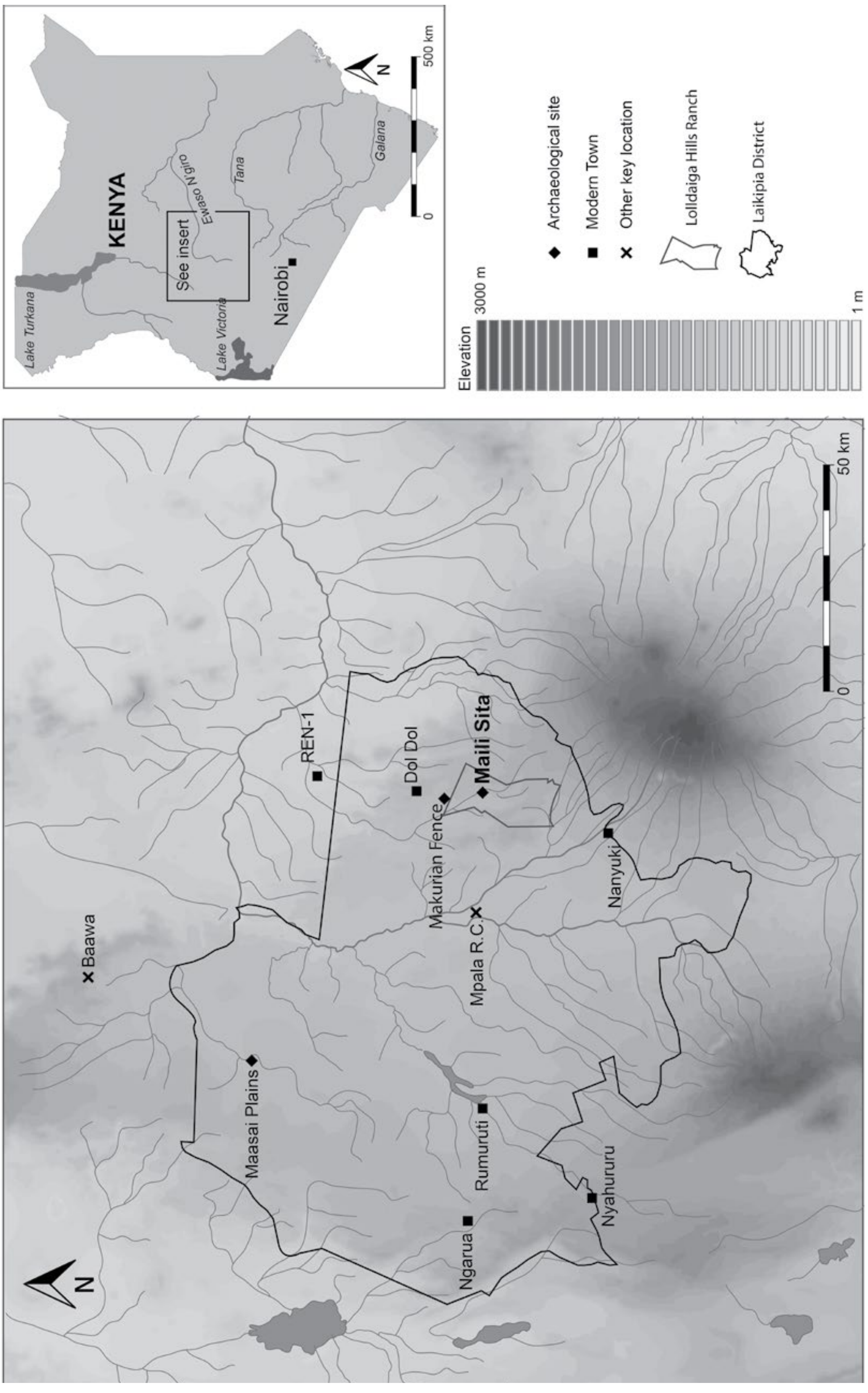


Figure 4.2. Map of Laikipia and key locations within. The plateau is visible as darker shading indicating higher elevations (adapted from 'FIGURE 1' Lane 2011:14)

to over 2600 m in the south, where the land rises steeply into the Aberdares. The plateau is comprised of two main geological formations. The dominant geology across western and central areas is Miocene-age phonolitic lava, with granites and gneisses of the Precambrian African Basement Complex mostly concentrated toward the east. The lavas resting atop the Basement Complex which form the highest part of the plateau, incline gently towards the more undulating terrain of the eastern zone, where the landscape is pocked with *kopjes* and *inselbergs*. The basin that lies between these geologies hosts the Ewaso Nyiro (sometimes Uaso Ngiro) river, fed in the upper part of the plateau by the Suguroi and Ewaso Narok. This river system constitutes the only perennial water body in the region. The Mt Kenya massif (5,199 m.a.s.l.) and the Aberdares (3,990 m.a.s.l.) are Tertiary volcanic formations (Siiriainen 1984; Hackman et al. 1989). Soils range from clay-rich 'black cotton' vertisols atop the main central part of the plateau, to reddish sandy loams in the eastern hill valleys. Both types are generally infertile and leached, though hill wash and alluviation sometimes create fertile channels in the valleys and seasonal river channels (Siiriainen 1984).

4.1.2 Climate

The climate in eastern Africa is primarily dictated by the north-south oscillations of the Inter-Tropical Convergence Zone ITCZ), which separates the dry northeast monsoon from the humid Indian Ocean monsoon to the southeast. Movement of the ITCZ is the primary contributor to the broadly bimodal rainfall pattern, though there is considerable intra-regional variation in timing and extent due to topography and latitude (Nicholson 1998). In Laikipia, the looming peak of Mount Kenya that dominates the southeast corner of the plateau exerts significant influence over climatic conditions; its rain-shadow, which obstructs the rain-bearing southeasterly monsoon winds, is fundamental to the diverse ecology of the district. There is a steep gradient in total annual rainfall; Mt Kenya and the Aberdares receive up to 2000 mm, while the plains below in the south of the plateau see only 500-700 mm. Central and northeastern areas can see as little as 300-500 mm. Rain falls primarily during two wet seasons: the so-called 'short rains' of April and May – named for the short, intense bursts of precipitation rather than the duration of the season – can account for up to 80 % of the annual total, and the 'long rains' of October and November, characterised by protracted but generally light rain events. A third rainy season, the 'continental rains' occurs in July and August, though is generally more sporadic, and is drawn from westerly migration of the Congo Air Boundary (CAB; Schmocker et al. 2016). Daily temperatures average between 22-26 ºC and range from night-time minima of 6-14

°C up to around 35 °C. Air temperature can increase by 10 °C within one hour of sunrise, causing accelerated exfoliation of rock faces and the formation of rockshelters (Siiriainen 1984), more of which later.

As described with reference to the history of pastoralism in chapter two, eastern Africa has seen significant climatic fluctuation since the mid-Holocene (e.g. Nicholson & Flohn 1980; Nicholson 1998; Verschuren et al. 2000; Bessems et al. 2008). This has had considerable impacts on local ecology. Palynological evidence from the northeastern part of the plateau, at the Loitigon Vlei (marsh) site on Mugie Ranch, indicates an increase in arid-adapted taxa over the last 2000 years (Taylor et al. 2005). Much of the evidence for climatic variability during the early part of the last millennium is contradictory, with patterns noted in sources from Lakes Tanganyika and Victoria (e.g. Stager et al. 2003) being absent in records from Mt Kenya (e.g. Barker et al. 2001). More clear, however, is the evidence for significantly lower levels of effective precipitation than today through the late sixteenth to late eighteenth centuries AD, bookended by periods of increased humidity (Robertshaw & Taylor 2000; Verschuren et al. 2000; Alin & Cohen 2003).

4.1.3 Vegetation

Several agro-ecological zones are recognised in Laikipia, largely related to altitude but partly a function of increasing aridity to the north with distance from Mt Kenya and its surrounding highlands (Pratt & Gwynne 1977). The greater part of the district, though, has been classed as Zone IV, 'semi-arid with marginal agriculture', according to the East African Rangeland Types specified by Pratt and Gwynne (1977). There is also considerable variability in vegetation complexes and land-cover – Taiti (1992) identifies twelve such categories along a spectrum from natural to human-induced. For instance, the well-irrigated plains beneath Mt Kenya and the Aberdares host intensive agriculture and plantation forestry, while marsh and wetland systems are present in the vicinity of the Ewaso N'giro, the major river system. Elsewhere, upland dry forest and leafy bushland and grassland types predominate. Vegetation is thus held to reflect a combination of precipitation levels, underlying soils and human modification (Liniger et al. 1998). Afromontane forest taxa, such as Mukinduri (*Croton megalocarpus*) and African Olive (*Olea africana*), are present in the wetter southern portion of the plateau, with fire-adapted C_4 grassland and *Acacia* bushland elsewhere (Lind & Morrison 1974).

The current savannah-type vegetation communities that dominate the plateau seem to be a relatively recent development. While potential sources of paleoenvironmental proxy data are rare on the plateau, swamp coring at Loitigon Vlei, a swamp within Mugie Ranch in northwest Laikipia and close to the archaeological site at Maasai Plains, which will be discussed in greater depth below, has revealed a dramatic change in the floral landscape around 2000 years ago. Taylor et al. (2005) have acknowledged a shift from pollen associated with Afromontane forest dominated by evergreen species like African cedar (*Juniperus procera*) – a pocket of which survives as the Mukogodo Forest (Pearl & Dickson 2004) – to *Acacia*-bushland and fire-adapted C_4 grassland, preceded by a sudden peak in charcoal particles. This acceleration in burning activity and reduction in vegetation cover has been linked to interventions by emergent stock-keeping communities and the clearing and improvement of grazing land, for instance through the reduction in tsetse-harbouring woodland. Burning may have been facilitated by reduced levels of effective precipitation post-2300 BP evidenced by low-stands in Lakes Tanganyika and Edward (Alin & Cohen 2003; Russell et al. 2003), though a link with broader patterns of climatic change is yet to be confirmed, with diatom records from Mt Kenya pointing to higher convective rainfall for the same period (Barker et al. 2001).

4.1.4 Archaeology and Pre-Colonial History

Evidence for human presence on the Laikipia Plateau extends back to at least the Middle Stone Age (c. 200,000 – 40,000 BP), based on the identification of lithic toolkits more diverse than those found in Early Stone Age deposits, with some examples bearing comparison with Later Acheulean types (Siiriainen 1984). Though absolute dates remain scarce, an overlying stratigraphic unit at Shurmai rockshelter (GnJm1), in the Mukogodo Hills, has been conservatively dated to 42,511 ± 5,356 BP (Kuehn & Dickson 1999). The most extensive archaeological record relates to hunter-gatherer communities and the emergence of food-producing societies during the Holocene. However, the breadth and intensity of archaeological research in the region, given its size and location central to the southward spread of herding, pales in comparison to that undertaken in the Rift Valley. In consequence, our knowledge of the archaeological sequence for the region is patchy.

The upper levels of Shulumai rockshelter, as well as nearby Kakwa Lelash, evidence occupation by Later Stone Age hunter-gatherers, with non-local material such as obsidian and chert suggestive of the exploitation of larger territories, or at least interaction with other communities across a wide area (Kuehn & Dickson 1999; Dickson et al. 2004). Investigations at other rockshelters in the region, such as Porcupine Cave and KFR-A4, have indicated that domestic livestock were present by 4000-3000 BP (Siiriäinen 1977) 1984), fitting the chronology for the spread of herding into and across eastern Africa outlined in chapter two. Indeed, at Ol Ngoroi rockshelter in the Lolldaiga Hills, charcoal recovered in association with both wild and domestic fauna, dated to 4090 ± 40 BP (Beta-189983; Mutundu 2005), compares with the very earliest dates for pastoralism in eastern Africa: 4160 ± 110 BP (SUA-634) at GaJi2 and 3945 ± 135 (SUA-637) at Dongodien (Owen et al. 1982). This may be an indication that domesticates reached the Laikipia Plateau some years prior to the establishment of herding in the Rift Valley, perhaps due to the reduced risk of epizootics presented by the high altitude (Causey 2008:107). Interestingly, Siiriainen (1984:90) cites substantial typological continuity in the lithic assemblages from these sites as evidence for the persistence of LSA ethnicities rather than wholesale demographic replacement. Additional weight to this position is given by faunal assemblages from these various sites that all include a combination of wild and domestic fauna, which may testify to a gradual adoption of herding by formerly specialist hunters (Mutundu 1999; 2005; Lane 2011). The use of rockshelters seems to continue with the advent of specialist herding; Lane (2011:16) observes that rock art at Ol Ngoroi rockshelter, in the western Lolldaiga Hills, bears comparison with designs found at Lukenya Hill to the south of Nairobi and linked to Maasai meat-feasting and initiation rituals (Figure 4.3; Gramly 1975).

Figure 4.3. Ol Ngoroi rockshelter (O. Boles)

He suggests that herders may have used these sites for their own purposes (though perhaps slightly later than the herder-hunters) and incorporated these locations into their own ritual landscapes. However, as Lane (2011:16) goes on to say, as in the rest of eastern Africa, without knowledge of the archaeologically-elusive open-air settlements likely occupied by incoming pastoralists – as there must surely have been, to a greater or lesser degree – the details of the transition to herding cannot be fully understood. How we identify and investigate such sites is, of course, one of the keystones of this dissertation.

From around 500 BP, lithic technology effectively ceases and a dominant ceramic tradition emerges, where previously no single style had prevailed. Kisima ware, common at sites of this period across Laikipia, was first recognised at Kisima Farm, in northeast Laikipia, where it has been recovered from layers overlying contexts containing Akira ceramics (Siiriainen 1984), elsewhere associated with hunter-herder interactions during the Pastoral Neolithic (Robertshaw 1990). The principal diagnostic feature of Kisima ware is a raised ridge and notch motif, and it has been compared with similar traditions further south as far as northern Tanzania, such as at Ngungani in the Chyulu Hills (Soper 1976) and Lake Manyara (Seitsonen 2006). Raised-notch decorated wares that may be Kisima, or variants of it, have also been recognised in the highlands south of Laikipia (Siiriäinen 2010) and – perhaps misleadingly – in Karamoja, northeastern Uganda (Robbins et al. 1977). Siiriainen (1984:66) also speculates that some recent Samburu pottery in the modern ethnographic collections held by the National Museum of Kenya is reminiscent of Kisima, exhibiting raised ridges sometimes with incised notching. Jacobs (cited in Siiriainen 1984:66) suggests that the Samburu never actually made any pottery but acquired it through links to Cushitic hunters; while there has since been a reconsideration of the existence of Samburu potters (e.g. Grillo 2012), the implication remains that Kisima ware may have been manufactured by Cushitic groups long before the arrival of Nilotic herders in Laikipia.

On the basis of these changes in material culture in Laikipia, Siiriäinen (1984:93-4) has speculated that the Maa-speaking, pastoralist Laikipiak moved onto the plateau at the expense of the semi-pastoralist, Southern Cushitic-speaking Il Tatua in the mid-second millennium AD. This narrative is supported by Purko Maasai traditional histories relating the Laikipiak moving into the region sometime prior to 1600 (Jacobs 1972), coinciding with Ehret's (1984) broader description of Maa linguistic divergence around this time, perhaps involving some degree of demic migration. It is tempting to conclude, as Siiriäinen does, that exchange relationships established between the emergent Laikipiak and autochthonous hunter-gatherers who posed no competition for pasture, trading honey and pottery for cattle products, brought about a degree of homogenisation of material culture and that

Kisima ware can therefore be directly associated with the former's expansion. However, a more comprehensive programme of archaeological research and, crucially, dating is required before such associations can be considered reliable.

The period prior to the emergence of the Laikipiak as the dominant group in Laikipia and, indeed, the actual period of their dominance remain poorly understood. A number of studies have attempted to reconstruct the chronologies and processes by which various modern groups, or their forebears, moved into and out of the region, and the inter-ethnic relationships that were formed. Unfortunately, linguistics-based reconstructions are hindered by the bilingualism and ethnic-fluidity that facilitated cultural and economic exchange between groups engaged in different strategies for food provision or from different linguistic backgrounds (Sobania 1993). This perspective echoes that noted by Vansina (1995), in a seminal paper, that the 'Bantu migration' out of the central African rainforests, previously associated with the spread of farming and iron technology and purportedly evidenced by comparative ceramic analysis (e.g. Phillipson 1977), was not a linear or continuous process. Instead, Vansina (1995:194) proposes multiple pulses of linguistic dispersal, but that the adoption process was patchy and often reversible, and, crucially, that the automatic association of material traditions with particular language groups is unsustainable.

The linguistic history of the spread of pastoralism in central Kenya has yet to receive quite such detailed investigation and, in lieu of comprehensive archaeological data, the most successful studies have used clan-lineages and oral traditions to reconstruct ethno-historical narratives (e.g. Sobania 1980; Schlee 1985; Waller 1989). As described in chapter two, the 'New Pastoralis[t] expansion' (Galaty 1991; 1993) of the sixteenth and seventeenth centuries depicts the Laikipiak, and other groups with some affiliation to a putative 'Maasai' core in the Central Rift Valley, moving outwards into areas presumably occupied by other, ethnically-distinct communities. For the Laikipiak, this would have brought them into contact with Cushitic groups like the Il Tatua. These Southern Cushitic herders, who engaged in limited cultivation, are mentioned in traditional histories of Bantu Sonjo farmers on the Rift Valley escarpment as invading the highlands from the Laikipia Plateau, from which they had been expelled by the Laikipiak, around or prior to 1600 AD (Jacobs 1972). Jacobs (1972) puts the arrival of the Il-Tatua in Laikipia sometime before 1400 AD, and their linguistic influence may be evidenced by the Cushitic *Yaaku* language spoken by the Mukogodo prior to their more recent adoption of Maa (see chapter two); the forebears of these hunter-gatherers were likely a remnant of autochthonous Khoisan-speakers (Ehret 1974; Cronk 2002) whose language was altered through interaction with immigrant

Cushitic herders (Heine 1974). Having been displaced from Laikipia, then, the Il Tatua seem to have moved south, eventually reaching northern Tanzania as the forebears of the modern Iraqw. Interestingly, and perhaps confusingly, Maasai traditions also describe the Il Tatua as the ancestors of the Nilotic-speaking Datoga (Jacobs 1972). The name Datoga is clearly a potential cognate of Il-Tatua, and perhaps the adoption of a Nilotic dialect can be traced to interactions between Il Tatua and Maa speakers present in the Rift Valley and southwestern highlands, after the former had been evicted from Laikipia.

A comparable and near-concurrent scenario of Nilotic and Cushitic groups coming together, peaceably or otherwise, has been observed to the north of Laikipia. The Samburu, who seem to have comprised another element in the Maa expansion, perhaps slightly preceding that of the Laikipiak (Galaty 1993), are said to have moved into their present heartland of Leroghi Plateau – essentially the northern tip of Laikipia – and the plains southwest of Mount Marsabit, where they displaced incumbent Borana herders (Sobania 1980). Schlee (1985) has discussed the notion of an Eastern Cushitic Proto-Rendille-Somali (PRS) culture, whose modern descendants are considered to include the Gabbra, Sakuye and Borana, as well as the eponymous groups who represent its western- and eastern-most fringes. The idea rests not only on these groups' common linguistic heritage but on a number of shared cultural traits including inter-ethnic clan relationships, circumcision and age-set organisation. Descendants of the PRS are thought to have undertaken the initial incursions by herders south from the Ethiopian highlands, establishing foundations for the groups occupying northern Kenya today; indeed, the PRS concept offers some explanation for the presence of the Il-Tatua in Laikipia. The Samburu have a long-held alliance with the Rendille (Spencer 1973) who at the time of the former's expansion into Leroghi had consolidated their position to the north in the Chalbi Desert (Schlee 1985). This relationship may stem from past cooperation in response to common enemies like the Borana, with whom the Rendille – while sharing linguistic roots – have a historically hostile relationship, and the Laikipiak, whose hostility towards both groups is well-documented (Sobania 1980; 1993). Furthermore, the Rendille concern with camels as opposed to the cattle-based economy of the Samburu largely negates the potential for resource-competition, and an alliance may have been mutually-beneficial from an exchange perspective. This is typified by the emergence of the Ariaal, a so-called 'bridge culture' that developed along the frontier between Samburu and Rendille territories and exhibits traits inherited from both (Fratkin 1991).

Essentially, then, the second millennium appears to have witnessed close contact between diverse linguistic communities in and around Laikipia, with groups mixing and merging, forming alliances or engaging in conflict, with little regard to earlier linguistic or ethnic ties. Indeed, these relationships seem to have been primarily based on the exploitation of both resources and social networks in order to negotiate a hostile, arid environment. The antiquity of these contacts and alliances is in some ways attested to by the coincidental emergence of age-set systems in the early nineteenth century, perhaps a result of communities consolidating in response to catastrophic drought (Anderson 2016; see also chapter two). The Iloikop wars and the north-westerly push of Purko-Kisongo Maasai from the Central Rift, coming in the wake of natural traumas, finally saw the Laikipiak pushed out of the plateau, with many becoming integrated into Samburu and Rendille populations to the north. These conflicts did not, however, mark the end of ethnic flexibility in the region, as exemplified by the case of the Mukogodo described in chapter two.

4.1.5 The Twentieth Century

Between 1904 and 1911, the Laikipia Plateau was designated the northern part of the Maasai reserve, designed to free up fertile land in the Rift Valley and highlands around Nairobi for European settlement. A subsequent deal in 1911, though, saw the Maasai relocated again, in a process thought to have seen some one million sheep and 200,000 cattle removed, and much of the most viable land apportioned for European holdings (Hughes 2006). The process was delayed somewhat by the outbreak of the First World War, soldier settlement schemes in the 1920s created an export-oriented economy and saw a rapid year-on-year increase in occupied farms. However, there remained vast empty areas, and by the 1930s many potential farmers declined to settle, citing the poor quality of the often water-deprived land. Issue was also taken with the size of the holdings available, which were normally in the region of 1000-5000 acres even though a viable livestock farm was widely considered to require at least 15,000. However, throughout the colonial period various processes whereby unoccupied land could be leased during periods of drought, as well as a relaxed view taken on farmers who exceed the limits of land they had licenced, ensured that European settlement persisted (a more comprehensive discussion of colonial land-use policy in Laikipia is given by Vaughn 2005).

While the process of Africanisation that followed Kenyan independence in 1963 saw many European settlers sell their ranches, around two thirds survive today (Lane 2005). Many continue to be run as privately-owned commercial livestock operations, often alongside interests in wildlife conservation. Other lands have been designated for community ownership as group ranches, as with the Makurian Group Ranch, owned and managed by

Mukogodo Maasai in the area around Don Dol. Many of the ranches in the southern part of the plateau, generally around Nanyuki, have been sub-divided for small-scale farming by communities from the densely populated Kikuyu tribal reserve (Kohler 1987). The sustainability of these farms is questionable, however, given that 8.4 percent of the district is already under cultivation, yet only 1.7 percent is considered to have high agricultural potential (Huber & Opondo 1995); annual population growth estimated at upwards of 7.6 percent (Heath 1996) can only exacerbate this issue.

4.2 The Lolldaiga Hills

One of these European-owned ranches incorporates the Lolldaiga Hills, a rare outcrop of raised topography located some 16 kilometres north of the equator in the eastern part of the Laikipia Plateau, between the Mt Kenya massif to the southeast and the Mukogodo Forest and Samburu escarpment to the northeast; west of the hills the plateau is dominated by the largely flat plains of the Ewaso N'giro basin. The ranch was established during the initial settlement drives of the 1920s, and has since been owned by a single family. At around 200 km^2 (19,880 ha), Lolldaiga Hills Ranch (LHR) is one of the largest private ranches in Laikipia, though it did not reach its current size until the 1950s, when additional land was acquired from neighbouring farms and the colonial government. Neighbouring Ol Jogi, Enasoit and Ol Naishu ranches share the remainder of the hills, while the Makurian community group ranch, part of the Mukogodo Reserve, lies beyond LHR's northern boundary. Its southern border is delineated by the Timau river, which rises in the southeast corner of the hills and is one of the few perennial water bodies in Laikipia and a key tributary of the Ewaso N'giro; this rare access to water surely accounts, at least in part, for the early acquisition of the land amid the generally underwhelming demand of the early settlement programmes, as well as the continued viability and subsequent growth of the ranch.

The landscape of LHR is divided into two distinct biomes with varying topographies and ecologies. The hills, which dominate the southern part of the ranch and comprise around half of the total property (104 km^2), are an outcrop of Precambrian Basement Complex, with quartzo-feldspathic gneisses with exposures of massive migmatites and granites that has evolved since at least the early Tertiary (Hackman et al. 1989). The hills take the form of a series of northward-trending, steep-sided ridges, rising to a maximum altitude of 2240 m.a.s.l. Soils in this part of the ranch are generally thin sandy clay loams – Chromic Luvisols (FAO-UNESCO 1974; Payton 2005) – with high quartz content, and are of low to

Figure 4.4. Erosion gullies along the main ridge, 200 metres south of Maili Sita (O. Boles)

medium fertility. To the north, the hills give way sharply to gently undulating plains (95 km^2, 1800-1900 m.a.s.l.) through a broadening valley between two continuations of the southern ridges, interspersed with seasonal river channels and isolated *kopjes* (or inselbergs). This area bears closer comparison to the more subdued topography of central and western parts of the plateau. Volcanic 'black cotton' vertisols in the valley bottoms are more fertile than the reddish-brown sandy loams of the uplands and interfluvial ridges, though being rich in clay are less permeable and are prone to flooding. Dramatic erosion gullies up to eight metres high can be found along the colluvial footslopes of the ridges enclosing the valley (Figure 4.4).

4.2.1 Climate and Vegetation

Rainfall varies considerably between the hills and the plains, with the former receiving an average of around 700 mm per annum between 1976 and 1992, twice that of the latter (Figure 4.5; Mizutani 1999). Vegetation is similarly differentiated; according to Pratt and Gwynne's (1977) categorisations for rangeland types in eastern Africa, the plains offer a Zone IV environment (semi-arid with marginal agriculture) – as characterises the greater part of Laikipia district – tending towards Zone V (arid with ranching and pastoralism) as one moves north. Within this broad category, five vegetal environments are recognised: dense shrubbed woodland, open shrubbed woodland, open shrubbed grassland, sparse shrubbed grassland and closed grassland (Taiti 1992; Figure 4.5). By far the most common tree species is *Acacia drepanolobium* ('Whistling Thorn'), which dominates in wooded areas, while larger species like *A. xanthophloea* ('Fever Tree') are found in the swampier river channels. Grasses include *Pennisetum stramineum*, *Themeda triandra* and *Cynodon* spp. The hills are Zone III (agricultural highlands), with flora comparable to the afromontane Mukogodo Forest. The dense shrubbed forest, open shrubbed forest, open shrubbed woodland and closed grassland communities host varying numbers of tree species such as *Olea* sp., *Acokanthera* sp. and cedar, and grasses *Pennisetum stramineum*, *Themeda triandra* and *Cynodon plechtostachyus*. While controlled burning of vegetation takes place occasionally, wild fires are rare but destructive; a blaze during my second field season in 2015 destroyed

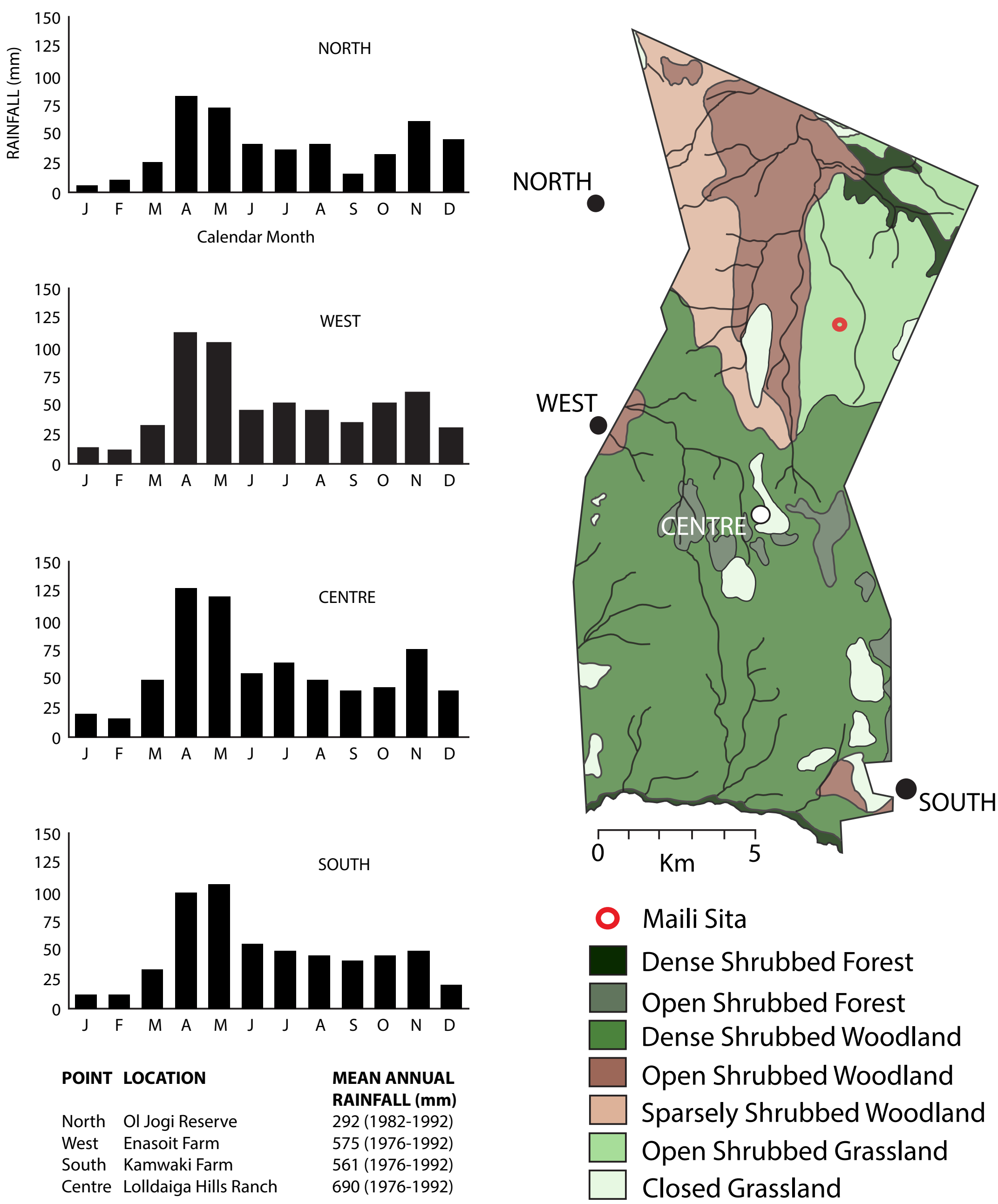


Figure 4.5. LHR annual rainfall and vegetation distribution, redrawn from Mizutani 1999:229

Figure 4.6. Hilly landscape of southern LHR , left, compared to the northern plains, right (O. Boles)

around 300 acres of ancient cedar woodland and important dry-season upland pastures in the southwest corner of the ranch.

4.2.2 Economy

LHR is operated primarily as a commercial livestock ranch, with around 4500 head of cattle, a crossbreed of the high-milk-yield English Red Poll (*Bos taurus*) and hardier local Boran (*Bos indicus*), and around 4000 Merino and Dorper sheep (*Ovis aries*). Since 1993 there has also been a small herd of around 200 camels. The average stocking rate is between 10 and 13 hectares per cow and 11 to 14 hectares per sheep. While the main livestock accommodation is at the farmhouse in the centre of the ranch, grazing is undertaken across the property. Animals are divided into herds of around 150, tended by one or two herdsmen. Bomas, smaller than the Maasai variety with no need for extensive human accommodation, are constructed from aluminium fencing and Acacia branches for the overnight corralling of stock and protection from leopards and other large, nocturnal predators. Bomas tend to be located adjacent to pastures at the edge of denser vegetation, and are moved fortnightly to avoid excessive dung accumulations. The peak of the dry season sees herding concentrated in the hills and valleys at the southern end of LHR, moving to the northern plains during and immediately following the rains. Water is pumped from the Timau River to supplement dam reservoirs that provide water for livestock and wild animals. Milk herds are watered twice daily when possible, while sheep are watered every second day. Calving is managed so as not to coincide with the January to March dry season, while lambing occurs in June at the end of the rains. Birthing takes places at the main farm complex in the centre of the ranch, with juvenile animals subsequently managed in separate herds. Off-take is around 800 cattle per year (Mizutani et al. 2012; Mizutani 1999).

Though fenced since the 1960s to combat illegal grazing and potential over-exploitation by neighbouring Maasai (R. Wells, quoted in Larsen & Lane 2005), the local Mukogodo are sometimes given permission to graze within LHR. This is facilitated by stock numbers within the ranch kept to a level well within the carrying capacity of the land (Mizutani 1999). These communities construct temporary stock camps that adhere broadly to the specifications noted in Maasai ethnography (Mbae 1990; Western & Dunne 1979), and in contrast to the LHR herds, are much more mobile; moving beyond their community-owned ranches to pastures across the plateau, as far as south and west as the slopes of Mt Kenya and Rumuruti, and east to the lowlands around Isiolo (J. Parkenga, pers. comm. 2014). Lands to the north become increasingly dominated by the Samburu, with whom the Mukogodo have an occasionally tense relationship, the former being reluctant to accept the latter's status as 'Maasai' (Cronk 2002).

Besides its commercial function, LHR is also managed as a wildlife conservancy. Some sixty species of large mammal are present within the 550 km^2 Lolldaiga Hills Conservation Landscape, an initiative between LHR and neighbouring ranches. This figure, which may be second only to the considerably larger (19,500 km^2) Kruger National Park in South Africa (T. Butynski, pers. comm.), includes at least 26 species of ungulate and 21 carnivores. Over 350 bird species and 500 plants are thought to be represented. The nascent 'Lolldaiga Hills Research Programme' (LHRP), part of the 'Sustainability Centre Eastern Africa' (SCEA), has been developed to establish ecological and climatic baselines and undertake applied ecological research in order to maintain and enhance the natural resources of the Lolldaiga Hills landscape.

4.3 Prior research: BIEA and HEEAL

Between 2002 and 2010, a sustained programme of fieldwork was undertaken under the auspices of the British Institute in Eastern Africa (BIEA) and, subsequently, the 'Historical Ecologies of East African Landscapes' (HEEAL) project (directed by P. Lane), for which the Laikipia Plateau was a key study area. These investigations examined the environmental history of the region, how the interaction of natural and anthropic factors transformed pre-colonial landscapes and the human societies living within them, and the consequences of these developments for contemporary issues of land-use and conservation. The agenda drew on historical data from the colonial and post-colonial periods to assess changes in land-use, wildlife distribution and demography alongside a comprehensive programme of archaeological excavation and paleoenvironmental reconstruction, in order to understand longer-term trajectories of landscape and social change. While earlier investigations by Siiriäinen (1977; 1984), previously the most-extensive archaeological fieldwork undertaken in Laikipia, focussed on rockshelters, an explicit aim of the BIEA/HEEAL research was to expand knowledge of the wider landscape through extensive survey and the identification of open-air pastoralist sites (Lane 2005). Efforts focussed on three privately-owned ranches: Borana, Mugie and Lolldaiga Hills. The latter two received the most concerted attention, by way of extensive excavations at Maasai Plains (Lane 2005; Causey 2010) and palynology at Loitigon Vlei on Mugie Ranch (Taylor et al. 2005; Muiriri 2008) and excavation and soil survey at Maili Sita (Causey 2010; Lane 2005; 2011) Payton 2005). Of particular relevance to my own project has been the PhD research undertaken by Causey (2008), which looked at pastoralist behaviour and the dynamics of glade formation and persistence at Mugie and Lolldaiga, and the soil survey of the Maili Sita ridge and the wider Lolldaiga Hills undertaken by Payton and colleagues during the 2004 field season (Payton 2005).

4.3.1 Maasai Plains

The Maasai Plains site (37 N 234789.76, E 80461.48), first recorded in 2003, is arguably the largest pastoralist site in eastern Africa (Causey 2010; Lane 2011). Located in a relatively flat open grassland glade within a wooded background, the site measures around 750 m in diameter and consists of a series of ash middens, 0.35-1 m high, arranged in concentric circles, clearly visible in aerial photography and satellite imagery, though fairly indistinct at ground level. Two further series of concentric circles extend to the east, in the direction of Loitigon Vlei, some 1.5 km distant. Excavations in 2004 bisected one of the mound features, which was composed of interleaved layers of soil rich in ash and burnt dung, and containing fragmentary faunal remains, occasional lithic flakes and Kisima ceramics. Such accumulations are resonant of midden deposits found at modern Samburu homesteads, created by the periodic removal of dung from stock pens (Lane 2011:19). Charcoal recovered from the base of one of these mounds returned a radiocarbon date of 480 ± 50 BP (Beta-189982), which calibrates to AD 1315-1616 at 2 sigma range (IntCal13; Reimer et al. 2013). The lithic assemblage is comprised mainly of modified blades with a high number of obsidian *outils écaillés*; given its similarities with assemblages from the western side of the Rift Valley and that the nearest documented obsidian sources are found in the

Central Rift near Lake Naivasha, it is possible that long-distance exchange networks linked the occupants of Maasai Plains with Elmenteitan groups to the south. Alternatively, the preponderance of *outils écaillés* and reworked flakes may reflect a low-waste strategy given the distance of the site from these Rift Valley sources (Causey 2010:118-119). The ceramic assemblage is exclusively Kisima ware, which in conjunction with the aforementioned ^{14}C date – currently the earliest date for the tradition – as well as those from Kisima Farm (Siiriäinen 1977; 1984) and Maili Sita (see below), provides a robust, fourteenth century *terminus post quem* for the occupation. While Lane (2005:111) is rightly at pains to point out the pitfalls of forging an interpretation based on a single ^{14}C date, available data from Maasai Plains is suggestive of fairly high population levels – arguably higher than today – in the region towards the middle of the second millennium AD. Furthermore, pastoralism seems to have been the dominant economic pathway; faunal remains show roughly equal proportions of cattle and small stock, with occasional wild species represented (K. Mutundu, pers. comm. in Lane 2011:19). Fertile soils in the area (Ahn & Geiger 1987) may have supported cultivation, though this has yet to be confirmed.

In form, the site resembles a Maasai *manyatta*, with refuse areas and supposed living spaces enclosing a wide central enclosure (Causey 2010; Lane 2011). While excavation has not yielded any evidence of domestic structures in between the middens, Causey (2008) suggests that the kinds of low-density, mixed artefact scatters observed in these areas are commensurate with those generated in domestic contexts (see also Mbae 1990; Grillo 2012). He also suggests that the form of the middens is indicative of refuse being taken beyond the limits of the settlement to be disposed of, rather than within the perimeter as at modern Maasai villages (Causey 2008:277; c.f. Mbae 1990). High resolution topographic data reveals small depressions between the middens, which on the basis of elevated soil nutrient content and support of rich grass taxa, Causey (2008:280-283) interpreted as smallstock enclosures.

Though the scale of Maasai Plains is considerably larger than any ethnographically-documented *manyatta*, early European accounts do describe 'Maasai' 'villages' in Laikipia containing up to 3000 warriors (e.g. Thomson 1885). Notably though, Thomson's famous journey across Kenya took place at the height of the Iloikop wars that wiped out the Laikipiak and it may be that the large size of the camps he observed was a function of this political hostility (e.g. McCabe 2004:53-54). The Sirikwa site at Lanet, close to the modern town of Nakuru in the Central Rift Valley, is arguably the closest archaeological correlate (Posnansky 1967; Sutton 1998); Lanet consists of a high concentration of 'hollows' (see chapter two) with associated mounds thought to represent domestic homesteads, alongside a much larger earthwork measuring several hundred metres across. A sub-circular central enclosure, where high soil phosphate levels evidence the corralling of livestock (Posnansky 1967:95), is ringed by a broad ditch, the spoil from which forms a series of mounds around the perimeter. Sutton (1998:33-36) observes that the position of the mounds outside the ditch contradicts the possibility of a defensive function, but rather that the site may have served as an occasional meeting place for Sirikwa and their herds from across a wide area, a function comparable to the modern Maasai *manyatta*. While a similar mid-second millennium date – c.365 BP – has been posited for Lanet (Sutton 1998:36), the ceramics recovered are very different from the Kisima-dominated assemblage at Maasai Plains (Causey 2010). Neither does Lanet show the kinds of concentric circular patterning that characterises the latter site, which also lacks the physical 'hollows' characteristic of Sirikwa settlements. The regularity of the midden locations and coherence as a circular feature presupposes that one or more of the 'rings' were created during the same occupation episodes, and the concentricity of the mounds seem likely to derive from a series of reoccupations, as one might expect at a *manyatta*.

A limited programme of soil analysis was undertaken at Maasai Plains, which revealed high levels of potassium and magnesium in glade soils and elevated pH in midden deposits. Again, this supports the notion that significant numbers of livestock were kept at the site; magnesium, for instance, is a known derivative of mono-hydrocalcite, a mineral compound observed to be contained in animal urine (Shahack-Gross et al. 2003 see chapter three). White calcium carbonate ($CaCO_3$) nodules were also observed within the middens during excavation and in the spoil from animal burrows; Payton (2005:57) contends that these may result from the leaching and nodular deposition of dense inputs of calcium derived from bone, dung and ash down the soil profile. Equally, an alternative hypothesis is offered wherein the concentration of soil cations are concentrated in termite mounds from where these are translocated through similar leaching processes (Watson 1974). While the regular concentricity of the mound features at Maasai Plains, not to mention the density of archaeological material found in association, likely precludes termite activity as the sole or even principal contributing driver of their formation, some combination with anthropic factors is plausible (Payton 2005).

4.3.2 Glades and landscape change

A key contribution of the BIEA/HEEAL programme has been towards the better understanding of how glades form and persist in the savannah landscape. In contrast to much of the literature generated by ecologists, however, this was approached with specific reference to archaeological evidence for human intervention. Palynological evidence from Loitigon Vlei points to an acceleration of the transition from *Acacia* bushland to C_4 grassland from around AD 1300 (Taylor et al. 2005), just a few centuries prior to the occupation of Maasai Plains, which, as discussed, appears to evidence a considerable population engaged in a livestock-oriented economy. This presupposes that herders' involvement in processes of landscape change in Laikipia has continued throughout the last millennium.

That same landscape has continued to experience rapid and intense changes during the twentieth century. Matched photography has been used at Lolldaiga Hills Ranch to examine geomorphological and vegetation change during the twentieth century. Larsen and Lane (2005) looked at family photographs of the area taken between 1930 and 1965, identifying the location and replicating the image in order to assess visible changes over a kown period. The approach has been used in numerous studies of landscape change in Africa and across the globe (e.g. Turner et al. 1998; Rohde and Hilhorst 2001). Of the Lolldaiga photographs, while a few showed a decrease in vegetation cover likely connected to ranching activities rather than climatic variation, Larsen and Lane (2005) observe a general increase in bush density since the mid-twentieth century. According to the current owner of the ranch, the land was heavily degraded when it was acquired during the 1920s, possibly as a consequence of the drying trend seen across eastern Africa in the early part of the last century (Nicholson 1998). One amelioration strategy is said to have involved laying down *Lantana* scrub branches to encourage regrowth (R. Wells, pers. comm. in Lane 2005:88). Other possibilities include the suppression of grass species in favour of small trees and shrubs caused by grazing on already-degraded rangelands (e.g. Mwihuri 1989). The decline of elephant populations across eastern Africa in the face of hunting, poaching and ecological disruption may have been an additional factor, with various studies from the wider region drawing correlations between fluctuations in vegetation density and elephant numbers (e.g. Hakansson 2004; Reid 2015).

Given that wildlife densities in the northern part of the ranch are said to have been very low prior to the construction of the dams – there being no perennial or reliable water source north of the Timau River – and only limited Maasai herding (R. Wells, pers. comm, in Larsen & Lane 2005:81), the sudden influx of grazing animals during the middle decades of the last century could certainly be expected to have effected ecological change on a considerable scale. Interestingly, this pattern of greater woody vegetation cover is at odds with the general decrease in forest and bushland noted by Ogutu (2005) in his remote sensing-based study of land-cover change across Laikipia district between 1973 and 2004.

It is possible, therefore, that the drivers of change in Lolldaiga do not resemble those across the wider plateau, lending support to the contention that a specific intervention like the encouragement of *Lantana* growth in the 1920s and 30s – a process not applied elsewhere, so far as is known – instigated localised trajectories of ecological development. Of course, it is possible that similar changes did occur across the region in the early part of the twentieth century and reached a peak prior to 1973 and the earliest land-cover data used by Ogutu (2005), but after the historic photographs of Lolldaiga were taken, between 1935 and 1965 (Larsen & Lane 2005).

A further outcome of the matched photography has been the recognition of glades in the main valley of the northern part of the ranch, as photographed in 1935, that remain clearly visible after 70 years (Larsen & Lane 2005:87). Ground survey has revealed that these locations also contain surface scatters of archaeological material associated with the Pastoral Iron Age and similar to that found at sites like Maasai Plains and Kisima Farm: namely, Kisima ware and obsidian *outils écaillés*. This has been taken as an indication of these features' considerable antiquity, and has prompted a more thorough investigation of how glades relate to archaeological material and ethnographic records of pastoralist settlement distribution (Causey 2005; 2008). Using Landsat satellite imagery, Causey (2008) identified a series of glades at Mugie Ranch, one of which included the Maasai Plains archaeological site, and was able to match these with glades visible in aerial survey photographs taken by RAF reconnaissance aircraft in the 1950s. Using both these sets of images, this study mapped and calculated changes in the extent of tree and shrub coverage within a known threshold area. Time Series Analysis (Causey 2008:173-183) showed a 31 percent decrease in glade size at Maasai Plains between 1950 and 2006, while other glades were seen to exhibit a similar degree of recolonization, albeit with slight variations based the size and function of the glade; glades found to contain archaeological material during field survey were seen to exhibit greater tree regrowth over the study period than those created by the modern ranching activities that began in 1955. This makes sense given that the latter type would only have been very recently established when the earliest images were obtained; there is extensive evidence from ecological studies of glades that suggests the first twenty years since pastoral use are dominated by grass species succession to the exclusion of woody taxa (e.g. Muchiru et al. 2008; Muchiru et al. 2009; Porensky & Veblen 2011; Riginos et al. 2012). However, given the time periods apparently involved – half a millennium since the occupation of Maasai Plains – the rate at which woody species seem to be recolonising the archaeological glades during the twentieth century suggests that conditions have changed, such that whatever factor(s) was preventing these succession patterns from taking hold has been reduced.

Figure 4.7. Maili Sita, looking south from the northern extension of the main ridge, with the col and archaeological site in the centre of the image. The cloud-covered of summit of Mt Kenya can be seen in the distance (O. Boles)

4.4 Maili Sita

Besides Maasai Plains, the other major single focus of investigation during the BEIA/ HEEAL fieldwork was at Maili Sita[1]. The site sits atop a low col (c. 1900 m.a.s.l., centred on 0°15'52''N 37°08'47''E), c. 500 metres wide and across which archaeological material is scattered, between the steeply-sloping tip of one of the north-south ridges that characterise the Lolldaiga Hills, and a continuation of this topography to the north. To the east and west the ground slopes moderately down to alluvial valley floors and seasonal river beds. The col itself is covered by open grassland, in contrast to the valley floors and main ridge-slopes, which are open scrub woodland with denser tree and shrub cover lining the river channels. The topographic context of the site echoes ethnographic descriptions of Maasai and Samburu settlement locations to the north and south of Laikipia in Amboseli (Western & Dunne 1979) and Leroghi (Spencer 1973), respectively. It also echoes the kinds of open-air, slightly sloping ridgetop locations noted for Savannah Pastoral Neolithic sites in and to

4.1. The name 'Maili Sita', 'six miles' in Kiswahili, refers to the six-mile ridge on which the site is located; previous publications (e.g. Causey 2010; Lane 2011; Iles & Lane 2015) have erroneously used the spelling 'Mili Sita', which translates, rather unfortunately, as 'six corpses'.

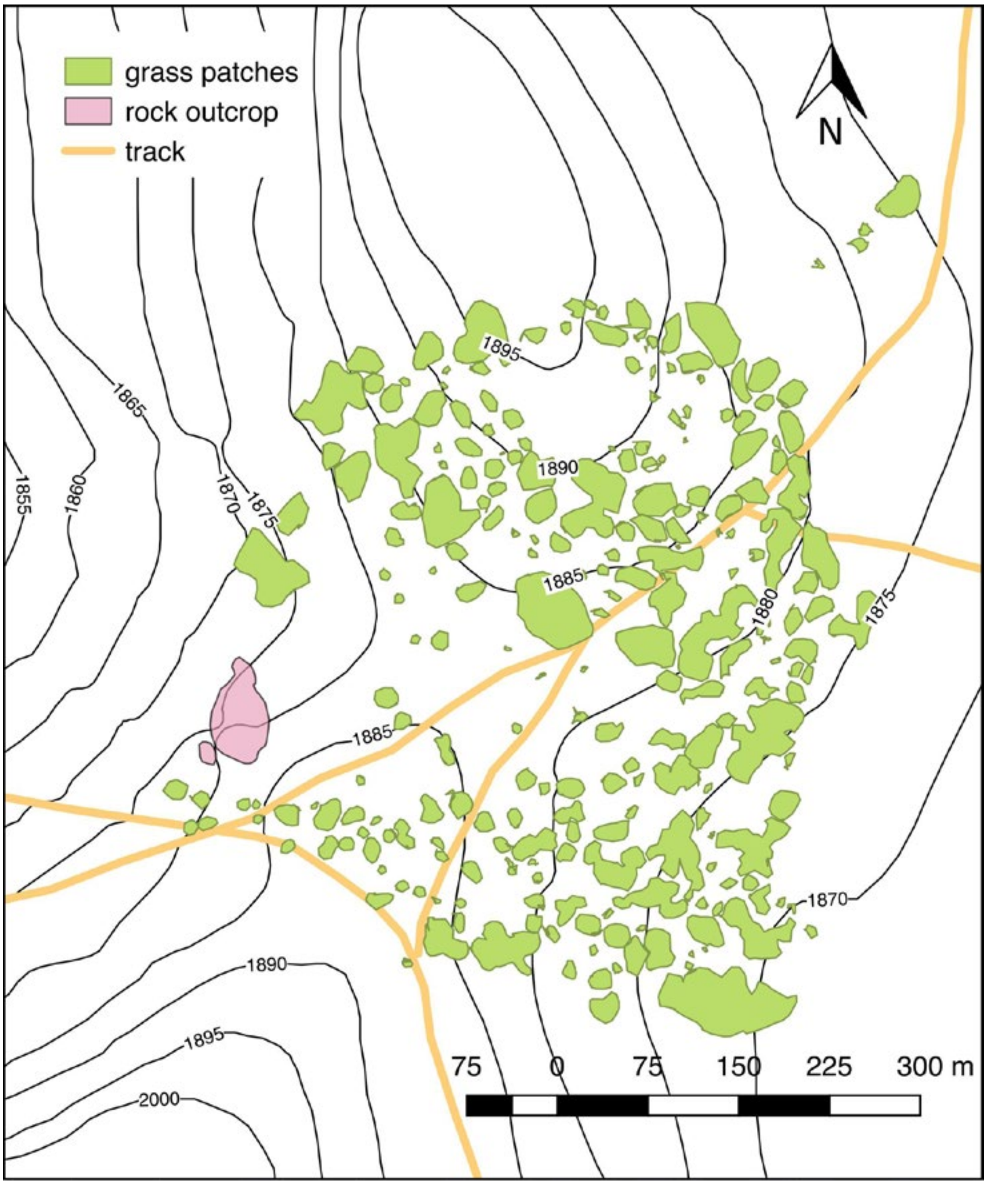


Figure 4.8. Maili Sita ridge, showing topography and main landscape features (prepared by O. Boles based on survey data provided by B Kimeu)

the west of the Rift Valley (Ambrose 1980; 1984), and follows the pattern noted by Causey (2008; 2010), and described above, for PIA sites in Laikipia. One of the most striking features of the site are well-defined, vaguely circular patches of long grass scattered across the col, and which – following the notions of soil enrichment and differential vegetation regrowth (e.g. Muchiru et al. 2008; Young et al. 1995) – the original investigators interpreted as relict features of former corrals. These were identified as *Cenchrus ciliaris*, 'buffalo grass', which in southern Africa has been shown to thrive atop mdden deposits (Denbow 1979), though recent reappraisal as part of the current research shows the Maili Sita patches to be largely composed of *Pennisetum stramineum*, as will be discussed.

4.4.1 *Excavations*

The site, first recorded during regional reconnaissance survey in 2003, was investigated over a number of field seasons between 2004 and 2010, though given the size of the col – almost half a square-kilometre – and the wide distribution of cultural material, excavation has not been comprehensive. In early 2004, excavation was focussed on the southern part of the site, with a 4x1 m unit (A/04) partially-located over one of the grass patches so as to check the aforementioned correlation with enclosure deposits or, indeed, any other

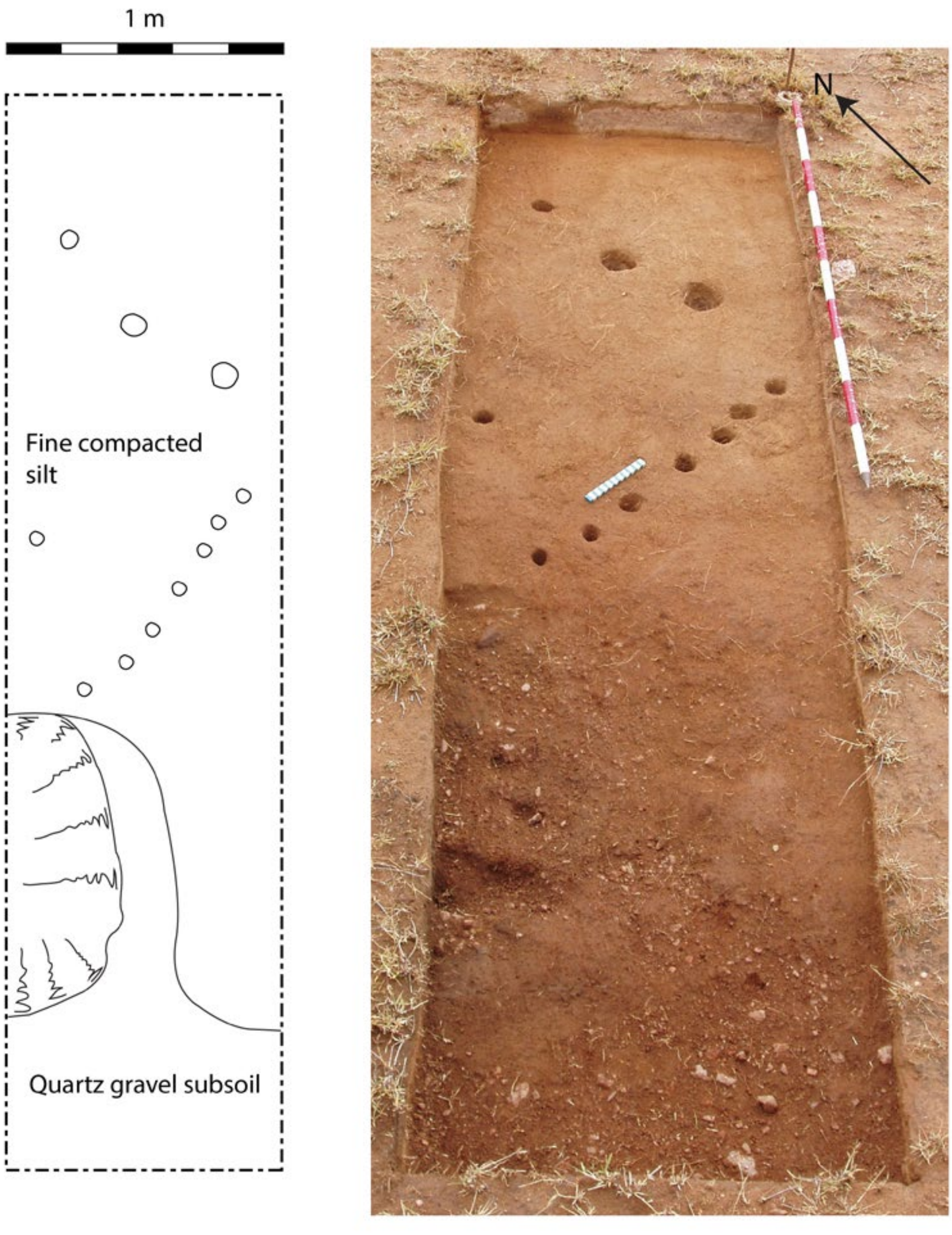


Figure 4.9. Unit A/04, showing post-hole series and hearth-feature in lower-left (photo and unit plan courtesy of P. Lane)

class of archaeological feature. Traces of bone, pottery and obsidian were noted on the surface, and these continued throughout the unit profile. Most notably, two linear series of cut features interpreted as post-holes were recorded in the northeastern part of the unit at approximately 5-7 cm depth; a sequence of seven such features ran roughly east to west and appearing to abut a line of three larger holes at right angles (Figure 4.9). Downslope, in the southern half of the trench was a shallow bowl-like feature cut into the natural sub-soil, that contained a series of ashy, charcoal-rich fills. This was interpreted as a hearth or ash dump.

Unit A/04 was reopened in mid-2004 and extended 1 m either side in order to establish the extent of these features (units AB-AE), and additional rows of post-holes were recorded, along with an area of compacted deposits thought to represent the degraded remains of trampled dung within a corral. The excavators felt that the combined plan of these features resembled the layout of a typical modern Maasai house (Lane 2005:101; see Andersen 1977), although it contrasts with the Pastoral Neolithic house found at Ngamuriak, which appeared to be broadly circular (Robertshaw 1990:56-65; see chapter two). Moreover, no floor surface was visible at Maili Sita, and it is possible that the post-holes relate to another type of feature, a corral, for instance. Additional units (BA-BE) of between 1x1 m and 2x2 m were excavated across the northern part of the site, also identified during earlier survey as having high archaeological potential. BA was positioned over a potential ashy midden, with intention of recovering a large faunal assemblage; this unit was indeed interpreted as a bone-dump during excavation. BC and BE were similarly located in areas of high archaeological potential, while BB and BD sampled additional grass patches. Although cultural material was recovered in these locations, no clear archaeological features were recorded in this part of the col.

The 2010 season opened a total of nine units across the southern and central part of the col (units A/10 to I/10); an additional trench (J/10) was sited on the eastern slopes, in order to investigate a possible midden, signified by surface exposures of faunal material within an ashy matrix. While unit A/10 was located very close to A/04, which exposed the post-hole complex described above, no comparable cut features were recorded. However, similarly ashy and finds-rich deposits were present, as well as a (roughly) circular charcoal-rich feature interpreted as a small hearth. Unit B/10 yielded a similar finds and sediment profile, though shallower than A/10, and was thought to be the northern limit of such deposits. This was borne out by the lack of charcoal or ash-rich deposits in the other units, which were located further along a northerly transect. Finds densities in these locations were low.

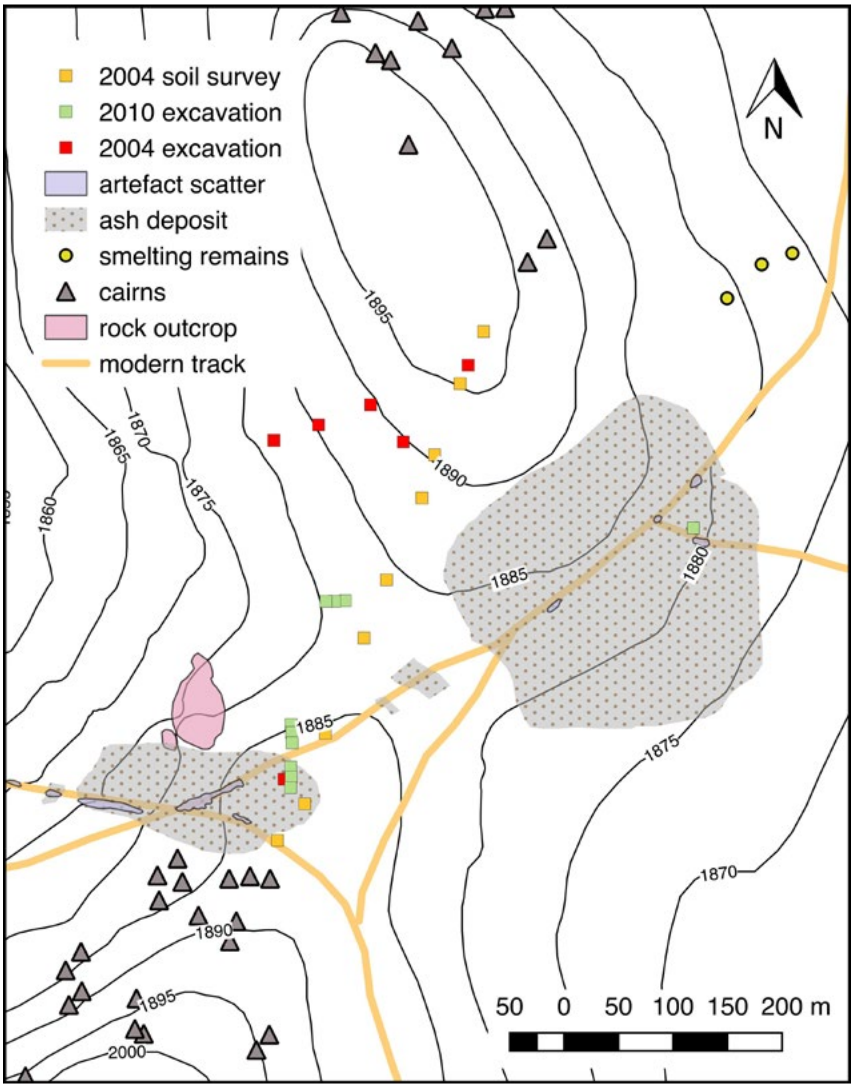


Figure 4.10. Distribution of excavation units and key features of Maili Sita (prepared by O. Boles, data provided by B. Kimeu)

4.4.2 Assemblages

A considerable array of samples was recovered from Maili Sita and intended for further analysis; besides the usual ceramics, lithics and fauna, sampling for palaeobotanical remains was undertaken, as well as fungal spores and an extensive programme of soil sampling for geochemical and micromorphological analysis. These analyses are in various states of completion, though in most cases work towards that has now ceased.

Unfortunately, the principal faunal assemblage from Maili Sita, generated during the 2010 field season, has been lost. Considerable effort was expended in trying to locate it, between searching the storerooms of the National Museum of Kenya and attempts to contact the original analyst, who remained determinedly unreachable. While the data generated by that original analysis is inconsistent and incomplete, the available information does point to a herding-focussed economy combining cattle and smallstock (sheep/goat), though with a large percentage of wild taxa represented (K. Mutundu, *pers. comm.* 2013). Indeed, of the total *number of identifiable specimens* (NISP = 143), 81 (57 %) were identifiable to taxon, of which 77 (95 %) were wild species, mainly small bovids (e.g. impala, Thompson's gazelle). A single specimen was reliably identified as ovicaprine, and three *Bos* sp. (*minimum number of individuals*, MNI = 2). Such a preponderance of wild taxa is unusual given the open-air setting of Maili Sita; hunter-gatherer sites in the region, at which such proportions would be expected, are very rarely found in such exposed positions, but are generally associated with rock-shelter environments (Mutundu 2010). The wild specimens were mostly recovered from surface and upper-level contexts, and it is my view that these are largely incidental and the result of natural accumulation of wild animal remains and not part of the archaeological assemblage. This position is supported by a lack of evidence of butchery or other processing of carcasses. The relative scarcity of domesticate remains is in line with the preponderance of off-site butchery and meat consumption among modern pastoralist populations, for example at Maasai *il-puli* meat-feasting sites (Mbae 1990; Mutundu 2010; Ryan & Karega-Munene 2012). What is more, bones from larger animals, like cattle, are more likely to be removed by scavengers, further skewing the recoverable sample in favour of small, wild taxa (Yellen 1977). Also noteworthy is that all three of the aforementioned *Bos* sp. specimens were teeth; Mbae (1990:286) observes that while an animal is butchered and consumed at the *ol-pul*, the head and neck, along with the viscera, are taken back to the *enkang* where they might be boiled for soup. Consequently, teeth, cranial bone and perhaps some cranial and cervical vertebrae would be expected to be well-represented in homestead refuse deposits. Interestingly, some of the tooth specimens (of which not all were reliably identified as domesticates) showed instances of enamel hypoplasia – deformities caused by disruption during the enamel formation process (Suckling 1980; Balasse et al. 2009) – which may suggest that the site was occupied during a period (or periods) of environmental stress.

Similarly, analysis of ceramics and lithics from Maili Sita has not been comprehensive. The former, though, is heavily-dominated by Kisima ceramics, linked by Siiriainen (1984) with the Laikipiak and found at pastoralist and hunter-gatherer sites across the Laikipia Plateau. A high density of worked obsidian recovered from lower stratigraphic levels may point to at least one occupation of the site prior to that to which the radiocarbon date pertains. Of the lithic assemblage more generally, modified blades and *outils écaillés* predominate, and obsidian, chert and quartz the main raw materials, which is again suggestive of links with the Elmenteitan tradition within and west of the Rift Valley (Lane 2011).

Beyond the main site, there are remnants of a reasonably intensive iron smelting industry some 50 metres northeast of the perimeter of the glade, and a considerable number of piled-stone cairns clustered immediately to the south at the tip of the main ridge and extending to the north. Archaeometallurgical investigations by Iles and colleagues (Iles & Martinon-Torres 2009; Iles & Lane 2015) of smelting remains at Maili Sita and other locations in the Lolldaiga Hills show similarities in technology and raw materials, yet furnace construction shows stylistic variation. This may point to multiple groups of smelters perhaps with shared ethnicity or tribal affiliation but who belonged to different kinship or clan-groups (Iles & Lane 2015). The smelting complex at Maili Sita has been dated to 170 ± 40 BP (post-1655 cal. AD, 2-sigma range, Beta-212297), and thus appears contemporaneous with the main site. However, it remains uncertain whether or not the smelters were pastoralists themselves; the location of the furnace remains close to but beyond the apparent extent of the settlement echoes that observed among contemporary Maasai, Samburu and Rendille, wherein smelting is attributed a certain ritual impurity and conducted outside settlements by a distinct sub-group, or 'caste' (Spencer 1973; Galaty 1982). The presence of Kisima ware at a settlement close to a similar cluster of smelting remains near Maralal on the Leroghi Plateau, to the north of Laikipia (Lane 2013), offers further indication that smelters and herders lived in close proximity, though drawing a firm correlation between a ceramic style and a specific economic regime would, of course, be problematic (see Ashley 2010; Lane 2015).

Roughly circular, piled-stone cairns have been recorded on and around the hilltop to the north of the Maili Sita col, atop two areas of raised topography to the east, and along the ridge line as it extends northward (Figure 4.10) The principal cluster, however, lies to the south of the site at the foot of the main ridge, where upwards of 55 have been recorded (Lane 2011). Also in this area are rock-engravings resembling *bao* or *mankala* boards. Only one of the cairns has been excavated thus far and was shown to contain a human burial, which though heavily degraded has been tentatively identified as a young adult female (Lane et al. 2007). No dates are presently available for the cairns, so links with the pastoralist settlement remain unsupported.

Preliminary phytolith analysis undertaken of samples across a single unit profile (unit BD) from the 2004 field season (V. Muiruri, unpublished data) shows that domestic species comprise up to 20 percent of the total phytolith assemblage throughout the occupation of the site. This figure, however, remains unconfirmed and is somewhat surprising given the environment and climate of the region today. Equally, neither is it impossible that some cultivation was practiced, especially given the possibility that the climate was generally wetter than today (e.g. Verschuren et al. 2000). Fungal spore data from the same study (ibid.), while again provisional, seems to confirm the presence of domesticated animals via a high proportion of *Sordoriaceae* spores, which has been noted in both modern and archaeological samples of cattle dung from southern Africa (Carrión et al. 2000).

4.4.3 2004 Soil Survey

In early 2004, a team led by Robert Payton and working under the auspices of the BIEA project, conducted a comprehensive survey of soils across the Lolldaiga Hills Ranch. This was intended to provide a chronology for sedimentation and erosion histories, evidenced in soil catenary sequences. In linking this data to the archaeological record, the work aimed to produce an integrated history of human land use and environmental degradation. A similar undertaking by the same researchers in Kondoa district, Tanzania, exposed a history of severe erosion significantly pre-dating the appearance of domesticated livestock, or, indeed, intensive farming (Payton et al. 1992; Lane 2009). At Lolldaiga, aerial photographs were used to identify landforms, erosion features and current vegetation distributions across the Sinyai river drainage system in the northern part of the ranch, following which a series of transects were established to cut across environmental gradients within the catchment of the Maili Sita site (Payton 2005).

As mentioned above, the northern plains of the Lolldaiga Hills Ranch – or more specifically, the footslopes of the hills as they drop into the plains – are frequently cut by deep erosion gullies, many of which combine to form extensive badlands. While topsoils are often poorly developed and prone to crusting, which exacerbates run-off and erosion, the walls of the gullies, which can be as much as eight metres high, show evidence of advanced soil development in the past, in the form of clay-rich argillic sub-soils which form over several millennia and at Lolldaiga likely date to the Pleistocene (Payton 2005:50-1). Along with features such as sandy surface wash deposits and pedestal features beneath rocks and shrubs, and the deep and weakly-developed sandy top-soils in the gully heads and valley floors, the evidence points to severe and relatively recent episodes of sheet or rill erosion.

Among the most dramatic gullying is located along the east pediment slopes of the main ridgeline immediately to the south of Maili Sita. Sheet erosion of hill slopes and the accumulation of sandy deposits on pediments and valley floors is a natural consequence of geomorphological and climatic processes in semi-arid savannah environments (Milne 1936). However, the slopes in question, lying beneath a steep sided, poorly vegetated ridge, are particularly susceptible to hill wash. Payton (2005:52) contends that this may have been partially triggered by the greater intensity of land use in the area by the occupants of the archaeological site. The daily movement of livestock in and out of the site may have trampled, de-vegetated and compacted the soil, exacerbating and concentrating run-off and accelerating the formation of the gullies; a modern parallel to this effect can be seen in the graded roads across the ranch, which become heavily rutted after periods of rain. There is certainly scope for further investigation of the gullies, such as the dating of stratigraphic bands and alluvial sediments, that may help diagnose the degree and nature of their potentially-anthropogenic origin.

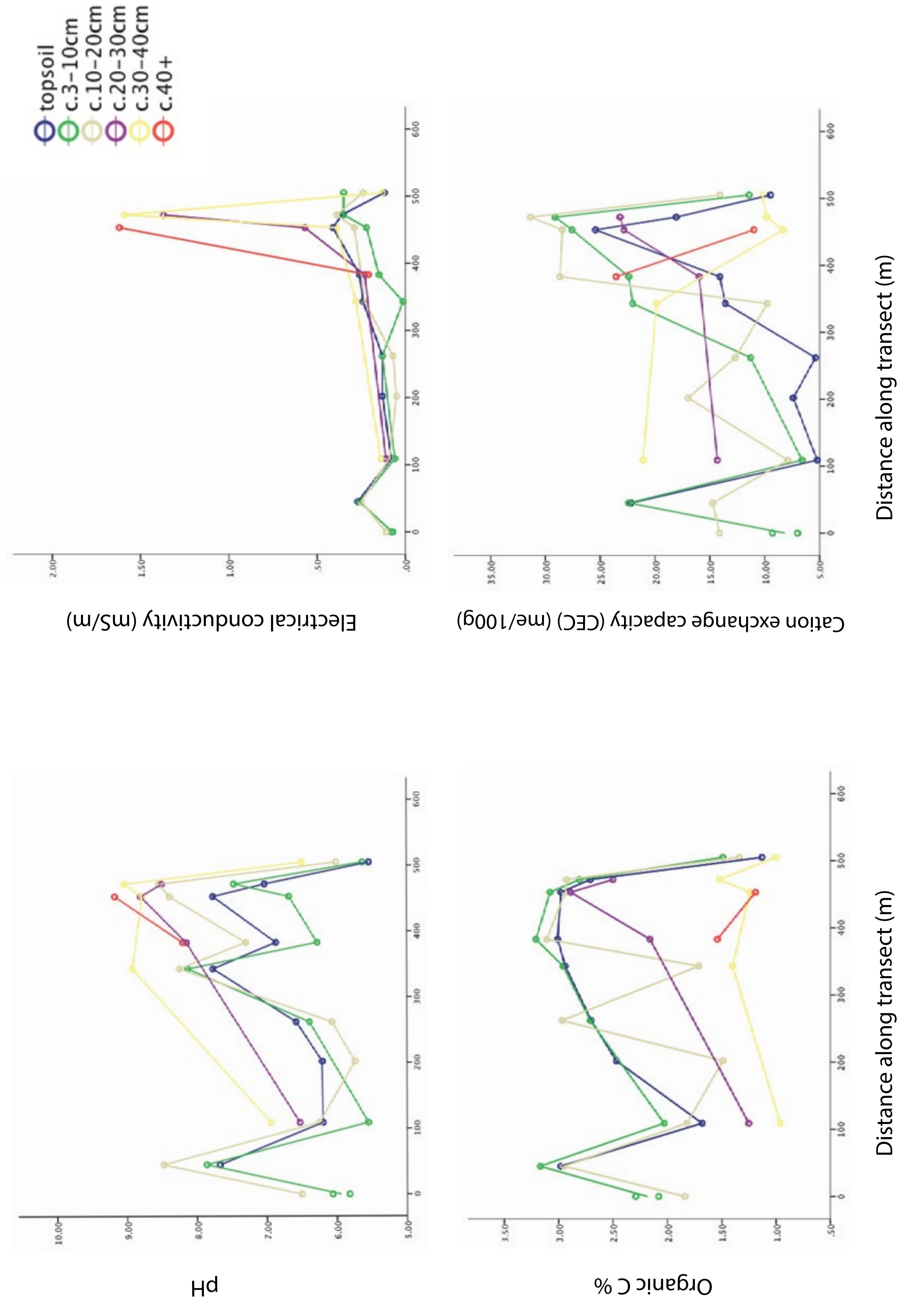
The richest dataset generated during the 2004 survey pertains to samples taken along two transects across the Maili Sita col. Bulk samples were taken every 10 cm at depths ranging between the surface and 40 cm, with locations spaced between 40 and 100 m. One of these transects (T2) began at the top of the ridge, towards the northern edge of the archaeological site, running in a west-north-westerly direction towards the Sinyai river valley, which today contains water only during and shortly following the rains. The transect was positioned so as to investigate the catenary sequence across the ridge flanks, highlighting land-forming processes and any evidence of erosion events. The second transect (T3), ran along the crest of the ridge, bisecting the archaeological, and was intended to establish the distribution of anthropogenic deposits. The northern-most sampling site along transect T3 was located in the same part of the site as the most westerly of T2, at the foot of the slope that marks the limit of the col and the northerly return of the main ridge-line. While the data generated during analysis of the soil samples remains unpublished, that which has been made available (P. Lane, pers. comm. 2013) is provided in the appendices; a discussion of some elements of the results can be found in Payton (2005) and is summarised below.

Payton (2005:54) notes that all soils across the ridgetop and down the flanks show evidence of severe erosion, despite the fact that there are no steep slopes in the vicinity that might produce significant runoff during heavy rains. Indeed, the eastern and western slopes rarely exceed 3-5°. These areas are characterised by shallow Chromic Luvisols, rarely more than 40 cm deep and lacking a well-developed A-horizon, which appears to have been stripped leaving deposits of quartz residuum. Loose sandy layers of 3-5 cm depth overlie weakly developed topsoil horizons comprised of loamy sands containing abundant angular quartz pebbles and rounded, nodular ironstone. At around 15 cm depth, these rest atop less stony, red argillic sandy clay loams or maasive, stony BC horizons at the transition to the underlying weathered gneiss.

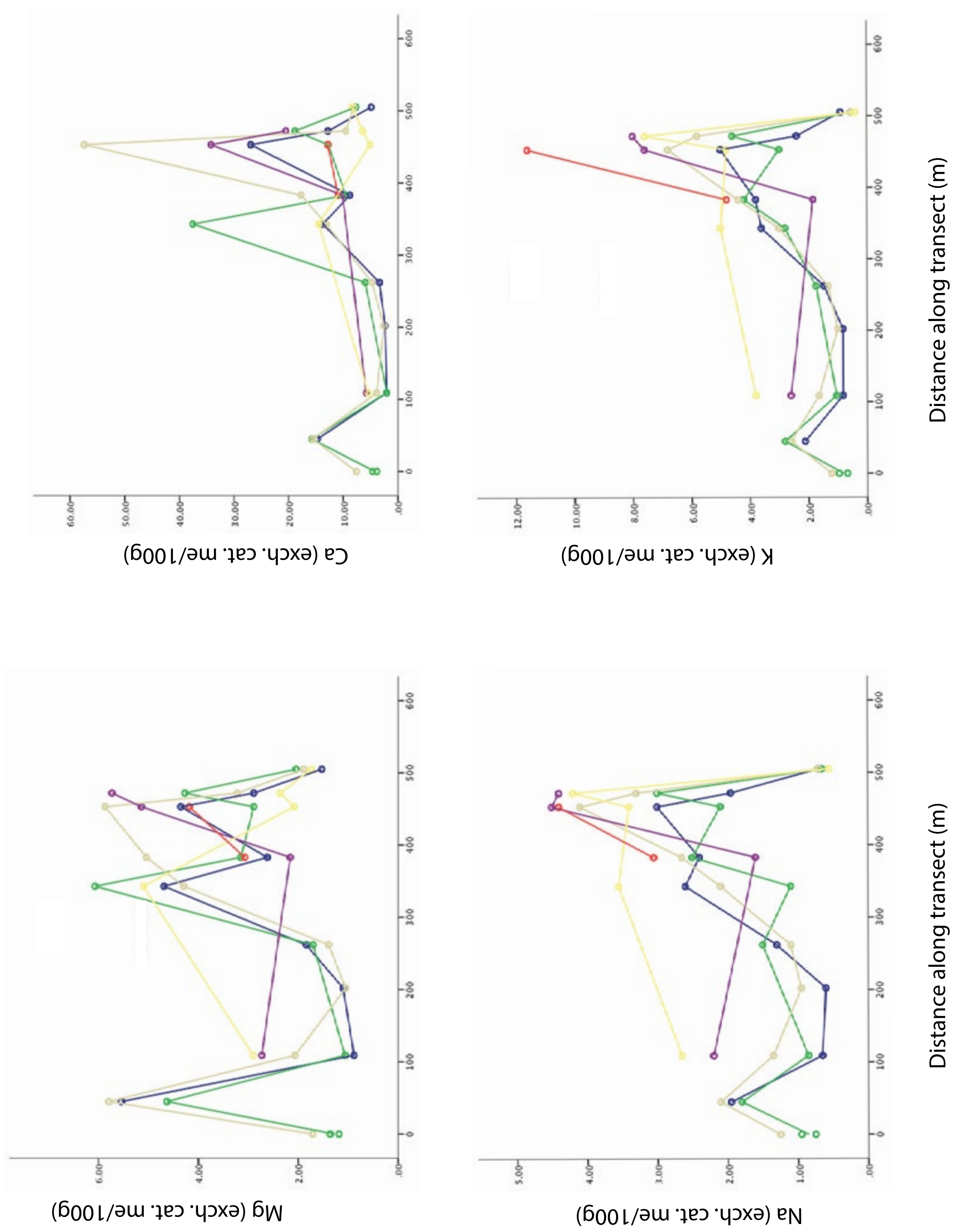
Samples were analysed for cation exchange capacity (CEC), Mg, Na, Ca and K exchange capcities, pH, total organic carbon %, electrical conductivity, and particle size (sand, silt and clay). The results are shown below (Figure 4.11). There is clearly significant variation across the site, most obviously with respect to the elevated organic carbon, electrical conductivity, pH, cation exchange capacity, and exchangeable Mg, Na, Ca, and K observed at the northern and southern ends of the col, and in the samples from the eastern ridge flanks. These elevations suggest considerable enrichment of soils in these locations, commensurate with that which might provisionally be expected to result from high inputs of dung, while the kinds of erosion processes outlined above might account for the transmission of these enrichments downslope towards the valley floor. For example, organic carbon is shown to be enriched in the topsoils of both the ridgetop and the valley bottom, while being notably depleted in the middle pediment slopes. Such a pattern could be expected to result from colluviation and the burial of the calcareous black clays (pellic vertisols known as 'black cotton' soils) in the valley bottom by underdeveloped sandy arenosols. The latter show the kinds of weak pedogenesis expected for relatively recent deposition.

Payton's (2005:53-55) own discussion of the soil survey data from Maili Sita seems to equate these enriched locations with the circular grass patches, proposing that the physical and chemical characteristics of soils within these areas are indicative of degraded dung and other refuse associated with pastoralist settlements, such as wood ash. He points to consistently higher organic carbon and enrichment in exchangeable calcium and potassium compared to other parts of the site, as well as more frequent instances of fragmentary charcoal as evidence of this. His records from the main soil survey are supported by an additional transect which saw samples taken at 25 metre intervals between two (unidentified) patches, noting slightly elevated pH and considerable increases in exch. K at either end. Notably, though, available phosphorus, an important if coarse indicator of degraded dung and other refuse at archaeological sites (Provan 1971; Conway 1983), shows little variation within and outside of the patches tested. The map made by the 2010 survey team (Figure 4.12) seems to corroborate Payton's findings, with patches arguably most densely concentrated at the northern and southern ends of the site, though error margins in the recorded locations of the transect samples and lack of written records of vegetation at each sample site make such associations tentative at best.

This soil data, then, supports that generated during archaeological survey and excavation in pointing to particularly intense occupation at either end of the Maili Sita col. With samples at 40 to 100 metre intervals, it is, however, fairly coarse, and at such a low resolution it



topsoil
c.3–10cm
c.10–20cm
c.20–30cm
c.30–40cm
c.40+
pH
Organic C %
Electrical conductivity (mS/m)
Cation exchange capacity (CEC) (me/100g)
Distance along transect (m)
Distance along transect (m)


Ca (exch. cat. me/100g)
K (exch. cat. me/100g)
Distance along transect (m)
Mg (exch. cat. me/100g)
Na (exch. cat. me/100g)
Distance along transect (m)

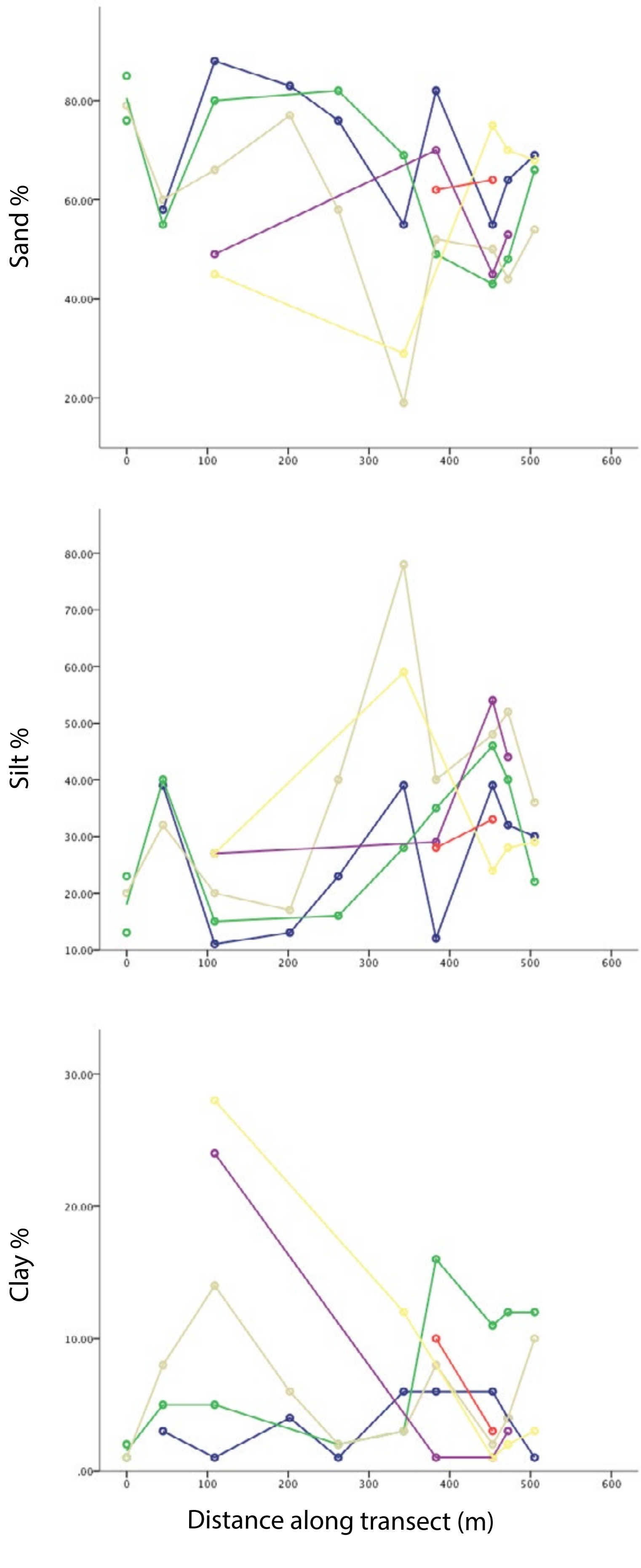


Figure 4.11. Results of Payton's 2004 soil survey transect 3, based on unpublished data (prepared by O. Boles)

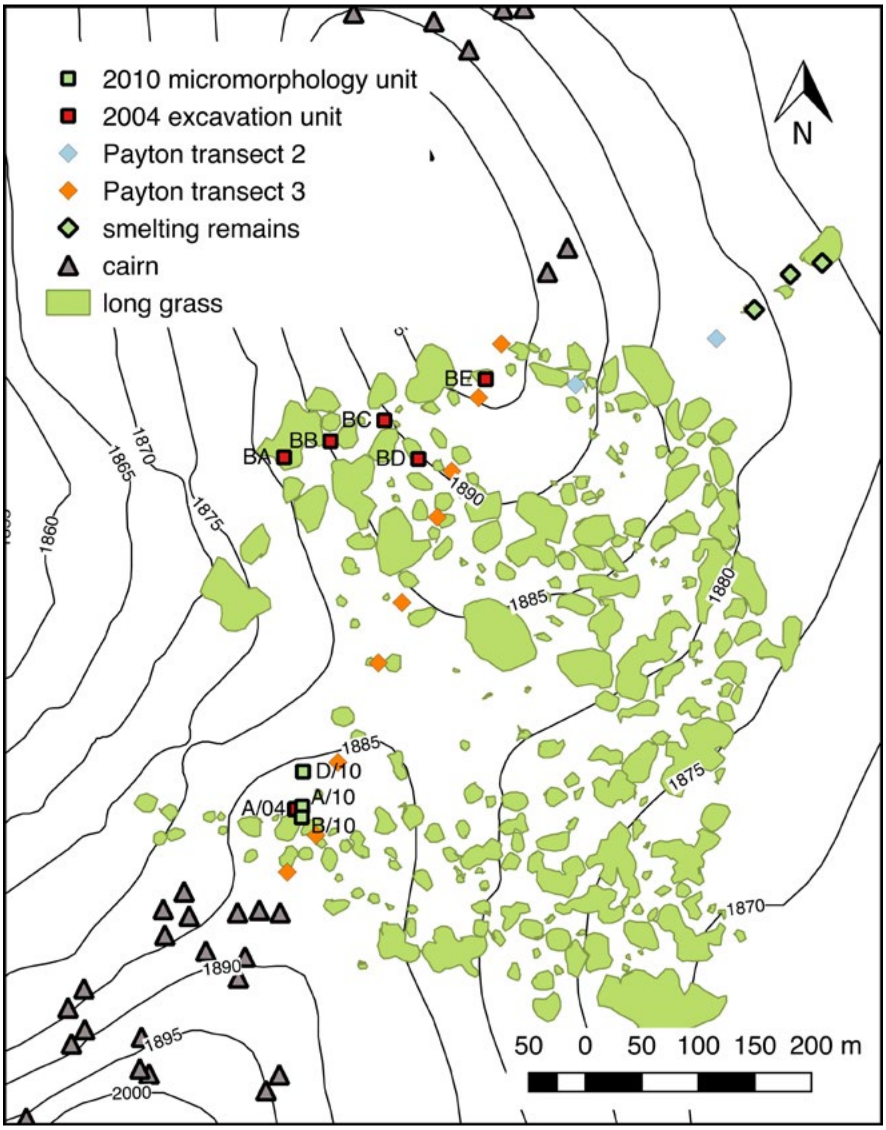


Figure 4.12. Grass patches and 2004/2010 investigative units ***at Maili Sita***

is difficult to be certain how closely the apparent spread of occupation deposits reflects reality. Furthermore, the variables tested are arguably better suited for an examination of soil productivity than in defining the human behaviours which create such deposits. While there is clearly interest in the suggestion that occupation at Maili Sita has been ecologically-beneficial, at least on one level, further work is needed before one can definitively comment on the anthropogenic processes behind these benefits.

4.4.4 Dates

Radiocarbon dates for Maili Sita are slightly problematic. Only two are presently available, one relating to the post-hole sequence in unit A/04, obtained from a piece of charcoal at the base of one such feature, and the date relating to the smelting remains to the

Table 4.1. Soil analysis by Payton of samples between two grass patches, redrawn from Payton 2005:55

Sample	Soil pH	Avail. P	Org. C %	Exch. K	Exch. Na
1	6.18	87.8	5.3	4.29	2.86
2	5.86	97.7	3.3	2.08	3.39
3	5.17	75.1	2.5	1.46	3.24
4	5.04	91.3	4.0	1.73	3.53
5	6.12	94.7	3.5	1.91	2.98
6	5.94	79.1	3.5	1.26	3.78
7	5.63	60.7	3.1	1.79	2.83
8	5.24	62.8	3.3	1.26	2.83
9	5.69	60.8	3.5	1.40	2.83
10	5.78	77.2	3.2	2.64	3.25
11	6.33	116.9	3.5	4.90	3.25

northeast of the main site, described earlier. The former returned a radiocarbon age of 240 ± 40 BP (Beta-189981)[2]; this unfortunately falls across a significant fluctuation in the calibration curve, and at 2 sigma (95% probability) returns merely a post-1530 cal. AD date. Consequently, previous interpretations have relied on the 1 sigma (68.5% probability) date of 1640-1670 cal. AD. Recalibration using the most recent curve improves things slightly, returning a date of 1520-1808 (2 sigma, IntCal13; Reimer et al. 2013), though a 300-year error margin remains of little use when attempting to link occupation with also-vague traditional ethno-histories; indeed, the date-range covers the entire period between the Maa expansion out of the Rift Valley (Galaty 1993) and the beginnings of Maasai age-set traditions in the early eighteenth century (Anderson 2016). The date from the smelting remains is scarcely better. A charcoal-rich fill at the base of a furnace yielded a radiocarbon age of 170 ± 40 (Beta-212297), returning a calibrated date of post-1655 cal. AD (2 sigma). While the possibility remains that the smelting and the settlement were contemporaneous, at least in part, it is plausible that the two represent distinct periods of human presence at Maili Sita, with smelting occurring later. Equally, a further date obtained from a furnace pit at the site of Cattle Dip, a cluster of smelting remains located around three kilometres north-west of Maili Sita, returned a date of 250 ± 50 (Beta-218135), post-1483 cal. AD (IntCal13; Reimer et al. 2013). It therefore might be tentatively suggested that iron smelting was undertaken in the Lolldaiga Hills across a period of several centuries

4.1. It should be noted that a typographical error in Lane 2005:102 gave the Beta-189981 date as 200 ± 40 BP. This was subsequently reprinted in Causey 2010:116 and Iles & Lane 2015:392. This variation leads to the *terminus post quem* for the site being stated as post-1642 cal. AD as opposed to the correct post-1520 cal. AD (IntCal13).

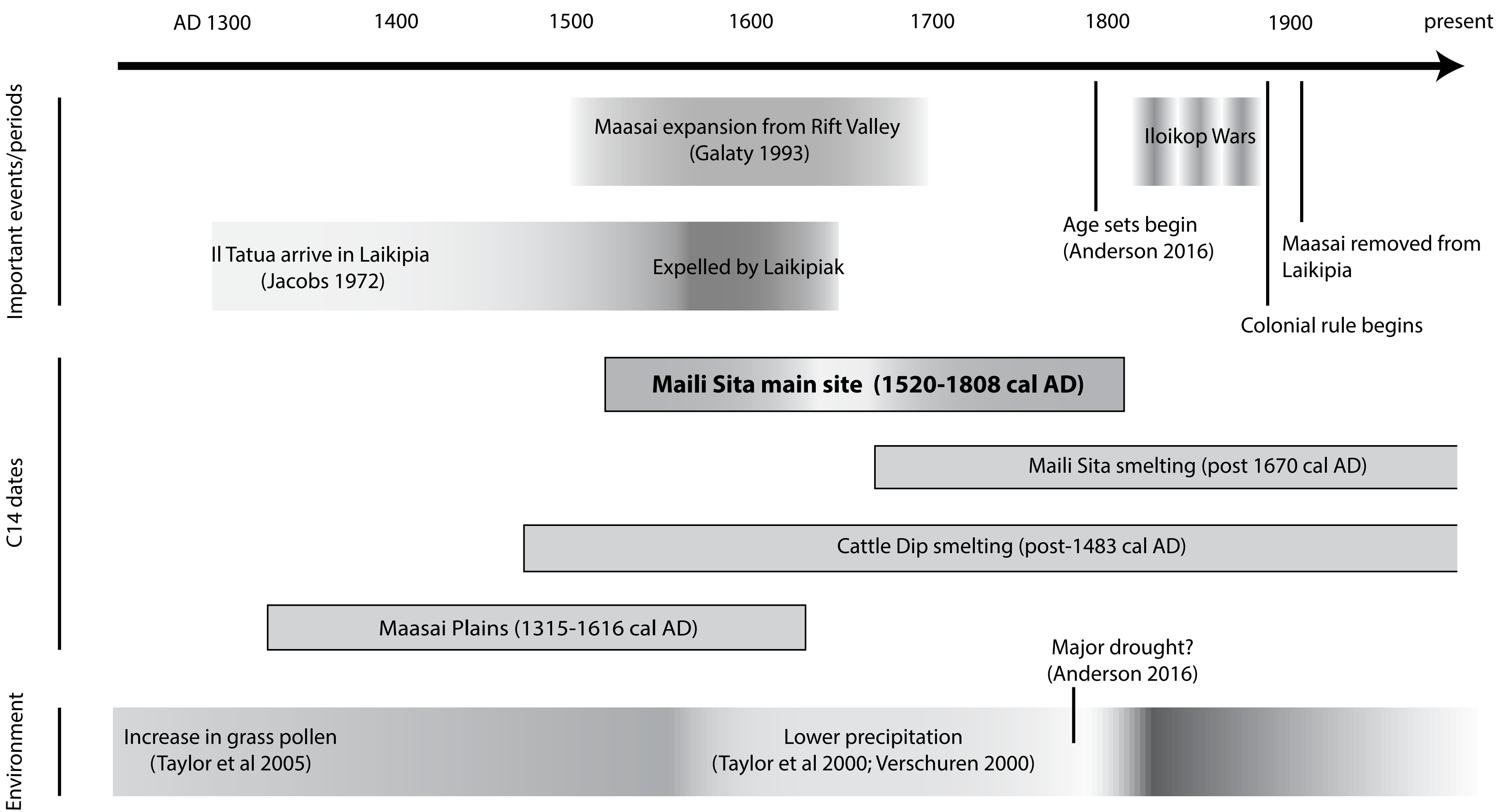


Figure 4.13. Major events and radiocarbon dates (2 sigma range). The pale shading within the Maili Sita main site date range indicates the calculation at 1 sigma range (prepared by O.Boles)

(Iles & Lane 2015), likely overlapping with pastoralist occupation at some stage. That the raw materials used by the smelters at Maili Sita and Cattle Dip appear to be identical, with ores derived from the titania-rich magnetite sands visible at the base of erosion gullies throughout the hills, yet the technologies employed in constructing furnaces differ, offers further indication that smelting was carried out by different groups at different times. Indeed, both sites lie close to potential ore-sources, and the proximity of smelting remains to the Maili Sita settlement may be little more than coincidental.

4.5 Possible interpretations

Much of the data generated by these previous investigations and the conclusions that were drawn are presented in various outputs (see Lane 2005 and sub-sections therein; 2011; 2013; Causey & Lane 2005; Causey 2008; 2010; Taylor et al. 2005). These have drawn on the wide range of datasets generated by the project(s) and attempted to position Laikipia and its history of human occupation within regional frameworks and narratives. In contrast to the mixed economic practices and fluid ethnic boundaries of the first and early second millennium AD, Maili Sita and Maasai Plains are presented as evidence for the consolidation of specialist pastoralism and the formation of Maa identities. Iron smelting and cairn construction are cited alongside the open-air settings and presence of domesticate-heavy faunal assemblages; such observations reflect the kinds of traits exhibited by modern Maa-speaking, specialist herding communities across eastern Africa. However, the possible interpretations of the sites vary. Maasai Plains is reminiscent of a modern Maasai *manyatta* or Samburu *lorora*, and has been interpreted as such (Causey 2008; Lane 2011), yet this ceremonial-association is based purely upon ethnographic analogy. The identification of discrete horizons in the accumulation of the concentric middens points to a series of occupations such as would indeed be commensurate with a *manyatta*-like function. However, a series of domestic occupations might well yield a similar pattern of deposition.

Possible interpretations of Maili Sita are yet more diverse. Based on the spread of archaeological deposits and material culture, it might be argued – and this is not an exhaustive list – that the site evidences: i) occupation by a large population for a short time; ii) occupation by a smaller population over a longer period, with small-scale horizontal shifting of enclosures; iii) isolated and intermittent settlement, perhaps by way of seasonal camps; iv) several contemporaneous and semi-independent settlements, perhaps linked by kinship ties. The first, (i), is based on the fact that there is no stratigraphic evidence for multiple occupations, nor can distinct periods or places of activity be distinguished on the basis of material culture, due to its broad surface distribution across the entire site as well as stylistic and typological homogeneity. Furthermore, the link drawn between the grass patches and former enclosures presupposes that almost the entire col was occupied at some point. However, the same reasoning can be cited as support for scenario (ii), in that the same group merely shifted corral locations as dung accumulations grew, as is well-documented ethnographically (e.g. Western & Dunne 1979). Such a pattern could clearly create such expansive distributions of archaeological remains within years or decades, however, the lack of precision in radiocarbon dates would likely preclude the ability to distinguish early from later phases of occupation. Likewise, it is unlikely that (iii) could be securely identified though absolute dating, though again, depending on the length of time Maili Sita was used as a camp location, the distribution of archaeological residues could have been formed by a sustained regime of seasonal use. Finally, scenario (iv) is based on the fact that the two main peaks in the anthropogenic content of soils sampled by Payton, as well as the highest densities of material culture, appear in the northern and southern edges of the col, and that there appears to be relatively little difference between these areas. Again, such a pattern of nearby, kin-linked settlements, perhaps representing individual households, is found in the ethnographic record (e.g. Spencer 1973 on the Samburu). However, Payton's soil sampling was undertaken at an insufficiently high resolution to be able to make definitive comment on the isolation of anthropogenic inputs. Such a scenario would also likely contradict Payton's claim that the grass patches are linked to former corral locations, their distribution being arguably too widespread and amorphous for multiple distinct settlements to account for it.

4.6 Current research agenda

Based on the available information, it remains unclear which, if any, of these scenarios best describes the nature of human occupation at Maili Sita. This lack of conclusiveness is evident in publications to have arisen from this work, which refer to the occupation in broad terms: '[the site] appears to have been used as an area of pastoralist settlement' (Lane 2011:20). Consequently, the results from Maili Sita and Maasai Plains have been used to paint broader picture of pastoralist landscape use, with the co-occurrence of Kisima ware, in particular, cited as evidence for a wide-ranging culture of specialised herding present throughout the middle centuries of the last millennium. Instead of addressing

Table 4.2. Summary of possible interpretations of Maili Sita

	Evidence	Benefits	Limitations
(i) Large single occupation	Homogeneous and widespread deposits	Explains scale of site and lack of material differentiation within	Equifinality with (b) and (c); overreliance on ethnographic analogy
(ii) Sustained, shifting occupation	Homogeneous and widespread deposits	Explains scale of site and lack of material differentiation within	Equifinality with (a) and (c); dating cannot confirm distinct phasing
(iii) Multiple seasonal/periodic occupation	Homogenous and widespread deposits	Explains scale of site and lack of material differentiation within; fits current models of herding in Lolldaiga	Equifinality with (a) and (b); dates cannot confirm distinct phasing; no means to assess seasonality
(iv) Independent contemporaneous homesteads	Areas of particularly high intensity of occupation deposits	Explains north-south split in Payton's soil data; documented ethnographically	Contradicts links between patches and corrals

archaeological questions, the answers to which are obscured by the available data, these broad narratives have been linked with palaeoenvironmental reconstruction and modern ecological observations in order to explore long-term patterns of landscape evolution (e.g. Taylor et al. 2005; Lane 2011). Paleoenvironmental data has indicated how fluctuating climatic conditions may have encouraged or discouraged certain forms of landscape use, and recorded changes in the ecological composition of Laikipia appear to reflect these economic decisions. While Causey's work linking glade formation with human occupation would appear to sit alongside the modern ecologies of pastoralism described in chapter three to promote a largely complementary view of the long-term role that herders have played in promoting biodiversity in the savannah, Payton's description of probable anthropogenic erosion at Maili Sita and around the Lolldaiga Hills highlights possible negative connotations.

The compilation of Laikipia's 'Historical Ecology' has to some extent been successful in illuminating the broad trajectories of landscape evolution and how human occupation has shaped and been shaped by its relationship with that savannah. The complexities with which localised processes of environmental change have been linked with socio-political developments since the beginning of the colonial period (e.g. Larsen & Lane 2005; Ogotu 2005; Vaughn 2005) – and the start of detailed social and ecological documentation – has furthered our understanding of how eastern African environments and cultures are entangled (after Lane 2016a). However, understandings of the functioning of these processes prior to the nineteenth century remain vague. An Historical Ecological perspective, to be able to contribute to these questions, requires ever more precise data, relevant to the short-term processes and events shown to be so important in shaping longer-term trajectories of change. Just as archaeology has found it difficult to explain the human experiences behind cultural-stratigraphic sequences based on the meagre data that investigations of pastoralist sites have been able to supply, Historical Ecology in Laikipia has thus far been unable to reconcile knowledge of the complexity of human-environment dynamics with the lack of precision in historical information. If archaeology is to help provide such resolution, I would argue that different questions need to be asked of it.

The current view of Maili Sita, in summary, is that its inhabitants were pastoralists engaged in intensive cattle herding but who may have had access to cultivated crops or wild grains, either by their own hands or through exchange with agriculturalist or forgaing populations, perhaps to the south on the slopes of Mount Kenya and the Aberdare Range. They may also have had access to wild resources through contact with hunter-gatherer populations like the Mukogodo. Iron smelting may or may not have been directly undertaken by the Maili Sita community, though it was certainly practiced in the vicinity of, and likely contemporaneously with, the main occupation, perhaps by distinct groups of itinerant metal-workers. The presence of Kisima ceramics is thought to indicate both the presence of the Laikipiak and the existence of exchange networks between herders and hunter-gatherers. The cairns remain slightly enigmatic though may point to the presence of or contact with Cushitic populations, though not necessarily contemporary with the main occupation. From an ecological perspective, Payton's work has drawn attention both to the dramatic and potentially-negative effects of herding activity, such as the formation of erosion gullies and the stripping of topsoils, while highlighting the enduring enrichment of soil nutrients within the settlement. His association of the circular grass patches with livestock enclosures implies, when considered alongside the 2010 map of those features (see Figure 4.12, above), that almost the whole col was under settlement at one time or another.

Questions, however, remain. As discussed, the available radiocarbon dates are too vague to allow the data from Maili Sita to be inserted into wider ethno-histories concerning the emergence and connections of the Laikipiak and other groups circulating around central and northern Kenya during the last millennium. With numerous groups potentially-sharing behavioural characteristics like specialist herding, metallurgy (or access to it) and cairn construction, let alone intangible traits like age-sets and clan-based social organisation, and a meagre corpus of archaeological data supported by often-contradictory oral historical records, interpretations remain largely speculative. Fortunately, the array of prior work at Maili Sita does highlight its potential, most clearly through the implication in Payton's work that human presence has had a demonstrable and differentiated impact on the ecological conditions of the col.

A key theme of these introductory chapters has been pastoralist experience and the particular realities of life in the savannah. I would argue that the central dynamics in this experience are mobility and ecology, and that one cannot be understood independently of the other. Herders are forced to move around their landscapes in search of pasture and water, or in order to connect with other groups that may themselves be mobile, a pattern that to a large extent must be facilitated by ecology and available resources; culture and identity must surely be structured within this, even if that relationship is recursive. By the same measure, pastoralism has been shown to influence the ecology of the savannah, most powerfully through processes of grazing and settlement. These influences must therefore feed back into how mobility is structured. This interaction between mobility and ecology – between practice and context – is something that previous work on the prehistory of Laikipia, and arguably pastoralism in eastern Africa more widely, has yet to meaningfully engage with.

The following chapters are concerned with exploring these key dynamics and their interaction in the specific context of Maili Sita. Firstly, I consider the application of isotope analysis of faunal material to assess herd management strategies and the climatic and environmental conditions within which these are enacted. As will be explained, this kind of analysis deals directly with data relating to the daily life of herders and herds, through experiences of mobility, seasonality, climate and diet. This information might then be used to infer the nature of occupation at Maili Sita: when were people there? Where else did they go? What resources were available, and when? Not only does this kind of approach explore the ecological conditions to which the inhabitants of the site were subjected, locally and within their wider sphere of activity, but it will inform on the function of settlement at Maili Sita. As indicated by the case studies discussed in chapter three – on the Maasai, Samburu and Rendille – settlement function has a significant bearing on its form – its size and intensity of use, for instance – and consequently on its ecological impact. I follow my discussion of isotopes with a detailed consideration of that impact, with a focus on the soil and vegetation ecology of Maili Sita. Thus I hope to answer the research questions first outlined in chapter one:

- What was the nature of herd management at the site?
- What are the ecological legacies of human presence at Maili Sita?
- How might these inform complex interpretation of the occupation(s)?
- How does this interpretation affect regional social and ecological histories?

5

Enamel isotopes: Potential and Pilot

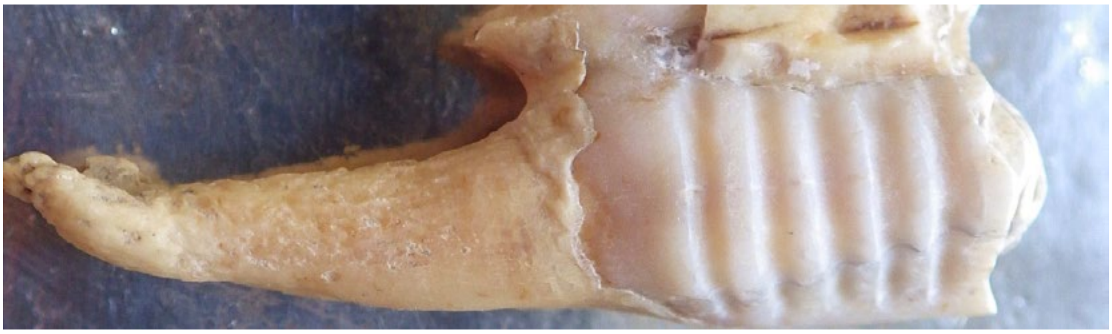


Figure 5.1. Tooth C12 from Maili Sita, showing bands of enamel sampled for isotope analysis (O. Boles)

This chapter explores how the isotopic composition of cattle tooth enamel might be used to investigate herd management strategies – mobility, seasonality, and diet – so as to aid the interpretation of the archaeological record at ephemeral pastoralist sites. The core notion here is that sites with specific functions might be associated with particular herding behaviours and conditions; I argue that knowledge of the latter – as accessible through isotopic data – might illuminate the former in instances where other archaeological residues are scarce. Following a review of the application of isotope methodologies in the context of pastoralist archaeology, hypotheses are set out for the kinds of isotopic signatures one might expect to find in cattle enamel given the practices associated with various forms of herder settlement observed ethnographically in eastern Africa. In conjunction with data drawn from modern analogue material, these hypotheses are then used as baselines from which to interpret isotope data pertaining to the faunal assemblage at Maili Sita. This pilot study was intended for expansion, curtailed for reasons explained previously (1.3.2, p.25).

5.1 ‘ You are what you eat…’

‘…(plus or minus a few parts per mil)’ (De Niro & Epstein 1976)

Many elements exist in different isotopic forms, wherein the number of neutrons present in atoms varies, changing the atomic mass. These isotopes can be either stable, existing in fixed proportions, while others are radioactive and subject to decay. While the latter exhibit changes in their relative abundance through time, stable isotope ratios can vary between environments and contexts, while always maintaining that global balance; understanding the processes that cause this variability can allow the origins of specific ratios to be identified. The information contained in such ratios has wide ranging application: isotope analyses of biological material have been used to address a range of archaeological questions, such as in relation to paleoenvironmental (e.g. Ambrose & DeNiro 1989; Sponheimer & Lee-Thorp 1999; Chritz et al. 2015) and dietary reconstruction (e.g. Ambrose & DeNiro 1986a; Sealy et al. 1987; Lee-Thorp et al. 1993; Murphy 2011; Brown & Thomas 2015), mobility (e.g. Balasse et al. 2002; Bentley et al. 2003; Balasse & Ambrose 2005b; Tafuri et al. 2006) and livestock management (Balasse et al. 2003; 2011; Henton 2012). The isotopic makeup of body tissue is largely derived from dietary intake, and therefore offers a direct link between an organism and its environment (Hedges et al. 2008). Furthermore, these links can be explored at a range of scales, from comparison between or within groups and communities, to the identification of specific events in the life history of an individual (Lee-Thorp 2008).

Biological tissues are formed during different periods within the life cycle of an organism, and their isotopic compositions can therefore be used to address different questions. Bone collagen, for instance, is constantly remodelled and averages dietary intake over the months prior to death; nitrogen isotopes ratios in bone, for example, can be used to differentiate populations with primarily carnivorous diets from groups reliant on fish or plant resources (e.g. Kiura 2005). Tooth enamel offers a different kind of information; once mineralised, enamel is not remodelled, such that its isotopic composition reflects conditions during tooth development (Weinreb & Sharav 1964; Moss-Salentjin et al. 1997). Furthermore, the mineral phase of enamel, bioapatite, is considerably less porous than in bone, such that the effects of diagenetic contamination on isotopic composition are minimal (Wang & Cerling 1994; Hedges et al. 2006); even still, the integrity of enamel bioapatite cannot be assumed (Lee-Thorp & Sponheimer 2003) and the analytical process includes various protocols to ensure against diagenetic alteration, as will be discussed in greater detail later.

In hypsodont mammal teeth, enamel forms by a process of accretion, growing incremental laminae such that enamel closer to the occlusal surface will have formed before that closer to the cervix and enamel root junction (ERJ; Hillson 2005; Hedges et al. 2006). Sequential samples at measured intervals across the enamel column can therefore offer a record of variability in isotope ratios across a known time-period, making it possible to determine if and when an individual has been subject to changing environmental and dietary conditions (Fricke & O'Neil 1996; Fricke et al. 1998; Balasse et al. 2001; Henton et al. 2010). It has been suggested that this can be achieved at a resolution of as little as five weeks in cattle teeth (Wiedemann et al. 1999).

5.1.1 *Oxygen - δ^{18}O*

Oxygen in mammalian body tissue is mainly derived from ingested water (Longinelli 1984), which for grazing animals in non-industrialised areas (i.e. areas with water-treatment facilities) is derived from surface sources as well as that contained in plants (Kohn et al. 1996). These in turn are related to the composition of meteoric water, 90% of which, on average, originates from evaporation over the oceans (Dansgaard 1964). Oxygen has two primary isotopes: ^{16}O and the molecularly-heavier ^{18}O, the numeric prefixes referring to the number of neutrons present. These are present across the planet in fixed relative abundances of 99.8% ^{16}O and 0.2% ^{18}O (Schoeninger 1995). Ratios in oceanic water broadly reflect these figures; the ultimate ratio manifest in enamel, then, is generally measured against that oceanic baseline, the international standard VSMOW (Vienna Standard Mean Oceanic Water). δ ^{18}O can also be reported in relation to the Pee Dee Belemnite (PBD) marine limestone standard, as is the case with the results presented here. Ratios are generally reported in δ notation in terms of parts per mil (‰), based on the equation below (Levin et al. 2009), where R is the ratio $^{18}O/^{16}O$:

$$\delta^{18}O(‰) = \left(\frac{R_{sample}}{R_{standard}} - 1\right) \times 1000$$

At every stage between evaporation over the oceans and the capture of a fixed ratio in mineralised enamel, the relative abundance of these two isotopes in water is subject to change, a process called fractionation; the ultimate interpretation of δ ^{18}O data relies heavily on the understanding of these mechanisms. For instance, in a process termed Rayleigh fractionation, initial evaporation favours the molecularly-lighter ^{16}O, while the heavier ^{18}O condenses more readily as precipitation (Gat 1996). Fractionation between these stages is mainly dependent on temperature and altitude, as water vapour is pushed over land and surface temperature decreases with altitude (Siegenthaler & Oeschger 1980; Poage & Chamberlain 2001). Consequently, δ ^{18}O in precipitation is depleted with distance inland (Dansgaard 1964). In temperate zones, high rainfall and low temperatures collaborate to produce severe depletions in δ ^{18}O during the winter months, while tropical, monsoonal climates show less pronounced variation (Dansgaard 1964).

Fractionation becomes more difficult to estimate once meteoric water is transferred to the earth's surface; the isotopic composition of surface water can be blurred by the mixing of various sources, such as ground-water and acquifers, as well as the distance water has travelled along a river system (Darling et al. 2006). Smaller bodies of water, however, are more closely linked to seasonal weather patterns (Leng et al. 2006) and are more severely affected by evaporation, which causes $\delta^{18}O$ enrichment through the preferential transfer of the lighter ^{16}O isotope (Gat 1996; Darling et al. 2006).

In cattle and caprines, enamel formation in the second and third molars takes place over the first and second years following birth (Brown et al. 1960) and in hypsodont teeth forms in layers downwards from the cusps to the roots (Hillson 2005). Sampling at intervals along the tooth crown can therefore show the full range of annual variation in isotope ratios, such as might be associated with behavioural and climatic seasonality. Oxygen isotopes have been used to tie these together, providing a temporal frame in which to view the kinds of behaviour-influenced data offered by other isotope ratios (e.g. Kohn et al. 1998; Henton et al. 2010; Towers et al. 2011; Henton 2012; Tornero et al. 2014; Henton et al. 2014). This has been applied in addressing various archaeological questions. For example, Balasse et al. (2002) used oxygen isotopes to explore the potential seasonality of variations in strontium and carbon in domestic animals at the coastal Later Stone Age site of Kasteelberg in the Southwestern Cape of South Africa. Though historical records document seasonal transhumance between coastal and interior upland pastures, this study identified mixed herding strategies, with some animals restricted in their movement while others were grazed further afield. A follow-up study (Balasse et al. 2003) considered management of sheep birthing seasons at the same site, noting a bi-annual breeding pattern that may have corresponded with peaks in the growth cycle of nutrient-rich grass species. Similar studies of breeding seasons have been undertaken elsewhere in the world; Henton (2012), for example, observes that lambing at Çatalhöyük was managed so as to happen in February, shortly before the arrival of the rich spring grasses. The argument is made that this may have been timed such that herds could be moved to the outlying pastures early enough to negate any risk of damage to crops in the vicinity of the settlement, a system employed by many agro-pastoralist societies engaged in seasonal transhumance (e.g. Barth 1961).

As described in earlier chapters, the climate of eastern Africa is primarily dictated by the north-south oscillations of the Inter-Tropical Convergence Zone (ITCZ), with longer term fluctuations connected to the east-west migration of the Congo Air Boundary (CAB; Nicholson 1996). Meteoric water in the region is therefore drawn from both the Indian Ocean – via the ITCZ – and transpired continental moisture from the CAB (Levin et al.

2009). While the CAB exerts greater influence in the Great Lakes region to the west and Ethiopia to the north, the rains in Kenya are generally drawn from Indian Ocean moisture. Consequently, inland precipitation exhibits $\delta^{18}O$ values consistent with those recorded at the Global Network of Isotopes in Precipitation (GNIP) station in Dar es Salaam, which sees rainfall drawn solely from Indian Ocean sources (Nicholson 1996; Levin et al. 2009; Soderberg et al. 2013).

GNIP, which is operated by the World Meteorological Organisation (WMO) and the International Atomic Energy Agency (IAEA), has recorded meteorological data relating to the oxygen isotope composition of precipitation, as well as temperature and evaporation rates, at numerous stations around the world since its establishment in 1960. Besides Dar es Salaam, stations in eastern Africa have been located in Kericho and Muguga, both in southern Kenya, and Entebbe, Uganda. The Muguga station only operated for two years, 1967-68, while the Kericho station collected sporadic monthly data between 1967 and 1970. More recently, monthly precipitation data has been recorded at the Mpala Research Centre (Soderberg et al. 2013), 20 km west of the Lolldaiga Hills, while Levin et al. (2009) have sampled water from rivers, springs, wells and rainfall at sites across Kenya, collected between 1975 and 2007.

There is a clear correlation between monthly $\delta^{18}O$ in precipitation at Kericho and Mpala, the two locations most useful for my purposes, with averages that match well with seasonal changes in rainfall. Precipitation at both sites shows enrichment during the January-February dry season of -1 to -2 ‰ and 0 to -1 ‰ in June through September, with Mpala showing a brief drop to -2 ‰ during August, probably associated with the continental rains. It

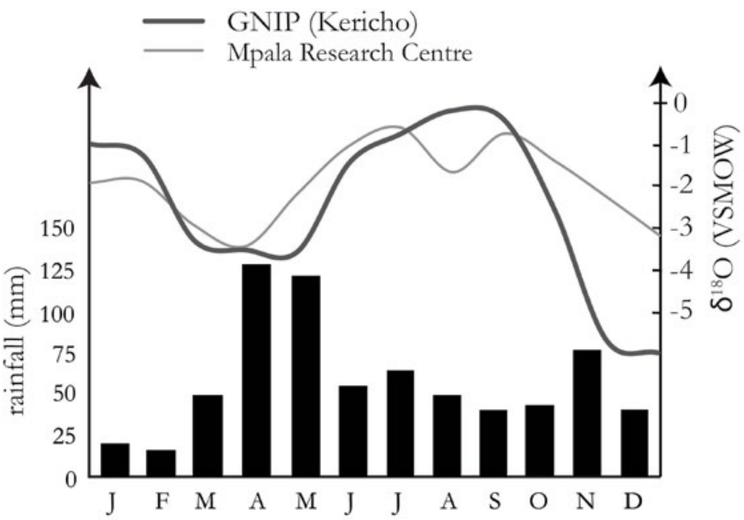


Figure 5.2. Oxygen in precipitation from GNIP Kericho and Mpala Research Centre, and Lolldaiga Hills average annual rainfall

should be noted, however, that some months received no rainfall and so provide no data. During the long rains of March-May, both sites show a maximum depletion of between -3 and -4 ‰, while the short rains of October-December see a maximum depletion of -6.3 ‰ at Kericho and -3.1 ‰ at Mpala. Therefore, $\delta^{18}O$ registered in the enamel of cattle in Laikipia should reflect this pattern of wet season depletion and dry season enrichment, as registered in the precipitation data.

5.1.2 Carbon - $\delta^{13}C$

$\delta^{13}C$ denotes the ratio of ^{13}C to ^{12}C, usually expressed relative to the Pee Dee Belemnite (PDB) marine limestone standard using the same equation as for $\delta^{18}O$ (R = 13C/12C; Ambrose & DeNiro 1989). In mammalian body tissue, this ratio reflects dietary intake (DeNiro & Epstein 1978), and in grazing animals is almost exclusively derived from ingested plants. Plants exhibit considerable variability in $\delta^{13}C$ based primarily on variations in the carbon-fixing process (O'Leary 1981); that is, the pathway by which carbon is assimilated during photosynthesis. C_3, C_4 and CAM (Crassulacean Acid Metabolism) plants process carbon in different ways; for instance, during the first stage of photosynthesis, C_3 and C_4 plants fix atmospheric CO_2 into unstable 3- and 4-carbon molecules, respectively (Ambrose & DeNiro 1989). These different processes cause differential fractionation of the ^{13}C isotope relative to ^{12}C, which is preferentially assimilated during photosynthesis (O'Leary 1995).

Broadly speaking, the photosynthetic pathway followed by a species is related to environmental conditions, such as nutrient availability, temperature, salinity and light intensity (Leng et al. 2008): C_3 plants are best-adapted to moist, temperate conditions, include all trees, most shrubs and most non-woody dicotyledonous species and exhibit the most depleted ^{13}C levels; C_4 plants are better adapted to warmer, drier conditions due to the ability to restrict moisture loss through the leaf surface, and include tropical grasses but no trees or shrubs; CAM, the least common pathway, is generally restricted to desert adapted taxa, and causes ^{13}C depletion between the values expected for C_3 and C_4, in the region of -20 to -10 ‰ (O'Leary 1988). Thus, animals that feed predominantly on plants of any one pathway will exhibit tissue $\delta^{13}C$ values reflective of those plants. Globally, the $\delta^{13}C$ values of C_3 plants range between -38 ‰ and -22 ‰; typically, higher values are associated with plants adapted to more open, dry environments, and lower values with higher humidity and/or dense canopy cover (Cernusak et al. 2013). C_4 plants yield values of between -16 ‰ and -9 ‰, in keeping with their better-adaption to arid conditions. (O'Leary 1988). It should also be noted that single species can also show spatial and temporal variation in response to local and short-term fluctuation in environmental factors such as climate as well as localised conditions such as tree cover. Furthermore, there are demonstrable differences in $\delta^{13}C$ between the parts of individual plants, with leaves and outer branches of trees depleted in comparison to the trunk (Heaton 1999). The carbon isotope ratios of plants are reflected in the tissue composition of animals that feed on them. Although there is a degree of ^{13}C enrichment in the transmission between ingested plants and tissue formation – in the order of 14 ‰ for bioapatite in medium and large herbivores (Cerling & Harris 1999) – there is little to suggest successive fractionation of these ratios occurs with increases in trophic level (Smith 1972). The body tissues of carnivorous animals (including humans) and their herbivorous prey would therefore be expected to exhibit similar $\delta^{13}C$ (Schoeninger 1995).

Carbon stable isotope ratios have been used to address a variety of archaeological questions, ranging from paleoenvironmental reconstruction (e.g. Ambrose & DeNiro 1989; Cerling 1992; Cerling et al. 1993; Balasse 2002; Zazzo et al. 2002; Chritz et al. 2015) to domestication and the inception of food production (Matson & Chisholm 1991; Cai and Qiu 1984; Murray and Schoeninger 1988). For example, Matson and Chisholm (1991) were able to track the introduction of C_4 maize, which replaced existing C_3 domesticates in North America, through analysis of midden deposits. In Southern Africa, studies of the dietary compositions of early farming communities have documented dependence on a combination of sorghum and other C_4 crops as well as on grazing livestock (Lee-Thorp et al. 1993); in this case, $\delta^{13}C$ ratios were considered alongside nitrogen stable isotopes $\delta^{15}N$ ($^{15}N/^{14}N$) in human bone collagen, the latter used to distinguish dietary trophic level, between primarily C_4-crop based consumption and carnivorous diets oriented towards C_4-grazers like sheep and cattle. Nitrogen stable isotopes, though, are not present in enamel bioapatite so will not be considered in great detail here.

While in Europe and other temperate regions the ubiquity of C_3 species hinders the modelling of specific environmental niches (Heaton 1999; Hedges et al. 2008), in eastern Africa there is a very clear altitudinal cline in the relative abundance of C_4 and C_3 grass species; grasses are exclusively C_4 below 2000 m and C_3 above 3000 m, while shrubs and woody vegetation is fairly consistently C_3 (Tieszen et al. 1979; Livingstone & Clayton 1980; Young & Young 1983). Consequently, it is possible to use $\delta^{13}C$ values to identify the feeding habits of individual animals (Ambrose & DeNiro 1986b; Ambrose & DeNiro 1989; Cerling et al. 2003) in order, for example, to distinguish between sheep and goat (Balasse & Ambrose 2005a) – primarily C_4 grazers and C_3 browsers, respectively

– notoriously difficult to differentiate based on skeletal morphology. In addition, it can be possible to model mobility patterns; Balasse and Ambrose (2005b) use the relative abundances of C_3 and C_4 plants between the floor of the Central Rift Valley in Kenya and the top of the Mau Escarpment, and their relative representation in livestock enamel to track livestock herding patterns. As with the studies of seasonal variation in oxygen isotope ratios described earlier, a programme of sequential enamel sampling was employed, so as to highlight seasonal dietary variability. Having tested the method on modern analogue samples from local Maasai herds, the study noted that at some of the key archaeological sites in the area – e.g. Maasai Gorge and Enkapune Ya Muto – cattle herding was largely restricted to the valley floor, while caprine management made use of more diverse feeding environments. Interestingly, however, the isotope data was unable to support a pattern of seasonal altitudinal mobility as noted in contemporary and historic ethnographic records.

The larger part of the Laikipia Plateau lies below the 2000 metre lower limit for the presence of C_3 grasses. There are, however, a number of locations where this altitude might be exceeded and a significant C_3 signature begin to register in the tissue of grazing species, namely, Mt Kenya (5199 m) and the Aberdare (Nyandarua) Range (3500 m average elevation). The Lolldaiga Hills sit between 1700 and 2300 m, a biotone at the C_4/ C_3 transition. When cattle are able to feed on grass, as they do by selective preference (Casebeer & Koss 1970 Dahl and Hjort 1970), an enriched $\delta^{13}C$ associated with a C_4 diet could be expected in most instances. Exceptions to this, however, might occur during severe drought and subsequent degradation of grassland resources, wherein animals might be forced to rely on browsing or herders might resort to foddering with C_3 taxa. Altitudinal mobility across the gradients presented by the Aberdares and Mt Kenya might also cause C_3-associated depletion of $\delta^{13}C$ values, though as described for the Central Rift (Balasse & Ambrose 2005b), prehistoric populations may not have utilised such a strategy. However, there have yet to be any concerted isotopic analyses of fauna relating to archaeological sites or contemporary pastoralist populations in Laikipia with which to test these assertions.

5.1.3 Strontium – $^{87}Sr/^{86}Sr$

While $^{13}C/^{12}C$ and $^{18}O/^{16}O$ consider the relative abundances of stable carbon and oxygen isotopes, with variability therein attributed to varying processes of fractionation between natural abundance ratios and eventual precipitation in biological material, most strontium isotope studies consider radiogenic ^{87}Sr in relation to stable ^{86}Sr. Both are present in geological substrata, yet vary in relative abundance. ^{87}Sr is a product of the radioactive decay of ^{87}Rb, which occurs at a known and constant rate, such that the ratio of radiogenic strontium isotope against its stable counterpart, ^{86}Sr, increases with geological age. While rock type does exert some influence, with some rocks containing more ^{87}Rb – and thus, producing more ^{87}Sr through radioactive decay – $^{87}Sr/^{86}Sr$ ratios can be broadly assumed to be proportionate to age of rock (Ericson 1985; Ericson 1989).

Strontium isotopic ratios in soils are in equilibrium with underlying geological formations due to processes of weathering (Dasch 1969; Ericson 1985; Sealy et al. 1991) and the composition of soils is ultimately transferred to plants (Ericson 1985; Hurst & Davis 1981) and then to animals feeding on those plants, continuing up the trophic levels (Sealy et al. 1991). Unlike $^{13}C/^{12}C$ and $^{18}O/^{16}O$, $^{87}Sr/^{86}Sr$ ratios are not subject to biological fractionation (Hurst & Davis 1981) and as with $^{13}C/^{12}C$ and $^{18}O/^{16}O$, the presence of particular ratios will reflect conditions during the period of mineralisation. An understanding of local and regional geologies can therefore be used to identify foraging sources based on the Sr ratios present in animal tissue (e.g. Koch et al. 1995; Chamberlain et al. 1996). Importantly though, there is a measurable and variable offset between the strontium composition of soil and rock and that of ground moisture, ultimately taken up by plants, influenced by an array of variables; atmospheric and ground water, geomorphological processes such as colluviation and alluviation, sea spray at coastal sites and modern inputs like fertilisers can significantly impact local ratios (Bentley 2006). These factors, among others, convene to determine the biologically-available strontium signature at a particular location. For example, Sillen et al. (1998), in a study of an early hominin site in South Africa, found that ratios in plants growing close to stream beds diverged from those of drier areas in the vicinity, exhibiting signatures more closely aligned with local geology. Consequently, for the purposes of provenancing biological material, it is important to understanding the proportion of *biologically-available* strontium across the range of possible source locations, which may vary considerably in composition across short distances.

Though perhaps more limited than C and O isotopes in terms of the types of questions that can be asked of them (Hedges et al. 2008), with fewer variables exerting a significant influence, the association of particular strontium signatures with particular locations has proven valuable for archaeological purposes. Examination of ratios in sequentially-sampled enamel has facilitated the tracing of patterns of mobility among human populations (Bentley & Knipper 2005; Tafuri et al. 2006; Giblin et al. 2013) and the migratory behaviour of prey species (Britton et al. 2011; Pellegrini et al. 2008 Henton et al. forthcoming). It has also been used to interpret the cultural significance of particular locations based on the distances over which influence is exerted, such as at Durrington Walls in southern

England, where cattle are seen to have been brought from as far as the Scottish Highlands for participation in large-scale feasting rites (Viner et al. 2010). Another recent application in an eastern African context has looked at how strontium signatures in ivory can be used to develop object biographies and understandings of the nineteenth-century caravan trade and big-game hunting (Van Der Merwe et al. 1990; Coutu 2015).

The geology of eastern Africa is complex and heterogeneous, with the relatively young volcanics of the Rift Valley interspersed with outcrops of the Precambrian African Basement Complex (Baker 1967; Hackman et al. 1989; Simonetti & Bell 1995; Rogers 2000). At a fundamental level, these diverse geologies would be expected to yield distinct strontium isotopic signatures and that these would be transmitted to the body tissues of local animal populations, with the volcanics yielding the kinds of lower values associated with younger substrata, and higher signatures overlying more ancient formations (Koch et al. 1995; Coutu 2011). Talbot et al. (2000) have suggested that young Rift Valley volcanics should yield values of up to 0.7060, while Precambrian formations might be expected to exceed 0.710. In Laikipia, the dominant geology is of Miocene-age phonolitic lavas, with outcrops of the Precambrian basement, of which the Lolldaiga Hills is one such outcrop (Hackman et al. 1989). While Mt Kenya is notably young, composed predominantly of Pliocene tuffs, the Aberdare Range, which delineates the southwestern boundary of the plateau, is a more ancient, Miocene formation (Allen et al. 1989).

Studies of strontium isotope ratios as manifest in animal tissue in eastern Africa are relatively scarce, largely restricted to tracing elephant mobility and the sourcing of ivory (Van Der Merwe et al. 1990; Koch et al. 1995; Coutu 2011; 2015). Koch et al. (1995) studied variation in carbon, nitrogen and strontium compositions across elephant teeth and bone from Amboseli National Park, finding that rather than moving long-distances, elephants were engaged in local migration between distinct habitats; strontium ratios varied between individuals by as much as ±0.003 ‰, and corresponded with variations in $\delta^{13}C$ and $\delta^{15}N$, indicating that animals were moving between different geological zones in order to exploit a range of resources (vegetation zones, water, etc), likely on a seasonal basis. Coutu (2011; 2015) has developed this approach, using a suite of isotopic analyses to develop an 'isoscape' for eastern Africa (sensu West et al. 2010), with a view towards provenancing ivory; though the geology of the region is seen as too complex to be able to reliably source archaeological material based purely on strontium ratios, equifinality can be reduced by mapping the distributions of $^{87}Sr/^{86}Sr$ values and exploring how these interrelate with geological, climatic and ecological parameters. Even so, Coutu (2011:201) concedes that with respect to elephants in eastern Africa, the method is more useful for recognising where an animal has not been, than where it has, at least until more comprehensive baseline data are available.

5.2 Enamel Isotopes and herding strategies

For reasons explained previously, the isotope component of this dissertation has been restricted to a pilot study, based on a relatively small set of samples and intended – assuming its success – to provide a framework for the interpretation of the more substantive geoarchaeological dataset presented in the following chapter. The 'isoscape' concept and the idea that in eastern Africa it may be easier to identify impossibilities and limits than draw positive explanations of isotope data (Coutu 2011:201) provide inspiration; rather than taking individual data and attempting to contrive an interpretation, I set out a number of scenarios based on ethnographic analogues against which isotope data might be compared. Essentially, these models describe the kinds of isotopic signatures – $\delta^{18}O$, $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ – that would be expected to correspond to the herd management strategies associated with particular settlement types. Consequently, it becomes less necessary to have access to comprehensive baseline data, the provision of which, given the relative scarcity of previous isotopic studies of pastoralism in the region, particularly involving strontium analyses, as well as financial and logistical constraints, lies beyond the scope of this project.

As described in earlier chapters, the current interpretation of Maili Sita links the occupation with the Laikipiak, thought to be an early incarnation of the modern Maasai (Lane 2011). With the exception of the Mukogodo Maasai, for reasons discussed in chapter two (see also Cronk 2002), since the early twentieth century, following the colonial reallocation of grazing lands in central Kenya (Hughes 2006), the pastoral Maasai in Kenya have been effectively restricted to two districts – Kajiado and Narok – close to the border with Tanzania. Modern ethnographies have therefore focussed on these areas, and have noted a certain amount of homogeneity in settlement forms (Mbae 1990; Shetler 2007; Spencer 1988; 2003), a pattern that colonial-period accounts (e.g. Hollis 1905; Merker 1910; Krapf 1854; Thompson 1883) depict for the Maasai area more widely. Detailed descriptions of the various forms of Maasai settlement and herd management strategies have already been presented in chapter three, as has the environment and ecology of the Lolldaiga Hills and wider Laikipia Plateau (chapter four). The following, then, are generalised hypotheses of the patterns one might expect of the isotopic composition of cattle teeth were the occupation of Maili Sita to resemble one or other of these 'ideal types' broadly common to other Maa-speakers like the Samburu (Spencer 2003). I would stress, though, that this is not intended as an exercise in direct historical analogy (c.f. Hodder 1982; Wylie 1985). The longevity of these settlement forms clearly cannot be assumed given the lack of archaeological correlates, and even were that the case, the assumption that Maili Sita was occupied by Maa-speakers (Lane 2011) has not been confirmed; indeed, as I will argue later in this dissertation, the assumption may be misleading. Even so, I propose that this exercise, and the use of ethnographic case studies, provides a useful framework for thinking about how isotope data might be able to distinguish between distinct forms of settlement and pastoralist engagement with the landscape.

5.2.1 Scenario A: Enkang (semi-permanent homestead)

This scenario assumes that Maili Sita was occupied on a semi-permanent basis as the primary settlement for a community engaged in herding activities comparable to that seen at modern Maasai *enkangiti (*pl.). These homesteads function as central nodes from which there is a daily movement of livestock to and from pastures within a 15-kilometre radius. While it should be noted that, due to their lower capacity for travel, younger animals are generally grazed at smaller distances from the settlement than mature stock, within the area known as the *ololopoli*, this can still encompass an area of some 80 km^2 (Western and Dunne 1979). The daily range must also include a reliable water source, usually within 10 km from the settlement (ibid.). *Enkangiti* might be occupied for up to four years (Århem 1985); livestock would therefore mostly be expected to spend their developmental years at a single *enkang*.

Regarding the potential isotopic signatures associated with this settlement type, one would expect that oxygen ($\delta^{18}O$) values – accounting for fractionation, dampening and time-lagging in the process of enamel formation (e.g. Balasse 2003) – would exhibit similar patterns of variation to those recorded locally in annual precipitation at Mpala Research Centre and regionally at the GNIP stations in Kericho and Muguga. Though slightly drier conditions than today appear to have prevailed during the period of occupation at Maili Sita (Taylor et al. 2005), albeit interspersed with wetter spells (Verschuren et al. 2000), archaeological specimens would be expected to show comparable $\delta^{18}O$ values to those of modern cattle from the Lolldaiga Hills Ranch herd. Cattle in Lolldaiga today are managed such that calving seasons coincide with the rains (M. Roberts, pers. comm., 2014), a common trait among stock-keeping societies (Dahl and Hjort 1976); teeth from the archaeological assemblage would therefore be expected to indicate such a pattern, with the same seasonal peaks and troughs in enamel $\delta^{18}O$ data corresponding to similar points in the enamel formation process, across the domesticate faunal assemblage (see Balasse et al. 2003; Henton et al. 2010; Balasse et al. 2011).

Carbon ($\delta^{13}C$) values would be predicted to lie firmly in the expected range for diets composed of C_4 plants and expected for grazers in a semi-arid savannah environment in sub-Saharan Africa (Ambrose & DeNiro 1986b). Strontium ratios would reflect the local environment of the Lolldaiga Hills; the hills provide the most reliable grazing in the area and there is perennial access to water from the Timau River immediately to the south, supplemented today by the twentieth century dam reservoirs. As an outcrop of more ancient geology, the hills might be expected to yield higher $^{87}Sr/^{86}Sr$ values than the surrounding plateau, particularly the volcanic plains to the west. It is possible that were the occupants of Maili Sita to have operated an *ololopoli*-like system of grazing immature animals close to the settlement, then bone collagen drawn from mature specimens might present non-local signatures indicative of grazing further afield, though testing this is beyond the scope of the present study. Essentially, one would expect that isotopic values from cattle enamel in an *enkang*-type occupation would be broadly similar to those registered in the modern ranch cattle.

5.2.2 Scenario B: Manyatta (ceremonial gathering)

This scenario assumes that occupation at Maili Sita was linked to ceremonial gatherings of a wider pastoralist community, comprising members of multiple *enkangiti* coming together for significant events. As described in chapter three, *manyatta* are associated with Maa age-set graduations, during which herders from across a wider territory converge for a period of feasting and ceremony that takes place every seven years or so and marks the transition of the young *il-murran* warriors into elderhood (Hodgson 2000). For instance, each of the sixteen Maasai sections is comprised of several *manyatta* territories, which can span thousands of square miles (Spencer 2003). In consequence, animals present at archaeological *manyatta* sites might therefore have spent their formative years at a considerable distance from where their remains are recovered. The idea that ritual congregation might be observed in isotopic data has been successfully explored in various contexts (Thompson et al. 2008; Madgwick et al. 2013). Henton et al. (2014), for example, linked stable isotope data with dental microwear analysis (Mainland 1998) and were able to show that Neolithic cattle at Shi'b Kheshiya, Yemen, were raised in a variety of environments but all slaughtered within the vicinity of the site.

Meteoric $\delta^{18}O$ is shown by the data from Mpala Research Centre and that collected by the GNIP stations at Kericho and Muguga not to vary substantially at a regional level. While it has been shown that the isotopic makeup of precipitation in northern Kenya and west towards the Great Lakes region is affected by the continental moisture of the Congo Air Boundary (Levin et al. 2009), the ITCZ remains the dominant meteoric influence in Laikipia (Soderberg et al. 2013). $\delta^{18}O$ in cattle enamel would therefore not be expected to vary significantly given the scale of movement exercised within a typical *manyatta*-territory. It is possible that the higher rainfall experienced within the Lolldaiga Hills compared to the surrounding plains (Mizutani 1995) might elevate the range of values registered locally (Poage & Chamberlain 2001), however this would likely be difficult to recognise. It is also possible that variation in the relative positions of high and low $\delta^{18}O$ values could be attributed to distinct calving patterns, such as might be expected between individual herds; again however, given the incentive for calving to be timed to coincide with the rains, it seems unlikely that there should be too much variability in this regard within a single *manyatta* territory.

$\delta^{13}C$ might also yield mixed data; during drier years or periods, herds living away from the more amenable conditions of the hills might resort to greater amounts of supplementary browse, and thus show greater $\delta^{13}C$ variability than, for example, modern LHR cattle with an exclusively-C_4 diet. The $\delta^{13}C$ depletion associated with a C_3-oriented diet might also be felt were the high altitude pastures on Mt Kenya and the Aberdares exploited, whereby animals would be grazing above the 2000 m lower limit for C_3 grass taxa (see Tieszen et al. 1979; H. J. Young & T. P. Young 1983).

Non-local $^{87}Sr/^{86}Sr$ ratios would be the most telling indicator of a *manyatta*-type occupation. As discussed, the Laikipia Plateau is geologically diverse, with the Lolldaiga Hills a distinctive outcrop of ancient rock among the relatively young volcanic plains; livestock brought to the *manyatta* ceremony would likely have been reared atop these non-local geologies and would thus exhibit strontium isotopic signatures distinct from, for example, modern LHR cattle. These non-local signatures might show intra-annual change as herds moved between grazing areas. Unfortunately, though, owing to the unknown time-lag for strontium incorporation into enamel bioapatite, which may be in excess of twelve months (Montgomery et al. 2010), it is unlikely that direct links can be drawn with temporal variability in $\delta^{18}O$ and $\delta^{13}C$, from which to explore possible seasonality of movement patterns. Equally, given that *manyatta* are a point of convergence for herders and livestock from across a relatively wide region, one could expect the Maili Sita faunal assemblage to reflect a diverse range of isotopic compositions, most keenly in terms of $^{87}Sr/^{86}Sr$.

5.2.3 Scenario C: Seasonal camp

Transient camps can be established up to 35 km from the main *enkang*, so as to exploit distant pastures during the dry season, or as rainy season outposts in order to spare grazing closer to the homestead (Mbae 1990). These can be comprised of a number of families and herds. Under this scenario, Maili Sita would have been the location of one of these camps, seeing herds moving into the Lolldaiga Hills to take advantage of the more reliable dry season grazing available. Given the generally drier climatic conditions in the region during the seventeenth and eighteenth centuries (Taylor et al. 2005), it is possible that the hills provided wet season pasture and that the drier months were met with a movement to the even higher altitudes of Mt Kenya and the Aberdares. However, were this to be have been the case, it is perhaps more likely that Maili Sita was established as something resembling an *enkang*, but one at which large herds were only present on a seasonal basis.

$\delta^{18}O$ and $\delta^{13}C$ values would not be expected to differ greatly from those associated with either an *enkang* or a *manyatta*, being generally reflective of climatic conditions across the Laikipia Plateau and seasonal recourse to high-altitude C_3-grazing when necessary. Strontium data would therefore again be crucial; where at a *manyatta*, $^{87}Sr/^{86}Sr$ ratios in livestock enamel would be largely non-local, a signature associated with a seasonal camp might show intra-annual fluctuation between local and non-local grazing areas. As described above, strontium is incorporated over a longer and unknown period to carbon and oxygen, thus precluding direct temporal comparison. Even so, one would expect a variety of signatures to be registered.

5.3 Enamel Isotopes at Maili Sita

The scenarios presented here are clearly not exhaustive and are based around a fairly narrow set of criteria derived from a limited number of modern ethnographic observations. It is also crucial that the ways in which Maasai – and any others herders – accumulate livestock is considered. For instance, Ryan et al. (2000:464) observe how cattle are acquired through inheritance, gift-giving (which might include bridewealth), raiding and purchase (see also Aktipis et al. 2011). Indeed, the means by which cattle are acquired remain a central part of the acquiring herder's relationship with them, with descriptions like 'gift from' being incorporated into the names given to individual animals. By this process, the lineage of cattle, as well as processes of credit and debt are remembered and perpetuated (Galaty 1989). A further consequence, and one of immediate relevance to this exercise, is that presence

	ENKANG	MANYATTA	SEASONAL CAMP
$\delta^{18}O$	▯ Similar to local precipitation values (reduced range due to post-ingestion fractionation) ▯ Similar initial values between animals (similar birth seasons) ▯ Little difference between enamel and bone tissue ▯ Similar pattern in archaeological and LHR animals	▯ Broadly similar to local values (similar precipitation values across Laikipia Plateau) ▯ Little difference with Maasai and LHR animals ▯ Possible variation in position of curve due to different calving patterns between herds/ communities	▯ Similar pattern as for *manyatta*
$\delta^{13}C$	▯ Generally high values associated with C_4 rich diet ▯ Consistent across samples, perhaps with some lower values (increased C_3 intake) associated with higher $\delta^{18}O$ (i.e. drier) periods ▯ Similar juvenile and adult values ▯ Similar pattern to LHR cattle	▯ Generally high values (high C_4 intake) with lower values (increased C_3, high altitude grazing) corresponding with high $\delta^{18}O$ (warm, dry conditions) ▯ Values similar to modern Maasai	▯ Similar pattern to modern Maasai, possibly greater range of values (exploitation of more extreme environments)
$^{87}Sr/^{86}Sr$	▯ Constant, local signature (little movement beyond Lolldaiga Hills) ▯ Possibly some non-local contribution in bone tissue (due to greater grazing range of adult animals) ▯ Similar to LHR cattle	▯ Broadly non-local signature, showing some variation (movement between pastures) ▯ Similar level of variation to modern Maasai (though different values/ different pastures exploited) ▯ Variation within assemblage (herds brought from different parts of the plateau) ▯ Bone tissue may begin to show local signature	▯ Local and non-local signatures, ▯ Pattern corresponds to shape of $\delta^{18}O$ data ▯ Local signature probably corresponding with high $\delta^{18}O$ values (Lolldaiga as dry season pasture) ▯ Bone values could be local or non-local

Table 5.1. Summary table of isotope signatures expected given particular settlement scenarios, based on idealised Maasai types

of a cow in a given herd, observed either ethnographically or as part of an archaeological assemblage, does not dictate that it has always been part of that herd. The isotopic conditions it was subjected to as a young animal may therefore have been significantly different to those experienced by animals that had grown up locally. For instance, Ryan et al (2000:465) cite an informant from Kajiado in southern Kenya who remembered an animal owned by his father that had been raided in Laikipia, several hundred kilometres away. While clearly these kinds of anomalies have the potential, where the archaeological record is concerned, to skew isotope signatures away from those expected had a herd been brought up under 'known' conditions, through the consideration of suitable sample sizes one would hopefully be able to control for such influences.

The above scenarios, then, highlight the range of information that might be gleaned from isotopic analysis of faunal assemblages at various sites, and how such data might be used to help define the function of a settlement. The following section outlines the approach and results of the analysis undertaken on a selection of faunal material from the Maili Sita assemblage, alongside specimens relating to the modern LHR herd and the local Mukogodo Maasai community. Using the modern material as a baseline, archaeological enamel isotope data can be compared with the scenarios outlined above; as well as developing the use of enamel isotope analysis in the context of pastoralism in eastern Africa, in defining the nature of occupation at Maili Sita this component of the dissertation presents a lens through which the geoarchaeological and other datasets can be interpreted.

5.3.1 Strategy

Initially, I had planned to select teeth for sampling from the faunal assemblage generated during the 2010 excavations. The list of identified specimens includes a number of *Bos* sp. mandibular second and third molars (M_2 and M_3), commonly cited as the most appropriate teeth for this kind of analysis (e.g. Balasse 2003; Fricke & O'Neil 1996; Balasse et al. 2003; Henton 2012) the larger part of enamel in M_2s precipitates during the first year of life (Brown 1960; Balasse 2002) and therefore, in a complete and unworn tooth, provides a record of one full annual cycle of isotopic variability. M_3s form slightly later and are fully developed by around two years. Though the enamel forms over approximately the same period, mandibular teeth exhibit a longer enamel column than their maxillary counterparts and are thus more suited to sampling at a higher resolution. Unfortunately, however, I was unable to locate the 2010 assemblage , and was forced to select specimens from the 2004 excavations; this material had been less rigorously recorded and no M_3 specimens were available. Furthermore, none of the teeth had been recovered with their associated mandible or maxilla; there is no reliable method for distinguishing bovid M_1s from M_2s on morphological criteria (Beasley et al. 1993), so it is possible that the specimens selected represent only the former. The M_1 forms at birth and develops rapidly, to be complete at around three months. Though I have attempted to work around this issue, as will be discussed below, a lack of M_2 and M_3 specimens clearly precludes data with the temporal span needed to look at seasonal isotopic variation. Equally, the purpose of this study is not to provide comprehensive data but to explore the potential of the approach, and thus, I argue, retains its value in spite of these obstacles.

5.3.1.1 Tooth selection

Four teeth were selected from the 2004 assemblage, according to condition and quality of contextual records. Tooth BA0A is a lower M_1 or M_2 recovered from unit BA – located towards the northern end of the col – from context #100 (0-10 cm spit). The unit was interpreted as a refuse dump by the excavators, based on the large amount of faunal material and ashy deposits. Tooth wear is indicative of an older animal (see Grigson 1982). Tooth BA1A is an upper M_1/M_2 recovered from the same unit (BA), context #101 (spit 10-20 cm). Tooth wear is consistent with a mature animal, though BA1A is considerably less worn than the other archaeological specimens. BA1B is a mandibular M_1/M_2, also from BA #101, though has been heavily worn. C12 is a maxillary M_1/M_2, recovered from unit AC, context #12, an ashy layer close to the post-hole complex observed in unit A/2004 (of which AC is an extension). Again, wear is consistent with an older animal.

Additional teeth were obtained from modern cattle for the provision of baselines. Mandibular second molars from the remains of two animals belonging to the LHR herd were selected (LH1 and LH2). Both teeth were in reasonably early stages of wear, consistent with early maturity. These animals had died of natural causes sometime during 2012 or 2013, and their carcasses left in a field behind the main farm, where they are disposed of quickly by hyena and other wild animals. Two left mandibles were selected to avoid taking multiple teeth from a single individual. The animals would not have left the confines of the ranch during their lifetimes, and so provide a record of isotopic conditions local to the Lolldaiga Hills.

A third modern specimen (MA1) was taken from an animal belonging to the local Mukogodo Maasai, which was reported to have died during the severe drought of 2008-2009. Its remains had been left just beyond the northern perimeter fence of LHR, close to the site of Makurian Fence, discussed later in this dissertation. I had hoped to obtain samples directly from the Maasai with more precise details of animals' individual life histories, however there was a fear that this might arouse suspicions of witchcraft and hinder community engagement with future research projects. However, the Maasai are known to move widely and seasonally around the Laikipia Plateau – particularly in its northern reaches where agricultural land and privately owned ranches are less of a limiting factor (J. Parkenga, pers. comm. 2014) – and therefore the isotopic composition of MA1 was considered a non-local comparator. Thus, between the ranch cattle and the Maasai animal, these modern specimens represent local and non-local baselines, as advocated for studies of mobility by Bentley et al. (Bentley et al. 2003); in terms of $^{87}Sr/^{86}Sr$ in the archaeological samples, I will consider any divergence from the local signature represented in LH1 and LH2 to indicate grazing beyond the confines of the Lolldaiga Hills.

5.3.1.2 Sampling

Enamel samples were obtained in accordance with the protocol established by Balasse (2002). To negate the requirement for export permits for whole teeth, for which Kenya requires CITES permission, samples were taken in the archaeology department of the National Museum of Kenya, in Nairobi. Firstly, the height of the enamel column was measured, from the enamel-root junction (ERJ) to the occlusal surface of the buccal side of the mesial cusp (where present; Klein et al. 1981). Enamel surfaces were then cleaned using a diamond-coated burr to remove cementum and any other contaminants, and the teeth wiped clean using de-ionised water. Enamel was sampled using a Dremel 4000 drill, fitted with a 1 mm diamond-coated burr. Beginning at around 4-6 mm from the ERJ, samples were drilled in horizontal, parallel bands (c.2 mm) across the enamel column. Preference was given to sampling enamel from the buccal side of the distal pillar, with additional enamel sampled from the mesial column and lingual side if required. Utmost care was taken to avoid contamination with dentine from drilling beyond the depth of the enamel. 20-25 μg was obtained from each sample. Samples were taken at approximately 3-4 mm intervals (measured from the centre of each band) across the length of the enamel column. The burr was cleaned between each sample using a sonicator and de-ionised water, and the tooth surface wiped clean.

Samples were brought to UCL for processing and analysis, where each was halved into roughly two 10 μg aliquots, one to be used for strontium isotope analysis, as will be described below, and one for isolation of the inorganic carbonate component for oxygen and carbon analysis, which are undertaken at the same time. Samples allocated for the latter were immersed in 2-3% NaOCl for around 18 hours to remove organic contaminants, after which these were centrifuged at 13,000 rpm for five minutes, and washed in de-ionised water three times. Next, in order to remove any diagenetic carbonates that may have formed subsequent to the death of the animal, samples were immersed in 0.1M acetic acid for four hours, before being centrifuged and washed as above. The aliquots were then dried in a drying oven at 40°C for two days. Analysis was undertaken by Dr Anne-Lise Jourdan at the Bloomsbury Environmental Isotope Facility (BEIF) using a ThermoFinnigan DeltaPLUS XP stable isotope mass spectrometer attached to a ThermoScientific Gas Bench II device. Samples were analysed alongside international and laboratory standards of known isotopic composition in order to account for drift. Ratios are expressed in relation to the PDB standard for both carbon and oxygen. All samples were subject to carbon and oxygen isotope analysis.

Strontium analysis was conducted by Dr Christina Manning at Royal Holloway University. 10-15 μg samples were dissolved in 4 M HNO_3 and the solution purified by extraction chromatography. The purified samples were analysed using a Thermal Ionisation Mass Spectrometer (TIMS).

Owing to the expense and labour-intensiveness of the process, $^{87}Sr/^{86}Sr$ analysis was conducted on a smaller set of samples. Samples were chosen based on the results of the carbon and oxygen analysis. In order to generate the strong comparative baseline, four samples each from tooth LH1 and MA1 were selected; a single tooth, BA1A, was selected from the archaeological assemblage as having the longest and most complete enamel column and therefore yielded the most samples, of which four were subject to $^{87}Sr/^{86}Sr$ analysis.

5.3.2 Results

The following section describes the results of this pilot isotope study, beginning with the precipitation data provided by GNIP and the Mpala Research Centre, followed by a discussion of the data pertaining to the modern analogue samples from LHR and Maasai cattle. This will form the foundation for discussion of the archaeological sample data.

5.3.2.1 *Atmospheric* δ ^{18}O

The data from the two locations clearly shows a similarly bimodal pattern, with a period of δ ^{18}O enrichment during the first months of the year and again between June and September (Figure 5.3); importantly, these are also the driest months of the year. Figure 5.4 shows the annual isotopes-in-precipitation cycle as if starting in each month of the year; this both highlights the degree of correlation between the precipitation values for Kericho and Mpala, and will facilitate more straightforward comparison with data derived from teeth, in order to address questions of seasonality.

5.3.2.2 *Lolldaiga Hills Ranch cattle*

The δ ^{18}O values in tooth LH1, which was taken from an animal that had recently died (probably late-2013), show a bimodal pattern of enrichment; two peaks are evident at around 6 mm and at between 18 and 25 mm, with a possible third at c.34 mm, though this is the final sample before the occlusal surface and truncation of the enamel column, such that the visible-continuation of the peak may be truncated. I would argue that these peaks can be correlated with those for January to February and June to September, respectively, with the third peak marking a return to the beginning of the annual cycle. For *Bos taurus*, there is a known lag of around six months between changes in the isotopic composition of

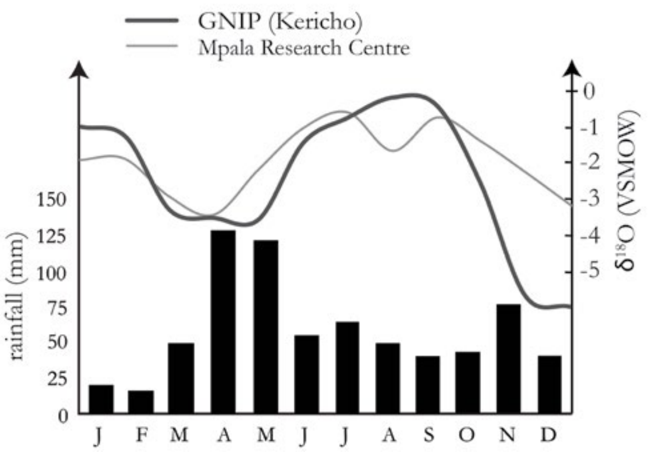


Figure 5.3. The above plot, presented earlier as Figure 5.2 shows intra-annual variation in precipitation δ18O at the two key collection points: the GNIP station at Kericho, for which the data represents monthly average for the period 1967 to 1971; and Mpala Research Centre, for which [precipitation] event scale data was provided by K. Soderberg. An average figure is presented here where there was more than one rainfall event in a calendar month. These are plotted against average monthly rainfall for the centre of the Lolldaiga Hills Ranch between 1967 and 1992 (Mizutani 1999).

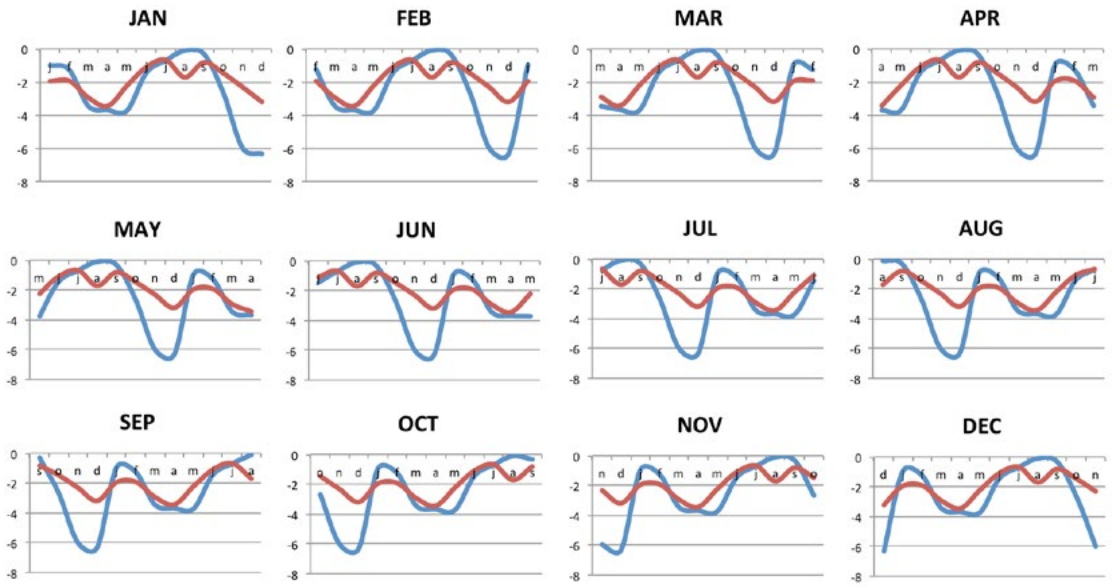


Figure 5.4. Variability at Kericho and Mpala, plotted using different start-months (prepared by O. Boles, data courtesy of GNIP and K. Soderberg)

diet and full registration in enamel, due to the prolonged process of mineralisation, which also has the effect of dampening the amplitude of peak and low values (Balasse 2002), a pattern exacerbated by relatively coarse sampling precision. By matching the shape in final enamel values (those nearest the ERJ, enamel formed at c. 12 months) with those of rainfall data plotted to begin the cycle with each month of the year (as above), and then subtracting six or seven months to account for delayed enamelisation, it becomes possible to estimate birth season; for LH1, the curves can be well matched to a cycle beginning in April, which returns a birth season estimate of September or October. This fits well with the known breeding strategy employed at the Lolldaiga Hills, with calving taking place following the August 'continental rains' and immediately prior to the 'short rains' in November (M. Roberts, pers. comm. 2014).

Tooth LH2 shows a similar pattern. Though owing to damage while removing it from the mandible, the enamel closest to the ERJ could not be sampled, there is arguably a good match between the peaks at c.35 mm and 16-27 mm and those at similar points in the LH1 data. This would again indicate a birth season of around September/October. Given that average enamel $\delta^{18}O$ values in an M_2 from a single individual are representative of climatic conditions during that first year of life, the mean value for LH1 (1.7 ‰) is considerably higher than that of LH2 (-1.5 ‰) and indicates that the LH2 animal experienced generally more hospitable conditions during its development.

Both teeth show similar and consistent $\delta^{13}C$ values across their respective enamel columns, comfortably within the expected range of -2 ‰ to 5 ‰ for a C_4-rich diet (see O'Leary

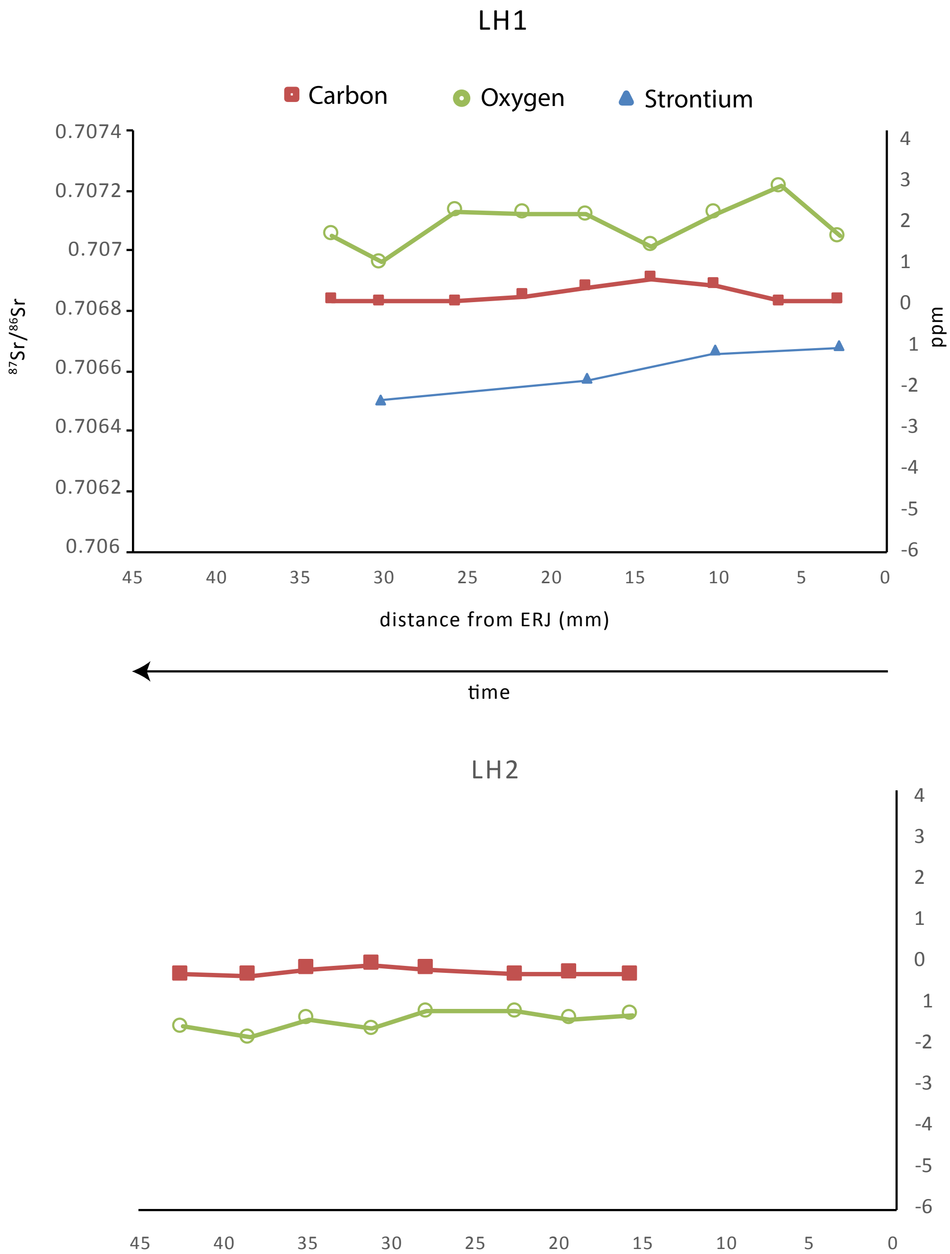


Figure 5.5. Isotope results for Lolldaiga Hills Ranch cattle LH1 and LH2

1981; Cerling & Harris 1999). This is to be expected given the altitude of the Lolldaiga Hills Ranch at or below around 2000 m, and the relatively rich and consistent grazing available.

Only LH1 was selected for strontium isotope analysis; observed values lie between 0.706501 and 0.706683, a narrow range consistent with the ranch herds' restricted ranges of movement. It was a little surprising that the value was not higher, given the ancient Precambrian geology of the Lolldaiga Hills, though the signature may be dampened by the accumulation of volcanic-rich soils in the valleys where much of the pasture is concentrated (c.f. Payton 2005). The narrow range of values, though, indicates that this is a reliable local signature, and according to the protocol proposed by Price et al. (Price et al. 2002) – using the mean local value +/- 2 standard deviations – provides a local biologically-available $^{87}Sr/^{86}Sr$ range of 0.706438 to 0.706777.

5.3.2.3 Maasai cattle

The tooth representing the Maasai animal (MA1) shows a very different set of isotopic signatures from those of the LHR cattle. $\delta^{18}O$ values are very similar to those for LH1, as is the shape of the plot, suggesting that the Maasai animal was also born sometime between the continental and short rains, during a reasonably temperate year. $\delta^{13}C$ values, on the other hand, are notably distinct; while the higher samples (those nearest the occlusal surface, and therefore from enamel formed closest to birth) fall within the C_4 range, there is a marked decline in $\delta^{13}C$ observed in samples nearer the ERJ, to a minimum value of -5.21‰. This is clearly indicative of a growing C_3 contribution to diet. The isotopic composition of early enamel is influenced by the dietary intake of the mother during pregnancy, effects that can last until mineralisation is complete at around six months (Balasse 2002). Further, some studies have suggested that depleted $\delta^{13}C$ in enamel mineralised shortly after birth might be related to the effects of milk suckling (e.g. Hobson & Sease 1998), though others have suggested that milk with low lipid content, as with human (Wright & Schwarcz 1998) and cattle milk (Oftedal 1984), would not be likely to impact enamel isotope composition beyond the order of a a few tenths permil (Balasse 2002). That $\delta^{13}C$ in MA1 maintains a constant level prior to the major decline which, based on its starting position at around halfway along the enamel column, can be considered to have begun at around six months since birth, suggests that grazing was readily available to the mother during the pregnancy as it was to the calf in the month following birth. At six months, however, there appears to have been a sudden decline in the availability of C_4 grazing, forcing the calf's diet to be supplemented by C_3, likely through increased browsing or foddering. Given that the Maasai and other African pastoralists generally reserve the richest grazing for young animals, through the *ololopoli* system (Mbae 1990), this pattern may reflect the onset of the major drought that ultimately killed the animal.

$^{87}Sr/^{86}Sr$ in samples from the lower part of the MA1 crown are consistent with values observed in LH1 and LH2 (0.7067 to 0.7068), and so may be taken as good indication that the animal spent part of its first year in the vicinity of the Lolldaiga Hills, though given that its remains were recovered close to the ranch fence and that tooth-wear data is consistent with it having died sometime in early maturity, this is perhaps unsurprising. Values from

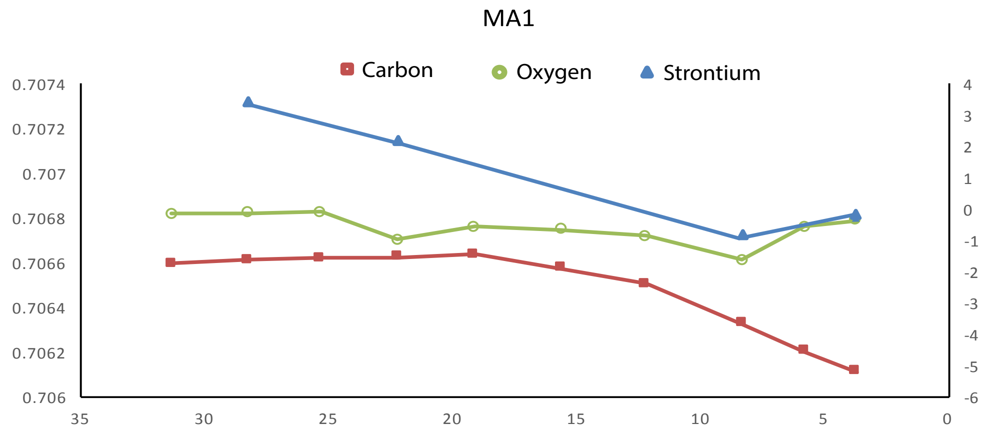


Figure 5.6. Isotope results for Maasai animal MA1

the earliest samples, however, yield a distinctly non-local signature of 0.7071-0.7073, which may indicate that the animal was born at some distance from the Lolldaiga Hills, before moving towards the hills.

That this non-local signature is consistent with more ancient geology than that observed in samples LH1 and LH2 – and therefore more ancient than the Lolldaiga Hills – is surprising only in as much as the LHR local value was lower than expected. The Precambrian stratum of which the Lolldaiga Hills are an outcrop runs north towards the northeastern edge of the Laikipia escarpment (Hackman et al. 1989), beyond to the town of Don Dol, the regional centre for the Maasai community; it is possible, therefore, that these signatures reflect a movement south from more northerly outcrops. As has been discussed, the Lolldaiga Hills see significantly higher annual rainfall than the surrounding plains, and during particularly adverse conditions LHR allows controlled grazing of Maasai livestock within the ranch boundaries; the presence of LHR-local strontium signatures towards the ERJ (most recent enamel) and a sudden recourse to C_3 feeding might be explained by the Maasai seeking more hospitable conditions close to the hills during a period of environmental stress, as the 2008-2009 drought surely was. It should be noted, however, that there is no concomitant fluctuation in $\delta^{18}O$ values that supports such a pattern of increased aridity, though water stocks in the LHR dams to which the Maasai animal may have had access could perhaps have alleviated water stress and reduced its effects on isotopic intake.

5.3.2.4 M_1/M_2 distinction

The data from the archaeological specimens is slightly more complicated to interpret than the above modern analogues, due partly to heavy wear having truncated the enamel column available for sampling. A more significant issue, however, is a lack of firm assignation

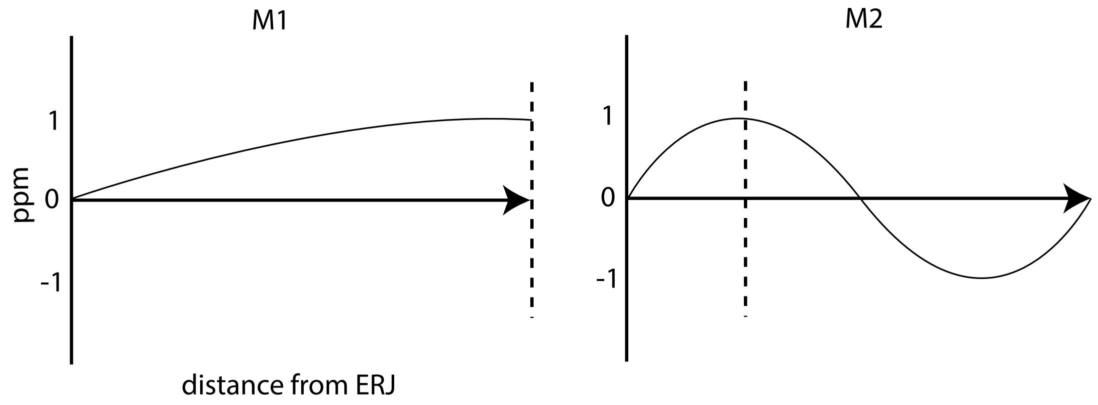


Figure 5.7. Hypothesised relative isotopic variation in M1 vs. M2 from same animal

as first or second molars, and thus whether the isotopic signature pertains to the first three months or first year of life, respectively. Loose, indeterminate teeth are a common feature of zooarchaeological assemblages, one that can be a barrier to the assessment of age structures (Beasley et al. 1993). There have been various attempts to differentiate ambiguous first and second molars on morphological grounds; for example, Beasley et al. (1993) looked at differences in cervical length and breadth, while Jones (2007), in contrast, looked at other measurements, including accessory pillar height. Marshall (1990), in an example from eastern Africa, undertook similar analysis of material from the site of Ngamuriak. While all three studies showed that the measurements for each tooth fell within a distinct range, there was significant overlap, such that though some indeterminate teeth might be identified, metrical data is more usually insufficient.

I propose that such differentiation might be made based on the rates of change exhibited in d18O values. Though first molar enamel develops in utero and is completed within three months following birth, while second molar enamelisation takes a full year (Brown et al. 1960), crown height is approximately equal. In consequence, enamel forming over a short period will be subject to fewer changes in [isotopic] conditions compared to the same amount of enamel formed over a longer period. For instance, a single 'peak and trough' cycle observed across an M1 crown might be observed in just the uppermost quarter of the M2 crown from the same animal, as illustrated in Figure 5.7. Both plots show hypothetical d18O in enamel across an M1 and M2, with the distance between the Y-axis and the vertical dotted line representative of three months of enamel formation. On this basis, and assuming that a location exhibits sufficient variation in environmental d18O to register observable intra-annual change, data showing relatively reduced or gradual variation might be more likely to be derived from an M1. An M2, on the other hand, would be expected to show a wider range of values and more dramatic variation between consecutive samples.

While the following interpretations of the archaeological specimens from the present study draw on this method, it must be stressed that it is a novel approach to M1/M2 differentiation and has yet to be rigorously tested. It could, however, prove a valuable tool for dealing with fragmentary faunal assemblages containing many loose, individual teeth; for example, strontium isotope analysis is considerably more expensive than testing for oxygen, and this approach might be useful for identifying worthwhile specimens for the former without excessive financial outlay. As with oxygen isotope studies more generally, I would expect the approach to only work reliably in environments with a strong seasonal change in rainfall and temperature.

5.3.2.5 Maili Sita cattle

The data suggests little variation in either carbon or oxygen isotope values between teeth from the Maili Sita zooarchaeological assemblage. $\delta^{13}C$ sits comfortably within the C_4 range, fluctuating no more than 0.8 ‰. $\delta^{18}O$ exhibits similar consistency, with all mean values falling between -1 and 1 ‰.

Based on the above approach for distinguishing M1 and M2, I would suggest that BA1A, C12 and – tentatively – BA0A are likely to be M2. BA1B, on the other hand, shows little variation and gradual change, with the curve of the data very evenly extended across the length of the sampled enamel, so is more likely an M1.

Only BA1A yielded enough samples to comment on birth season, fitting reasonably well with the November curve. This corresponds to a birth sometime in May/June, shortly following the long rains of March to May, when vegetation is at its peak. This was also the only archaeological specimen subject to strontium analysis. $^{87}Sr/^{86}Sr$ values in BA1A are closely aligned with those from LH1, falling within or just outside the locally-defined range (0.706438 – 0.706777) described earlier, and given that the local range is based on a single specimen, sufficient flexibility to include this single outlying value seems reasonable. The BA1A data also follows a similar gradual elevation in Sr ratios between the earliest and latest samples; this may be particularly convincing given that BA1A is an upper molar and therefore has a shorter crown height; based on relative position along each crown, the BA1A and LH1 values match almost exactly, serving to highlight the anomaly of the early MA1 values, as shown in Figure 5.9.

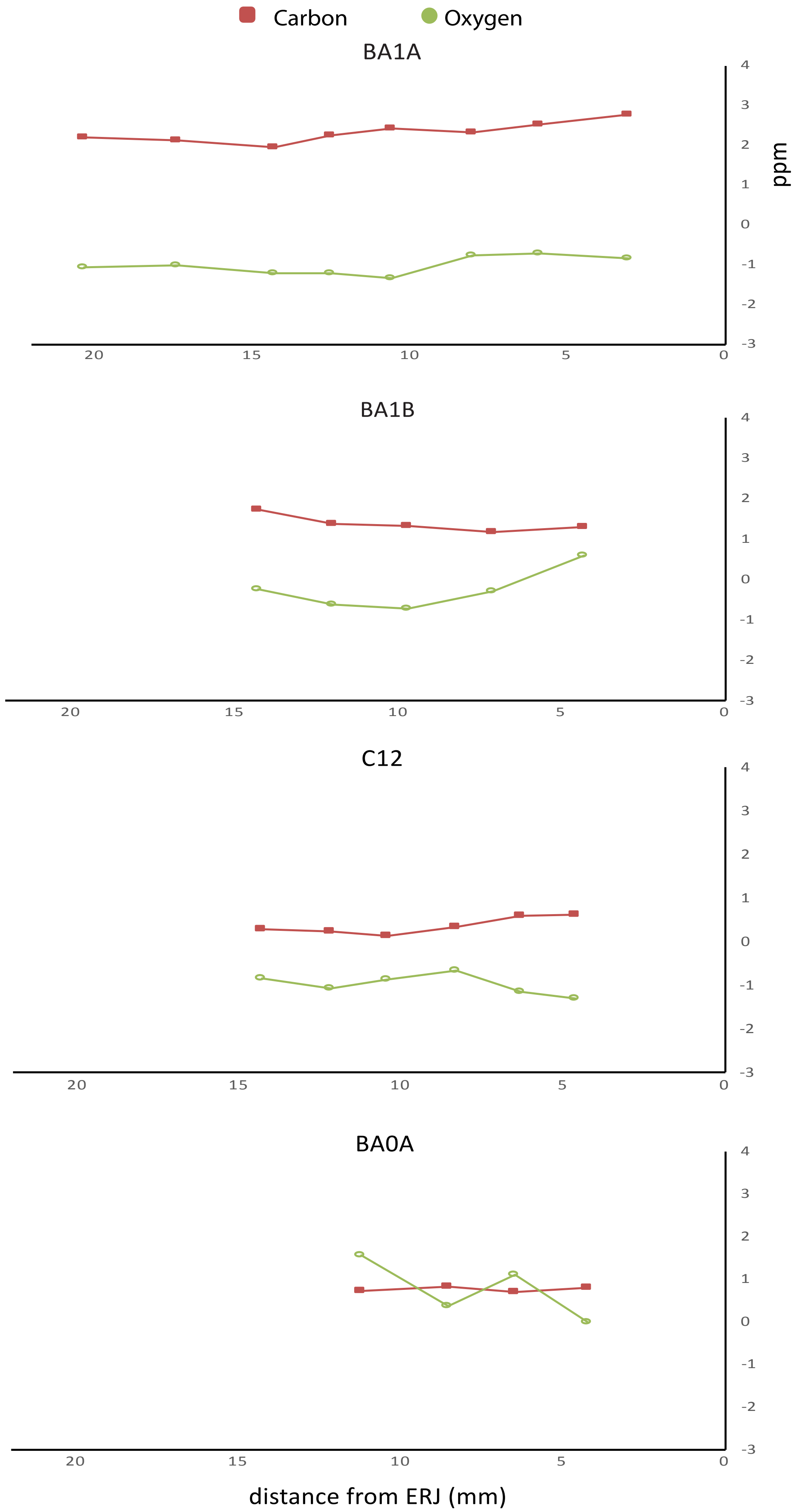


Figure 5.8. Carbon and oxygen isotope data from Maili Sita cattle

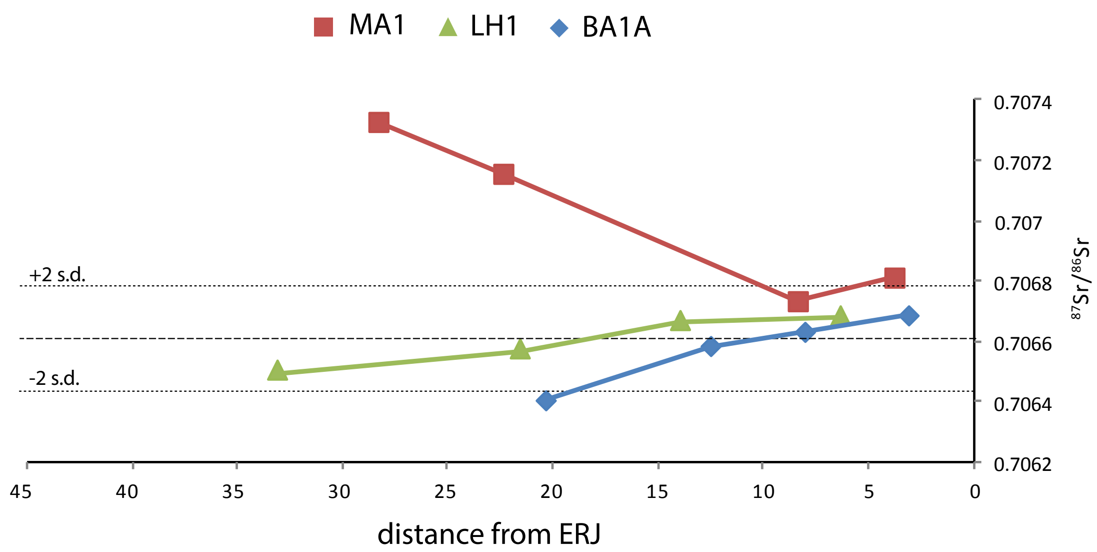


Figure 5.9. Sr ratios for each specimen, including the local range for ranch cattle based on the mean LH1 value +/- 2 s.d. (after Price et al. 2002)

5.4 Discussion

To recap, there are several important points that might be made regarding the isotope data presented here. Beginning with the modern analogue material, it is clear that the Lolldaiga Hills offer rich C_4 grazing, and that animals living with the confines of the ranch have no need to engage in browsing nor the herders to provide fodder, at least during normal climatic conditions. Conversely the Maasai, living to the north of the hills in the more marginal conditions of the Laikipia plains, appear forced to resort to secondary food provision during periods of stress. One coping mechanism during such periods is to move closer to the hills, where conditions are more hospitable and there is the possibility of permission to access the less-competitive grazing resources inside the ranch. In this case, the narrative depicted in the strontium and carbon isotope data is supported by personal observations made in the field and in conversation with herders and ranch managers.

There is perhaps too little intra-annual variation in meteoric $\delta^{18}O$ – a function of relatively constant annual temperatures and bi- or even tri-modal rainfall, compounded in enamel by the effects of standing water in the LHR dams – to expect to make definitive statements as to seasonality, of birth season or otherwise. I would stand by the estimates for LH1, LH2 and MA, as these are derived from near-complete crowns and are sufficiently similar as to reflect general conditions rather than those experienced by a specific animal. The estimates also fit well with the known preference among eastern African herders and ranchers for calving during or shortly following the rains (Western & Finch 1986). The archaeological teeth are more difficult, however; though I feel reasonably confident that my discrimination here between M1s and M2s is accurate, it is clear that the degree of wear in all specimens except BA1A precludes the breadth of data necessary to investigate such practices. In addition, mandibular teeth would be much preferred, and would allow enamel to be sampled at the high resolution that may be required to distinguish the marginal seasonal variations observed in $\delta^{18}O$, both meteoric and biological, in eastern Africa.

More informative are the carbon and strontium data. Though the latter has been limited by financial constraints, there is a strong correlation between the local range established from the LH1 samples and that in BA1A, both of which – along with the other archaeological specimens – show $\delta^{13}C$ values firmly reflective of C_4 diets. This is in sharp contrast to the Maasai animal, with its non-local signature corresponding to a C_4 diet, with an increase in C_3 input at around six months appearing to correspond with a movement towards the Lolldaiga Hills, perhaps, as discussed above, in response to environmental pressures.

Though more strontium analysis across a wider array of samples would be required to draw firm conclusions in this regard, I would argue that the isotopic compositions of the archaeological specimens bear closer comparison with those of the LHR animals, and therefore that herd management during the occupation of Maili Sita was likely to have functioned similarly to the modern ranching operation: a grass-rich diet based on the exploitation of pastures within the Lolldaiga Hills, probably with calving scheduled to coincide with the rains and optimal grazing conditions. In terms of the scenarios outlined earlier, this pattern most closely resembles 'A', that which might be expected for an *enkang*-type occupation: i.e. a semi-permanent homestead providing a central node around which herding activity takes place throughout the year (Mbae 1990). As enamel data only reflects conditions during the first year of life, it can only support an interpretation that positions the Lolldaiga Hills within an *ololopoli*, the grazing zone closest to the settlement that the Maasai reserve for young animals. However, given that the earliest enamel in BA1A – that which remains influenced by in utero conditions – yielded a strontium signature not significantly divergent from that of the later-formed, post-birth enamel, it seems likely that the mother was subject to the same conditions, in the same location as the calf. By that token, were tooth MA1 to have been part of the archaeological assemblage, an argument might be constructed for the occupation resembling a *manyatta*, with herders bringing cattle from further afield to participate in ceremonies at Maili Sita; in such a case, the introduction of C_3 food at around six months might reflect a preference for foddering over labour-intensive grazing during the ritual period.

5.5 Summary

This pilot study demonstrates, through the modelling of isotopic scenarios and comparison with modern analogue and archaeological data, how an understanding of settlement function and herders' daily experience of the mobility-ecology dynamic might be gleaned directly from archaeological material, in this case, faunal remains. Although, a limited sample size has been used, for reasons already described, the data is sufficient to highlight the merits of the approach and the potential for future expansion if and when additional material becomes available. The data shows a strong resemblance to that expected for scenario A, an *enkang*-like occupation; to return to the possible interpretations of Maili Sita outlined in the last chapter, based on the results of previous investigations, it might be argued that (iii) – multiple intermittent occupations, as would be expected for a *manyatta* or a seasonal camp – might be rejected. Scenario (i) – a large single occupation – might also be questioned, in that this would, based on the above scenarios, yield a wide range isotopic signatures; even if a *manyatta* is discounted, the numbers of livestock present at such a large settlement might require recourse to much more distant pastures. Such reliance on analogy is clearly problematic, but in the absence of more precise data there is little else to go by. We are left, then, with (ii) – sustained, horizontally shifting occupation – and (iv) – multiple semi-independent neighbouring homesteads – as the most plausible descriptions of how the occupation functioned. In order to confirm whether either hypothesis is sustainable and, if so, to refine them further, I turn now to the effects that occupation has exerted on the ecology of the ridge, by looking closely at the extent of anthropogenic influence on soil and vegetation patterns.

6

Soils and Vegetation at Maili Sita

Figure 6.1. Auger sample location at Maili Sita (O. Boles)

It should be evident from the introductory chapters that if we are to gain an understanding of sites like Maili Sita, both from a social-historical and an Historical Ecological perspective, we must look beyond the standard archaeological toolkit. As the previous chapter showed, the integration of isotope data into analyses of faunal assemblages facilitates a very specific understanding of how herding functioned on daily basis. A next step is to understand the way that those daily practices and environmental conditions relate to settlement structure, yet it is just this capacity to recognise and define spatial organisation that has proven difficult with respect to mobile pastoralism. However, if we accept Balee's tenet for Historical Ecology, that "all of the nonhuman biosphere has been affected by human activity" (Balée 1998), it follows that as great a hindrance to our ability to unravel the archaeological record at ephemeral sites is a lack of methodological understanding leading to the perception of lack of evidence. The record is there, and we must learn how to read and interpret it.

This kind of methodological shortcoming is keenly felt with respect to soils. While soils and sediments are the fundamental medium for the transmission of archaeological residues – by which I mean the entire spectrum of archaeological remains from construction remains and material culture to potential proxy indicators of human presence, such as charcoal and domestic phytoliths – in many instances, their formation is entangled with human action, such that they constitute an archaeological residue in themselves. The degree of this entanglement is of course subject to great variability; Amazonian *terras pretas* are clearly an extreme example of anthropogenic ecological alteration, wherein the evolution of an environment and the human and other biotic communities living within it has been shaped by intervention in soil formation processes (Limbrey 1975; Sombroek et al 2003; Arroyo-Kalin 2008; 2010). However, while dark earths are among the best-known cases, anthrosols – soils whose formation and composition can be attributed to anthropic activity and inputs (Limbrey 1975) – in various forms can be found almost everywhere (FAO-UNESCO 2014): i*rragic* anthrosols, for instance, are formed by the deposition of sediments suspended in surface water diverted for irrigation agriculture and are noted in arid environments from the American Southwest (Woodson et al. 2015) to coastal Peru and the Himalayas (Baade 2013); *plaggic* anthrosols, which are thought to cover up to half a million hectares of northwest Europe (FAO-UNESCO 2014), bear closer comparison with *terras* pretas, being formed by the application of nutrient-rich *plaggens* – sods of grass or heather used as bedding for livestock over winter – as fertiliser to cultivated land (Blume & Leinweber 2004).

Geoarchaeological investigations of these and other forms of anthrosol have addressed numerous questions bridging the kinds of social-historical and historical-ecological concerns mentioned in the opening paragraph of this section, and have been able to do so at a range of scales; the specific compositions and formation processes of anthrosols can often be associated with particular human actions, sometimes at the level of the individual, while their endurance and integration into local and regional landscape ecologies may be considered in investigations of longer-term trajectories of human-environmental interaction. Analysis of vegetation patterns and how plants respond to soil variability is an obvious counterpoint to such investigations, with plants providing the fundamental medium of interaction between humans (and animals more generally) and soils, of which pastoralist glades are a prime example. This chapter sets out how I have applied this kind of multi-scalar approach at Maili Sita. Below I present the methods used to situate the site within the social history of pastoralism and in the ecodynamics of the Lolldaiga Hills and the wider Laikipia Plateau. Crucially – and this point will be returned to in my concluding discussion – I attempt to demonstrate how social history and ecodynamics are linked, how the story of Maili Sita and other such sites is every bit an 'historical ecology'.

6.1 Methods

6.1.1 Sampling Strategy

The major data-generating component of this research project is a geoarchaeological analysis of deposits from across the Maili Sita col. One subset of this considers undisturbed block samples cut from the walls of excavation units during the 2010 field season. I used these samples to manufacture of thin sections for micromorphological analysis, as described below, and took bulk samples from the columns at 5cm intervals using a palette knife. The major component of bulk sampling was, however, conducted using a bucket auger to retrieve samples from across the Maili Sita col, at a number of depths.

I undertook bulk sampling at intervals along two main transects, shown in Figure 6.2. High resolution (2.5 m) multispectral satellite imagery of the Maili Sita col and its environs (25 square kilometres, centred on the site) shows a pattern of pale deposits that appear to encircle the archaeological site, demonstrably coincident with the areas of high soil nutrient content evidenced in Payton's 2004 survey, as described in the previous chapter. My own soil survey was designed to examine the nature of these deposits, using transects bisecting the col. The first, SN1, was oriented approximately SSW-NNE and follows the line of the ridge. It provides samples from across the breadth of the archaeological site and minimises the effects of lateral hill wash that might affect deposits on the eastern and western flanks. Though not following the exact path of the transect employed by Payton in the 2004 survey, the two are similar enough to allow broad comparison. Samples were taken at intervals of 10-30 m along the 530 m transect – 34 locations in total – with three depths sampled: surface, c.10cm, c.20cm. Soils at two locations (waypoints 13 and 34, at 200 m and 530 m, respectively) were too shallow for 25 cm samples to be taken. The transect is 530 m long, with a topographic profile that, beginning at the southern end, is comprised of a slight rise followed by a depression towards the centre, before it rises again into the continuation of the main northerly ridge. The total altitudinal range is around 15 m, between c. 1982 and 1996 m.a.s.l.

A second transect, WE1, was oriented west to east, running from the western-central part of the site, down the eastern flank of the ridge towards the seasonal river valley. Beginning some 70 m west of the intersection with SN1 (close to the mid-point of the latter), the transect continues beyond the eastern limits of the open grassland covering the col, into the *Acacia*-dominated bushland beyond. This transect was intended to assess the lateral

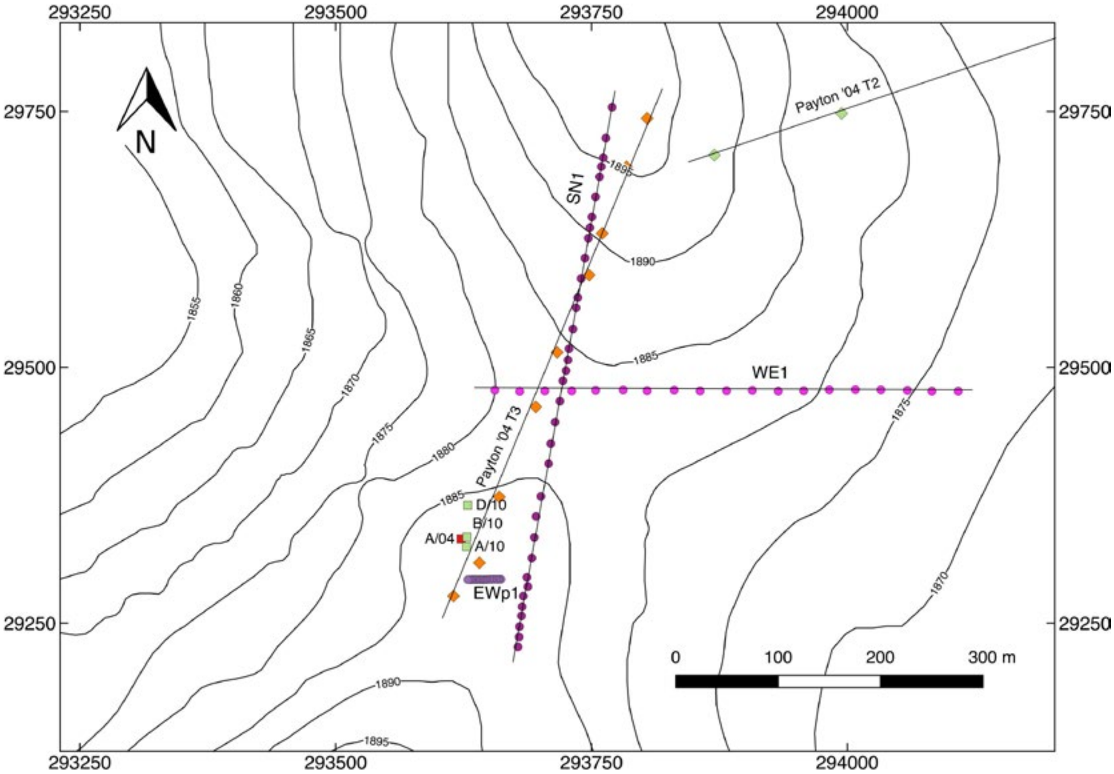


Figure 6.2. 2004 and 2015 soil survey transects and sample points, and key excavation units.

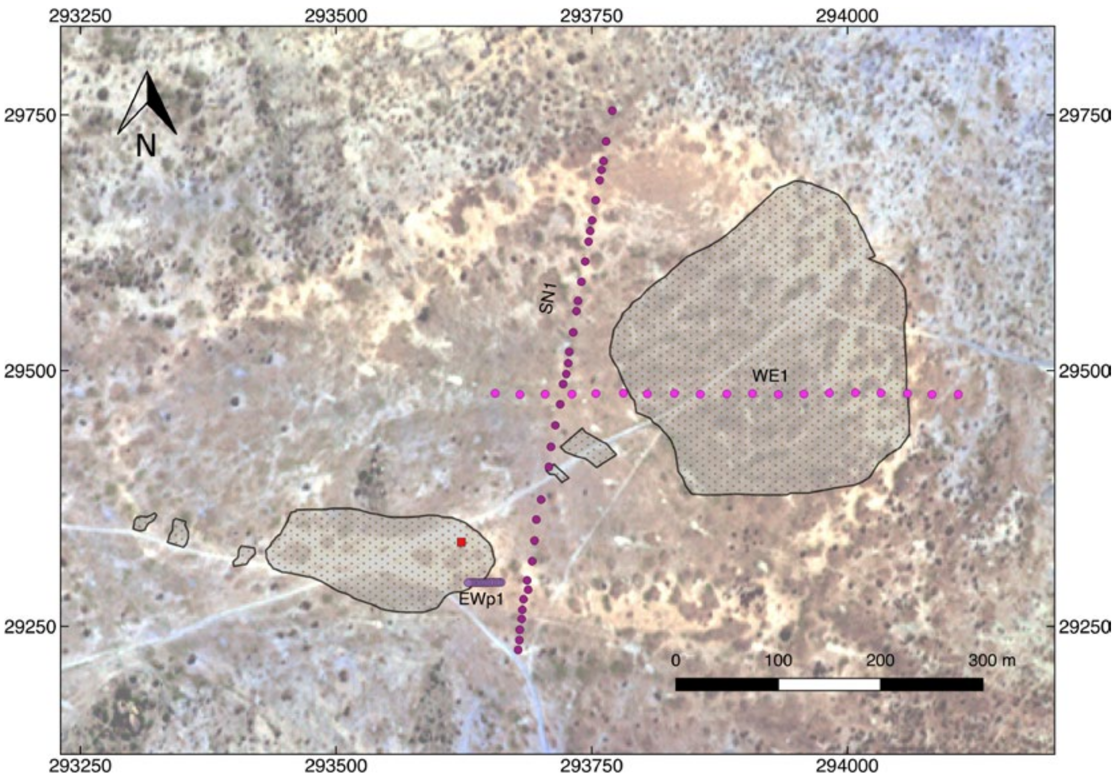


Figure 6.3. Four-band (R,G,B,NIR) Worldview-2 satellite image of the Maili Sita col, showing the 2015 soil survey transects. Note the pale deposits encircling the col and how these coincide with the 'ashy deposits' mapped by the excavation team in 2010

distribution of anthropogenic deposits at Maili Sita, and explicate the aforementioned processes of erosion that might affect the ridge flanks. Payton's second transect, also aimed at exploring the impacts of erosion, followed a different path, running northeast along the fall-line of the eastern ridge slopes from the northernmost limit of the col. The WE1 transect rises to the apex of the ridge before gradually descending to the top of the pediment slopes of the seasonal river valley. Samples were taken at three depths – surface, c.10 cm, c.25 cm – at intervals of 25 m. Soils at one location (waypoint 49, 225 m) were too shallow for 25 cm sampling. The transect is 475 m long, and crosses SN1 at approximately 65 m.

A third transect was established running east to west along the southern part of the col, close to units A/2004 and A/2010, between two of the grass patches. The intention here was to develop Payton's (2005) claim that the patches exhibited distinct chemical compositions, by considering additional variables and better situating the transect in the context of the excavation data and main geoarchaeological study. Samples were taken at much closer intervals than either SN1 or WE1, every 2 m for a total of 34 m. The entire transect falls within the southern area of high $CaCO_3$, pH, and organic C observed in SN1.

Roughly 500ml of soil was obtained for each sample and around 100g (the total amount required for all the planned analyses) later removed and bagged for transportation to the UK. In total, 176 bulk samples were gathered from 74 locations during the auger survey.

In addition to sample collection, I made records of vegetation and any animal dung within a 0.5 m radius of the sample point. This was done in January 2016, shortly following the rainy season, such that vegetation was near peak levels; I had undertaken soil sampling in March (2014 and 2015), at the height of the dry season, by which point vegetation across the ranch had been heavily grazed or otherwise denuded. Sample points were relocated using a handheld GPS, and many of the holes left by the augering ten months previously were still visible. Using reference texts (Weiss 1989; Dharani 2002; Agnew 2013), and with the assistance of Julius Mwenda, wildlife guide at LHR, plant communities and animal faeces within each sample locale were identified to species, where possible. Where multiple distinct vegetation communities were present within a locale, such as at the edge of one of the grass patches, that which characterised the precise point from which the soil sample was obtained was prioritised, with note made of proximity to varying conditions. More general observations of the botanical character of each part of the col were also recorded.

6.1.2 Micromorphology

Micromorphological analysis of soils and sediments in thin section permits the description of features in their original spatial context. Rather than considering one variable at a time, as with most other forms of geoarchaeological analysis, micromorphology allows the relationships between variables to be explored, such that interpretations can be made as to the formation and relative composition of a soil fabric. It further facilitates the assessment of (micro-) stratigraphic processes and relationships that would be unclear to the naked eye.

While undisturbed block samples were collected from all 2010 excavation units, of which there were ten, only three were selected for this study. Though this was mainly due to a lack of contextual information for some units and indications from other data that certain areas were likely to yield more useful information that others, the laboriousness and expense of manufacturing thin sections from block samples was an additional limiting factor. The blocks removed by the excavators were significantly larger than necessary; these were cut down and encased in square-sectioned plastic piping, and finally wrapped in clingfilm for transport from Kenya to the Institute of Archaeology in March 2014, where I conducted the first stages of thin section preparation. This was conducted under the guidance of Drs Richard Macphail and Manuel Arroyo-Kalin. Though the samples were dry when removed from the excavation units and had been kept in dry storage conditions in Nairobi, as a precautionary measure the wrapping of each block was opened and left to air-dry for two weeks, in order to remove all moisture. The samples were subsequently placed in plastic containers, where they were impregnated with a mixture of one part analar-grade acetone to four parts epoxy resin, to which was added a small amount of MEKP catalyser. The resin mix was added in several stages, between which the samples were placed in a vacuum chamber, so as to force the release of any trapped air bubbles. Once fully immersed, the blocks were placed in a 40 °C oven in order to activate the catalyser and harden the resin. These blocks were then cut using a diamond edged circular saw into c.1cm slabs, and along the profile of the soil column to the final dimensions of the thin sections (75x50 mm).

One slab was selected for each sample (i.e. 0-75 mm, 75-150 mm, 150-225 mm, etc) and sent to Spectrum Petrography in Vancouver, Canada, for the final phases of manufacture, for which the necessary facilities are not available at UCL and so as to minimise turnaround time. The process involves affixing the slab to a glass slide using a similar resin to that described above. It is then mechanically ground to a thickness of 50-80 μm, and hand-polished to a final thickness of 30 μm is achieved. The correct thickness is indicated by the uniform white-gray first order interference colours observable for quartz grains under polarised light. A glass cover would then normally be affixed to the sample surface, but in this case it was left exposed to allow for investigation of mineral composition using scanning electron microscopy, though this was not undertaken in the end.

A relatively recent and useful addition to the analytical procedure of soil micromorphology has been the use of flat bed scanners to produce mesoscopic images of the dataset under consideration (Arpin et al. 2002). A high-resolution scan using standard equipment produces images of sufficient quality to withstand a certain amount of magnification, so that comparison of features between slides is straightforward. Unfortunately, while transmitted light scanners are available, to which polarising film can be added in order to produce images in cross-polarised light (XPL), only standard reflected light machine could be sourced for this project, which offers imagery only in plain-polarised light (PPL).

Microscopic thin section analysis was undertaken at the Institute of Archaeology using a Leica DM EP microscope, at between x25 and x400 magnification, with observations made under transmitted plain-polarised (PPL), cross-polarised (XPL) oblique-incidence (OIL) and ultraviolet (UVL) light. Descriptions were made based on the procedures and terminology advocated by Bullock *et al.* (1986) and Stoops (2003), and interpretations made based on comparison with wider literature from soil science and geoarchaeology, along with advice and assistance from R. Macphail and M. Arroyo-Kalin. A total of ten thin sections were manufactured from three undisturbed block samples retrieved from three excavation units.

6.1.3 Bulk analyses

In order to complement the existing data generated by Payton, and keeping in mind the findings of Shahack-Gross *et al.* (2003; 2004; 2008; 2011; see discussion in chapter three) and those of the modern ecologists working on glades elsewhere in the region, samples were subject to analysis using a suite of standard geoarchaeological analyses. The approach has been designed to determine the physical and chemical composition of soils across Maili Sita, and the possible transformative effects of human presence and activity, in an efficient and replicable manner. Samples were analysed for organic carbon composition (%), calcium carbonate (%), magnetic susceptibility, particle size, and pH. The aforementioned 100g samples were air-dried, and ground lightly using a pestle and mortar, and sieved to a <2 mm fraction. At this point, the colour of the sediment was characterised with reference to a Munsell chart. Organic carbon content was measured via loss-on-ignition (LOI) using a muffle furnace, with weights taken before and after two hours combustion of c.15 ml aliquots at 550 °C. Samples were then returned to the furnace for a further hour at 1000 °C, whereupon further weight measurements were taken to estimate calcium carbonate ($CaCO_3$) content (after Nelson & Sommers 1996). The magnetic susceptibility (MS) of 10 cc samples was measured using a Bartington MS2 low-frequency sensor, and expressed in tesla SI units of magnetic flux density. Four grams of sample were mixed with 10 ml deionised water, and the pH of the resulting solution using a calibrated hand-held meter. Measurements were recorded after submersion of the filament in the solution for 60 seconds.

Samples were sieved down to 500 μm, treated with a 4.4% Calgon solution for 24 hours to destroy organic matter, and centrifuged at 3500 rpm for 13 minutes. The calgon was then decanted, and the sample homogenised by hand mixing. Particle size analysis of the <500 μm fractions was then conducted using a Malvern 2000 Laser Particle Analyser. This analysis was initially restricted to samples from transect SN1 (see below) and the archaeological excavation units; the process is relatively time-consuming and as no clear pattern emerged in the data from these initial analyses, the remaining samples (transects WE1 and EWp1) were not subject to it.

X-Ray Fluorescence (XRF) analysis was used to assess the elemental composition of the samples, using a portable InnovX instrument. Elements measured included: P (phosphorus), S (sulphur), K (potassium), Ca (calcium), Ti (titanium), Cr (chromium), Mn (manganese), Fe (iron), Ni (nickel), Cu (copper), Zn (zinc), Rb (rubidium), Sr (strontium), Y (yttrium), Zr (zirconium), Ba (barium), Au (gold), Pb (lead). Readings are expressed in parts-per-million (ppm). The machine was calibrated against four clay standards: JA1, NIST 2702, NIST 2810 and NIST 2710a.

6.2 Results of the geoarchaeological survey

6.2.1 South-North transect (SN1)

Soil pH

Based on analysis of control sediments collected beyond the established perimeter of the archaeological site, natural soil pH across the Maili Sita ridge is slightly acidic, varying between c.5.8 and 6.5. Two peaks are immediately clear in the pH data from SN1; at either end of the transect, with a third minor peak in the centre visible in the data for the deepest

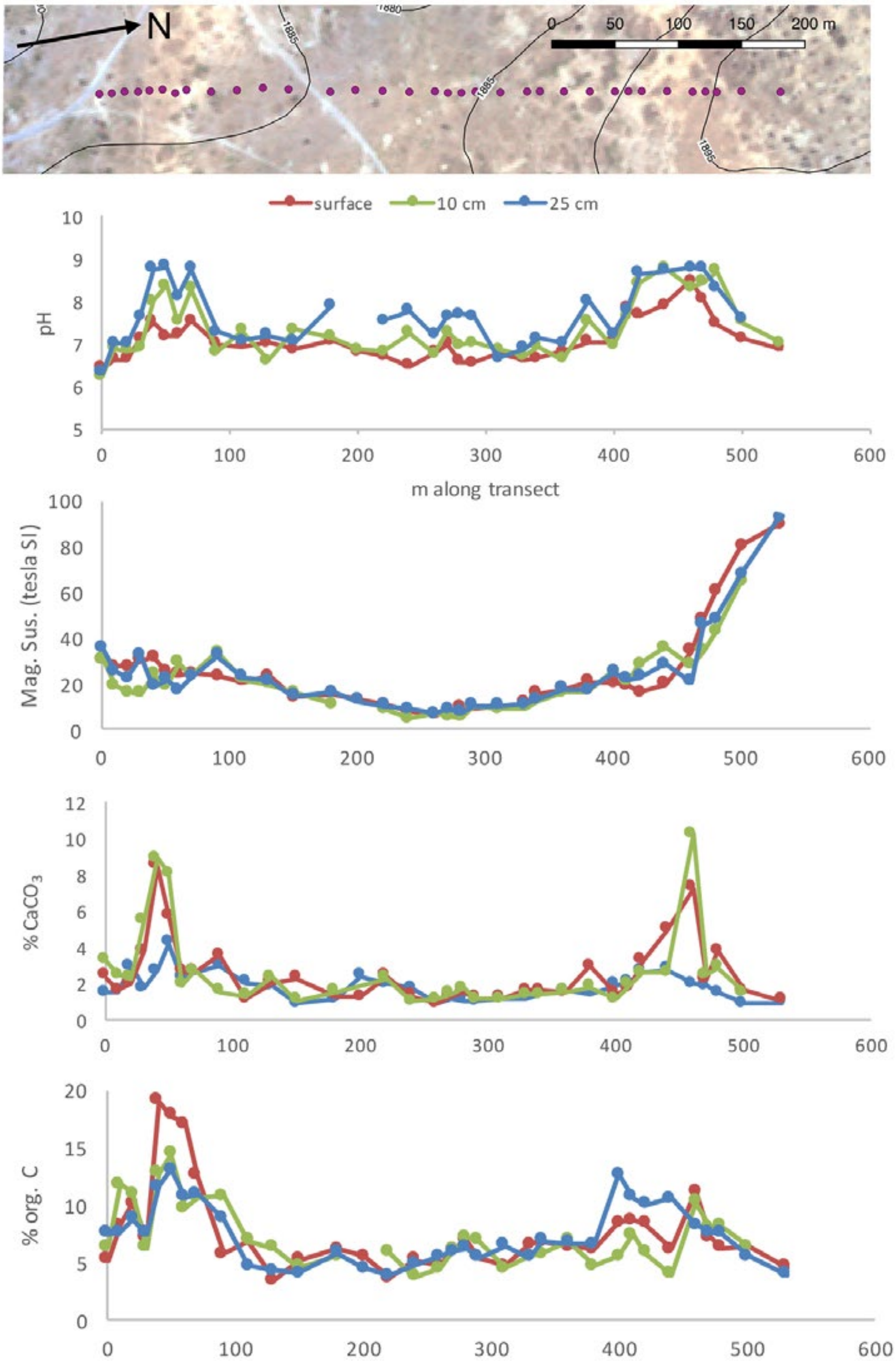


Figure 6.4. Transect SN1, results of pH, magnetic susceptibility, CaCO3 and organic C analyses, with section of Worldview-2 image showing sample locations

sample, at c.20cm. Moving from the southern-most sample location (as the order in which samples were taken in the field), the major peaks are positioned between c.30-70 m and 410-500 m along the transect, at the edges of the site as defined by artefact scatter. The minor peak is evident at 180-290 m. Soil pH in these areas reaches 8.8; the maximum value within the first peak (40-70 m) is 8.8 (mean = 8, n = 12, s.d. = 0.6), and 8.79 in the second (420-480 m, mean = 8.36, n= 15, s.d. = 0.42). Given that the mean pH for the transect is 7.35 (n=100, standard deviation = 0.67), these represent significantly distinctive values. The minor central peak is less convincing, offering a maximum value of 7.91, with a mean of 7.11 (n = 23, s.d. = 0.42). Both major peaks fall within the areas of pale deposits visible in the satellite imagery.

There is also clear variation in pH with depth; all three peaks show increasing pH down the soil profile. Given the slight acidity of natural deposits in the area, this may indicate either leaching of topsoil nutrients or, particularly in the case of the northern-most peak situated below the steeply sloping continuation of the ridge, a consequence of sheet erosion depositing natural material atop the anthropogenic sediments. The latter is perhaps unlikely given that the central, minor peak is only really evident in the lowest deposits, at c. 25 cm, the location of which, given the shallow gradient of the slope depicted in the topographic profile (Figure 2), is unlikely to have been affected by such processes. There may also be an element of grazing by wild animals removing organic matter from the centre of the site (*sensu* Augustine 2003) that might otherwise contribute to alkalinity, though one would expect this pattern to be observable around the inner edge of the 'glade', the zone most favoured by, for example, zebra, one of the more common wild grazing herbivores across eastern Africa (Young et al. 1995).

Magnetic susceptibility

Magnetic susceptibility along SN1 shows a pattern that appears to follow the topographic profile of the transect, being positively correlated with gradient and height. The northern end of the transect shows a considerable increase in magnetic susceptibility at around 470 m. The mean value south of this point is 18.6 (n=89, s.d. = 8.1), while from that point northwards this rises to 61.2 (n=11, s.d. =19.6) with maximum value of 92.27 (min. 34.32). There is little to suggest that magnetic susceptibility varies significantly with depth, though at the northern end (after 470 m), surface values are around 25% greater than those for sub-surface deposits. Both these observations could be associated with erosion of non-magnetised material from hillslope deposits, particularly at surface level. At the centre of the site there is little variation with depth, while the southern end shows mixed patterning. There is no clear link between the pale areas on the satellite image and variation in magnetic susceptibility.

Calcium Carbonate $CaCO_3$

$CaCO_3$ shows the same bimodal pattern as soil pH, though with more contained peaks, falling between 30-50 m and 420-470 m. The remainder of the transect shows fairly consistent $CaCO_3$ percentages; exclusive of the samples associated with peak values, the mean for the transect is 1.7 % (n=79) with a narrow range of 2.88 % (s.d. = 0.67). Within the peaks, however, the mean is 4.5 % (n=21) with a range of 8.6 % (s.d.=2.65) and a maximum value of 10.2 %. As with pH, both peaks fall within the pale areas on the satellite image.

As with pH, there is variation with depth; surface deposits show much less $CaCO_3$ enrichment than do the sub-surface samples. The maximum value recorded in the former is just 4.2%. It may be possible to argue that the peaks for surface data are more widely spread, a pattern seen to a lesser degree in the 10cm samples, while the deepest (25cm) samples are most tightly contained. It might also be noted that the spread appears to move northwards from the south peak, and southwards from the northern peak, which given the topographic profile of the transect could reflect erosion of initially well-contained deposits downhill. At the relatively flat centre of the site, c.110-330 m, there is no significant variation with depth; the mean here is 1.4 % (n=38) with a range of 1.5 % (s.d.=0.45).

Organic Carbon

Organic C shows two peaks that appear to be more contained than those for soil pH but are less narrow than those just discussed for $CaCO_3$. The first peak lies between c.40-90 m, and the second between c.400-480. As with observations of pH and $CaCO_3$, the mean within these areas is significantly higher than in the central part of the col, and the ends of the transect, which lie beyond the supposed limits of the archaeological site: 9.9 % (n=36, range=15.1, s.d.=3.4) and 6.0 % (n=64, range=8.3, s.d.=1.6), respectively. Again, there appears to be a link between elevated organic carbon and the pale areas of the satellite image.

There is a slightly unusual shape to this data, as while the southern peak – the more pronounced of the two – shows significantly greater levels of organic C in the 10 cm sub-surface deposits, with comparable levels observed in the surface and 25 cm samples, the northern peak shows surface levels peaking some 50 m further south than do those in deeper deposits. This could again be a function of the movement downslope of surface deposits, with organic C not being prone to translocation down the soil profile.

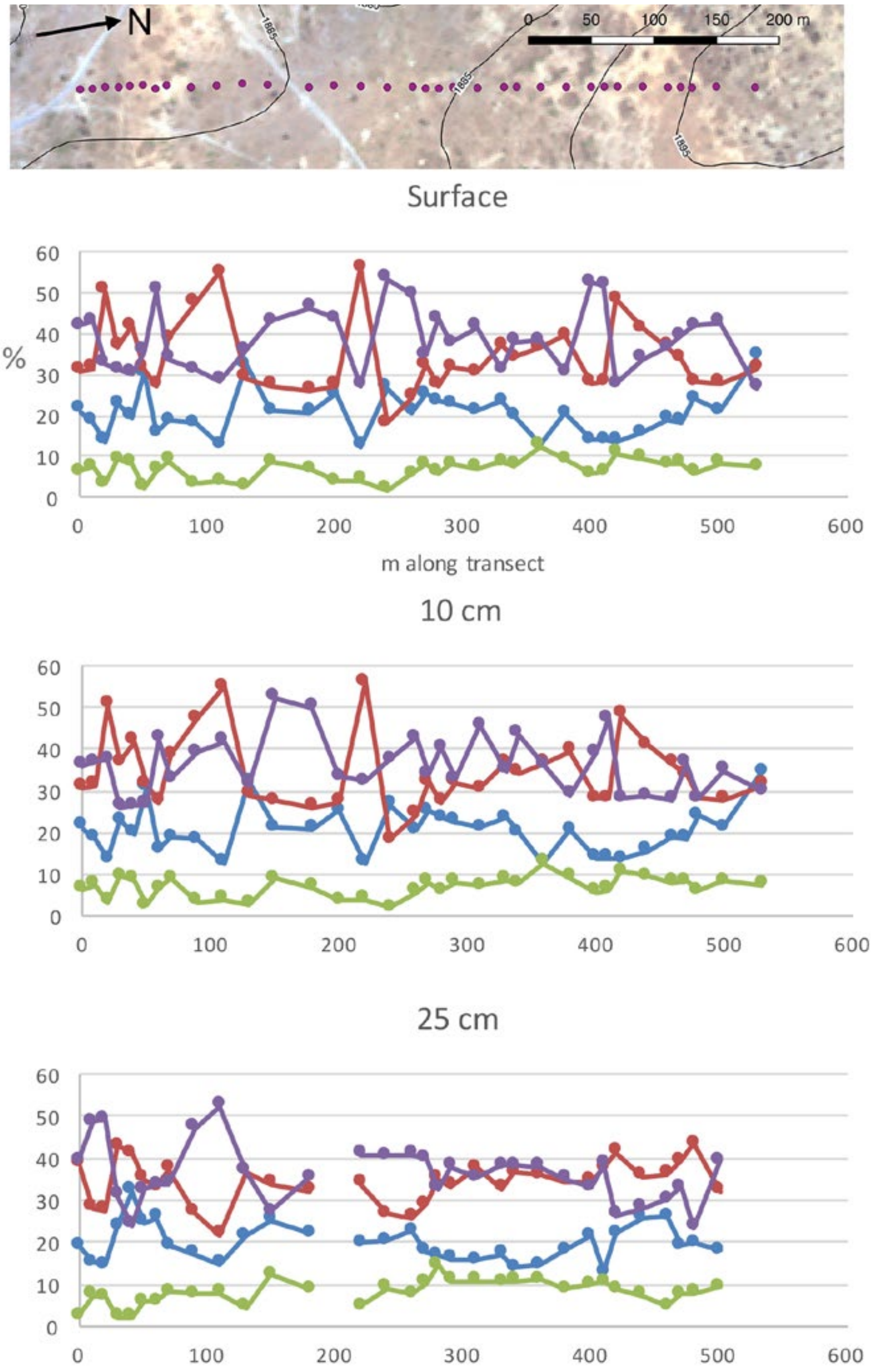


Figure 6.5. Particle size distributions along SN1, by depth

Particle size analysis

Though the plotted data does not show an immediately clear pattern to particle size distribution across SN1, bivariate correlation analysis (between the four particle size classes) indicates a strong negative correlation between coarse sand and silt in surface ($r = -0.796$, $n = 34$) and 10 cm ($r = -0.749$, $n= 34$) deposits, though these are not related in the deepest (25 cm) samples. At 25 cm, however, there is a strong positive correlation ($r = 0.631$, $n = 32$) between fine sand and silt.

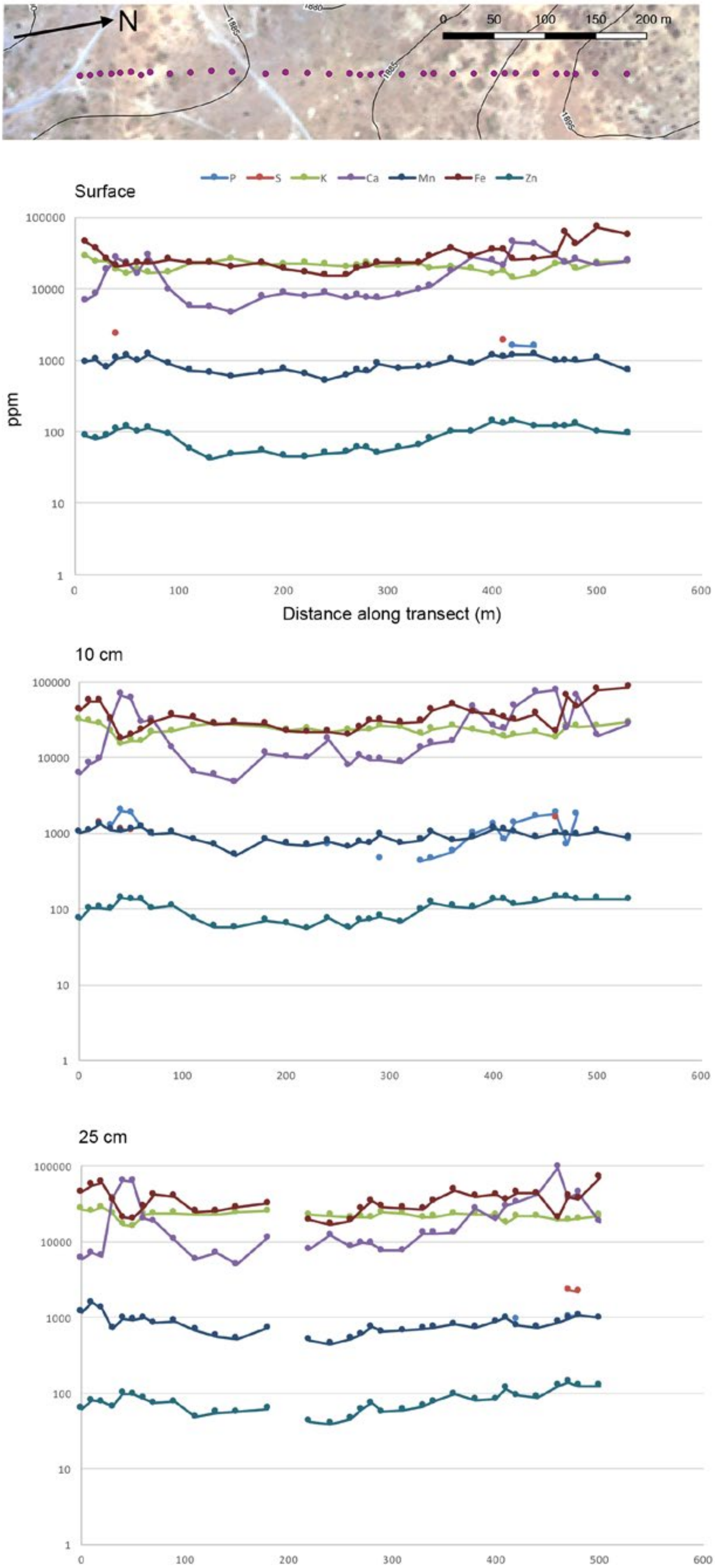


Figure 6.6. Transect SN1 XRF results, by depth

X-Ray Fluorescence

Only P, S, K, Ca, Mn, Zn and Fe have been selected for detailed consideration here, based on recognised associations with occupation residues – for instance, P with dung (e.g. Augustine 2003) and Ca with ash (e.g. Canti 2003) – and patterns emerging during visual inspection of the data. Levels of Ca, Mn and Zn peak towards either end of the transect, with the highest content registering in those same samples that registered peaks in organic C, $CaCO_3$ and pH, at distances of around 40-70 m and 420-480 m along the transect (south to north), within the pale areas in the satellite imagery. Levels of P and S sufficient to register a pXRF reading are also restricted to these areas, where, conversely, K, Fe and Ti show a proportionate decline.

Correlation analysis

Correlation analysis for the variables discussed above suggests two key patterns; firstly, there are positive correlations (of varying strengths) between organic carbon, $CaCO_3$, pH, P, S, Ca, Mn, Zn and silt-sized particles, with, secondly, a concomitant negative correlation between these variables and K, clay and coarse sand. A further strong correlation is noted between Fe and magnetic susceptibility. This patterning is most pronounced in the mid-depth (10 cm) samples but is also evident at 25 cm and in surface deposits. This pattern, alongside the observation that the peaks in the data are spatially constrained to the northern and southern ends of the transect – and thus the northern and southern limits of the Maili Sita col – suggests that the sediments can be grouped into two distinct categories sharing similar properties.

Vegetation

Grass cover was dominated by *Cynodon dachtylon* with some *Harpachne schimperi*, particularly across the central part of the transect, where quality was also highest and cover densest. Within the vicinity of the peaks in soil carbon, pH, etc, at the northern and southern ends of the transect, where samples did not fall within the grass patches, coverage was generally sparse, with relatively large expanses of bare ground. The patches themselves were dominated by *Pennisetum stramineum*, with some *C. dachtylon*, *H. schimperi* and *Panicum* sp. with occasional herbs, sedges and shrubs such as *Kyllinga* sp., *Solanum incanum*, *Achrycanthes aspera* ('Devil's Horsewhip'). *Acacia drepanolobium* ('Whistling Thorn') was present in the southern- and northern-most locales, and was only observed once towards the centre of the col, though nearby rather than within the sample locale. These 'off-site' samples showed grass cover increasingly weighted towards *C. plechtostachyus*, *P. stramineum* and *Themeda triandra*, with particularly dense areas of *P. stramineum* and *C. plechtostachyus* in the immediate vicinity of *A. drepanolobium*.

Animal dung

The recent dung recorded along transect NS1 was dominated by a variety of grazing ungulates, including Grant's gazelle, impala and occasionally eland and buffalo. Zebra and cattle being the most frequently observed across the col. Giraffe were also present, as were elephant, though the latter seemed to be most common towards the denser vegetation at either end of the transect, with the exception of a single instance in the centre. Scrub hare and baboon were also frequently recorded, with the latter likely associated with a troop occupying the rocky outcrop on the western slopes of the col.

Figure 6.7. View south along transect NS1 and the top of the Maili Sita col, note the P. stramineum-dominated patches in the foreground, and surrounding bare soil

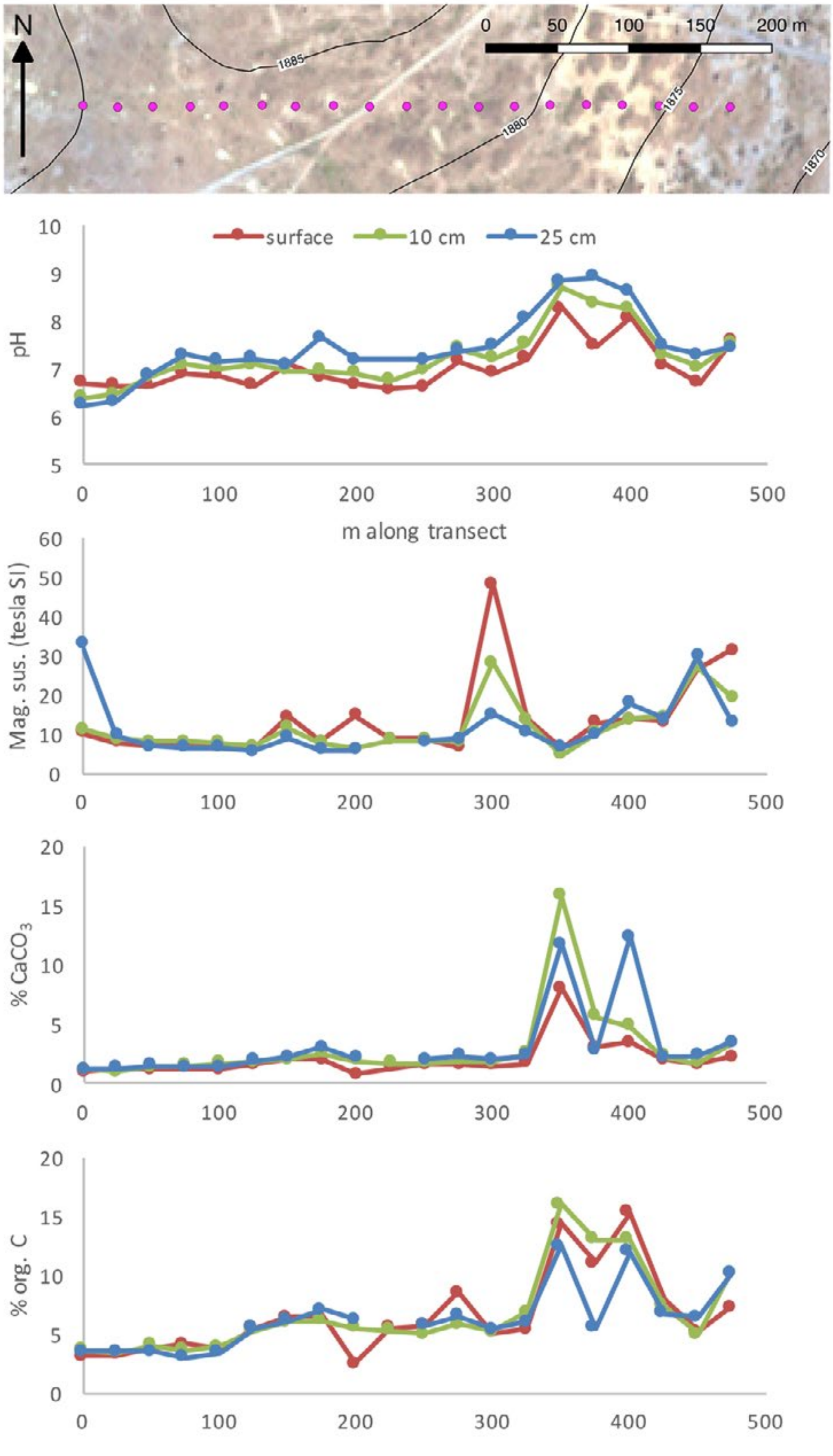


Figure 6.8. Transect WE1, results of pH, magnetic susceptibility, CaCO3 and organic C analyses

6.2.2 West-East Transect

Soil pH

Topsoils at the far western end of the transect are slightly acidic, and remain at or below neutral in surface sediments until 325-350 m. While at the beginning of the transect acidity increases gently with depth (though not by much), between 50 and c.325 this is reversed, such that the 25 cm samples are the most basic. At 325-350 m there is a significant increase in alkalinity at all depths, though a positive correlation between depth and pH is maintained. These samples are located within an area of similarly pale deposits to the two peak-pH areas of transect SN1. pH reaches 9 in the 25 cm sample at 375 m, though this coincides with a drop in the surface sample. The surface value climbs again at 400 m, suggesting that the drop might be a function of some anomalous occurrence, perhaps an unusual inclusion in the sample. All samples show a return to near neutral pH after 425 m, at levels comparable to those between 50 and 325 m.

Magnetic susceptibility

Magnetic susceptibility in the surface and 10 cm deposits remains fairly consistent across the transect, though rises gradually beyond c.400 m. The deepest (25 cm) deposits show an unusually high value at the western end of the transect, before becoming broadly aligned with the results for the upper deposits for the remainder of the transect. There is, though, a divergence of this pattern in the easternmost sample, wherein surface values are considerably higher (38%) than those of underlying deposits. At c.300 m there is a considerable spike in MS that does not register at all in any other variable. This peak is most dramatic in the surface deposits, and though decreasing in severity down the soil profile, is still recognisable at 25 cm. The sample location was not visibly different from others along the transect, nor is the spike evident as an anomaly in any other variable tested. As such, while the peak may be a consequence of a hearth or other human activity, it may be better explained by a brief super-heating of the topsoil caused by a lightning strike (Maki 2005). There is no obvious link between MS and variation in deposits as visible in the satellite imagery.

Calcium Carbonate $CaCO_3$

$CaCO_3$, as a percentage of the total sample, is consistently very low (<3%) in all samples, at all depths, from 0-325 m. Beyond this point there is a very sharp rise, particularly in the 10 cm and 25 cm samples, c.16% and c.12%, respectively. Surface deposits rise only as high as

8%. There is immediately a sharp dip at 375 m, followed by a further steep increase in the 25 cm deposits, though this is observed as a plateau nearer the surface. This peak is closely aligned with that in pH and the area of visibly paler deposits. At 425 m there is a return to levels comparable to those noted east of 325 m.

Organic Carbon %

Organic C content increases gradually from the start of the transect to 325 m, with minor fluctuations in surface levels at 200 m (drop) and 275 m (rise). Between 325 and 350 m there is a sharp increase, with maximum levels observed at 10 cm depth, though comparable throughout the profile. There is an immediate sharp decline at 375 m, most dramatic at 25 cm, a further increase at 400 m, and an immediate return to base levels, again aligned with the extent of the pale deposits. The final sample, at 475 m, seems to show a slight upward trend at all depths.

X-Ray Fluorescence

Levels of Ca show a considerable enrichment towards the eastern end of the transect, between 325 and 425 m, which at 25 cm appears as a double peak. Mn and Zn appear to be present in similarly elevated levels at the same location, while there is an attendant drop in Fe and K. There is a gradual increase in Fe down the eastern flanks of the col. A single sample yielded a reading for P, in the surface sample at 400 m, therefore falling within this 'peak' zone and the pale area in the satellite imagery. No results for S were obtained.

Correlation Analysis

Correlation analysis using Pearson's R demonstrates a weakly (p=0.01-0.05) positive relationship between soil depth and pH, such that deeper soils are more basic. As with transect SN1, pH is strongly (p=<0.01) correlated with % organic C and $CaCO_3$, which are also strongly correlated themselves. There is also a strong relationship between these variables and Ca, Zn and Mn. All these are strongly negatively correlated with K. A strong positive correlation is observed between magnetic susceptibility and Fe. As with SN1, this co-patterning suggests that the deposits can be assigned to one of two categories representing distinct types of deposit.

A correlation analysis based on depth using data from both transects SN1 and WE1 strengthens these relationships. Importantly, the minimum and maximum values, and

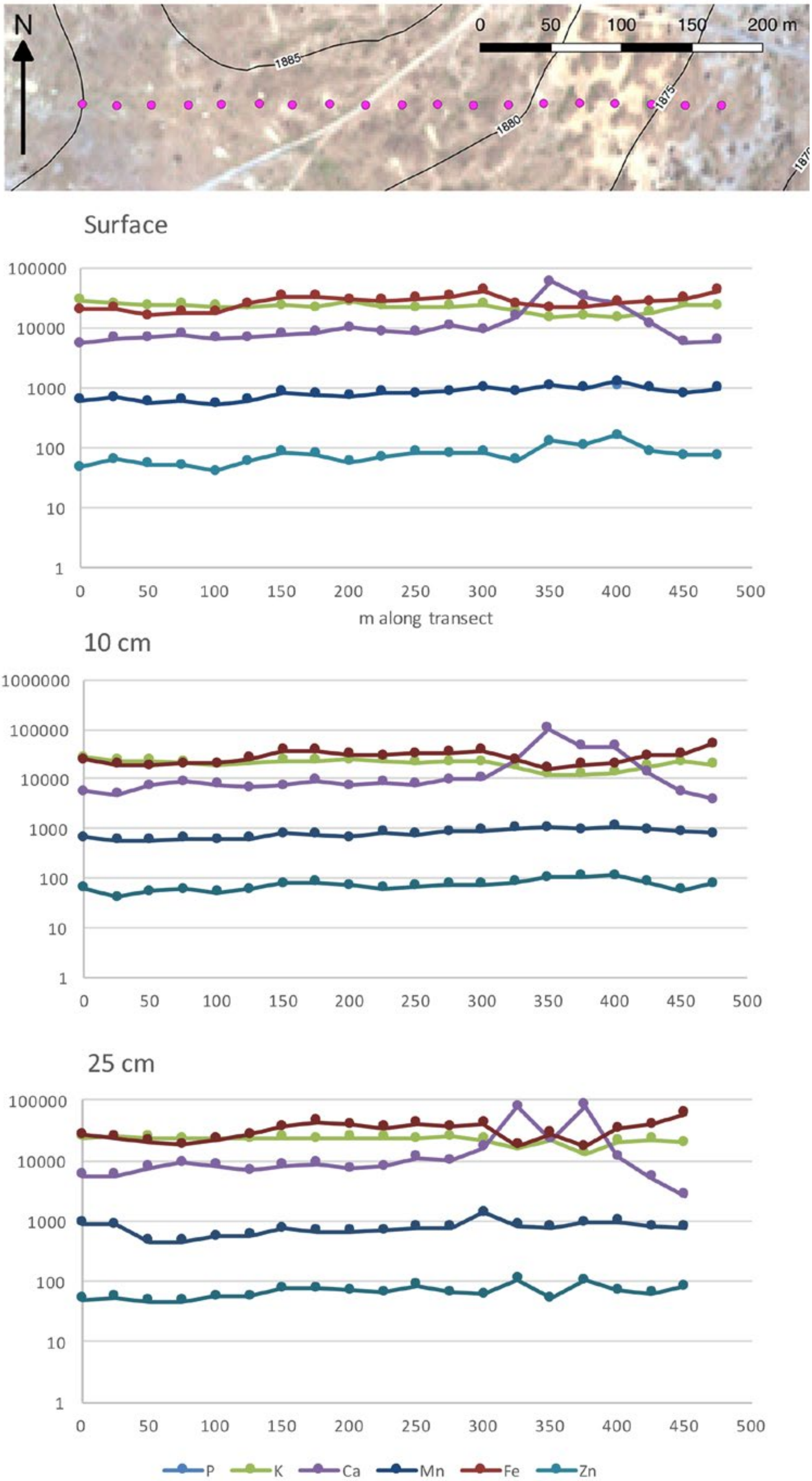


Figure 6.9. Transect WE1, XRF results by depth

consequently the range, for the correlated variables – particularly $CaCO_3$, organic C and pH – across each transect are similar. This indicates that northern, southern and eastern areas of the site are characterised by similar deposits, while the central part of the col compares closely to off-site conditions.

Vegetation

Vegetation was observed to follow a similar pattern to that described above for transect NS1; western end and centre of the transect, which relates to the centre of the col, was dominated by *C. dachtylon*, with occasional *H. schimperi*. The grass patches were again dominated by *Pennisetum stramineum*, with some *C. dachtylon*, *H. schimperi* and *Panicum* sp. with *Kyllinga* sp., *Solanum incanum*, *Hibiscus* sp. and *Achrycanthes aspera*. Overall coverage was generally sparse in the vicinity of the eastern peaks in the soil data, becoming denser as the transect moved into the *A. drepanolobium* thicket that delineates the edge of the archaeological site. As with NS1, grass cover at these off-site sample locations was distinct from that atop the col, being dominated by *P. stramineum*, *C. dachtylon* and *T. triandra*.

Animal dung

Species representation was mostly the same as NS1: zebra (most frequent), cattle, impala, eland, Grant's gazelle, giraffe, buffalo, scrub hare and elephant, with the addition of warthog and Egyptian goose. Elephant again tended to be denser close to wooded areas, with other species relatively evenly distributed.

6.2.3 Patch transect pEW1

Soil pH

Soil pH appears to rise just outside the perimeter of the first patch, before levelling out. However, while between patches 1 and 2 there may a be a slight reduction, most notable in samples 12 and 13 (and perhaps 14, which lies just inside the edge of patch 2), followed by a return to a more basic level at sample 15, inside patch 2. However, there is then an immediate decline in pH in samples 16 and 17, which lie towards the centre of patch 2. Values all reflect the basic deposits previously noted for the 'ring' observed in transects SN1 and WE1.

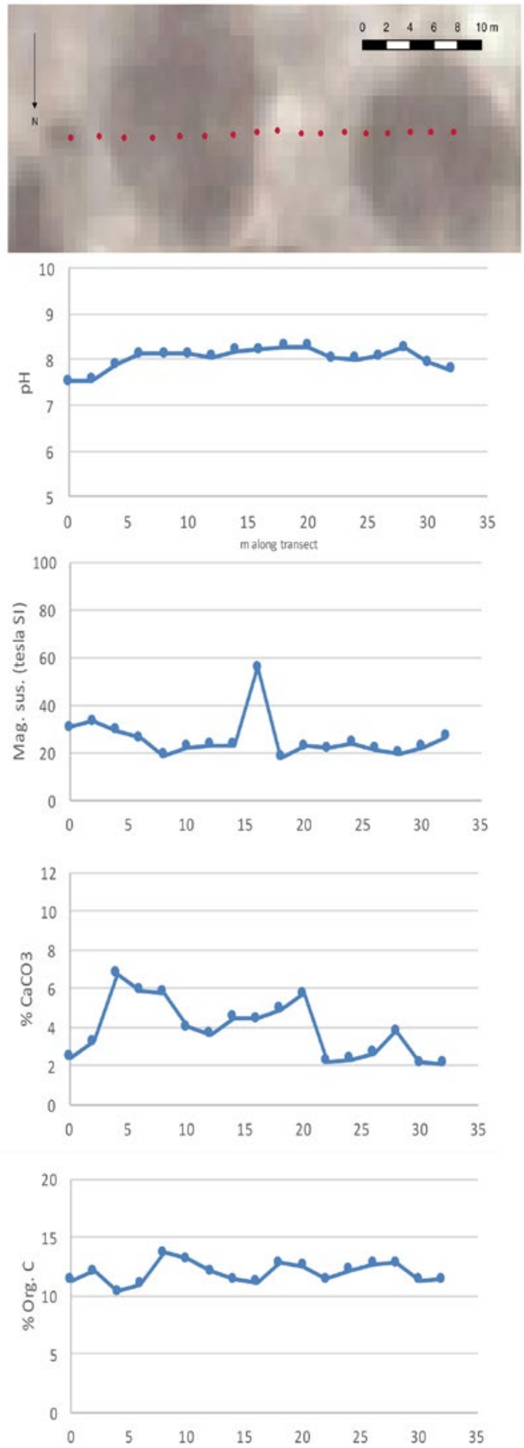


Figure 6.10. Transect pEW1, results of pH, magnetic susceptibility, CaCO3 and organic C analyses

Magnetic susceptibility

Magnetic susceptibility levels of 20-30 are comparable to those observed for this area of the col in transect SN1, and do not differ greatly from those noted in control samples from beyond the notional perimeter of the archaeological site. There is, however, a significant spike in sample 9, 0.5 m inside the western edge of patch 1, an anomaly similar to that noted in transect WE1 at 300 m. Both spikes fall slightly below the highest MS values noted for the northern end of transect SN1, on the steep slopes of the northern Maili Sita ridge. As in the WE1 data, the feature may be a relic of a lightning strike (Maki 2005).

Calcium carbonate $CaCO_3$

$CaCO_3$ levels do not appear to vary depending on the presence of grass patches, and fluctuate between the peak values observed for this part of the site in SN1 (c. 7 %) and levels slightly above those that might be expected to occur naturally (c. 2%), based on values observed in off-site samples, at the ends of transects SN1 and WE1.

Organic carbon

As with $CaCO_3$, there is no clear pattern to the distribution of organic C levels across the transect, with all samples maintaining value between 12 and 14 %. This again falls within the range of values expected for the 'ring', as observed in SN1 and WE1, some 10 % higher than one would expect for natural deposits.

Particle size analysis

No link could be established between patch/non-patch samples and variation in particle size. The only correlations noted with other variables include a strong negative relationship between pH and percentage silt and a strong positive link between pH and coarse sand. Similar, weaker relationships are observed between $CaCO_3$ and silt and coarse sand.

X-Ray Fluorescence

There is no discernible pattern of compositional change between and within the circular grass patches assessed. P levels are recorded for all except two sample locations, and remain fairly constant. Ca, Fe, K and Zn levels are comparable with those recorded in the nearby SN1 samples, which happen to fall within the southern of the two 'peaks'.

Correlation analysis

Correlation analysis using Pearson's R suggests that organic C and magnetic susceptibility have a weak ($p=0.046$) negative relationship; as organic C increases, MS decreases. This pattern contrasts with that noted elsewhere in the world, where an increase in microbial activity encouraged by the introduction of organic material, such as manure, is met with an increase in soil magnetism (Evershed et 2007; Mullins 1977). However, given this weak statistical relationship, the pattern is unlikely to be of particular consequence. Magnetic susceptibility is shown to be strongly correlated with total K, while Ca is strongly linked to $CaCO_3$.

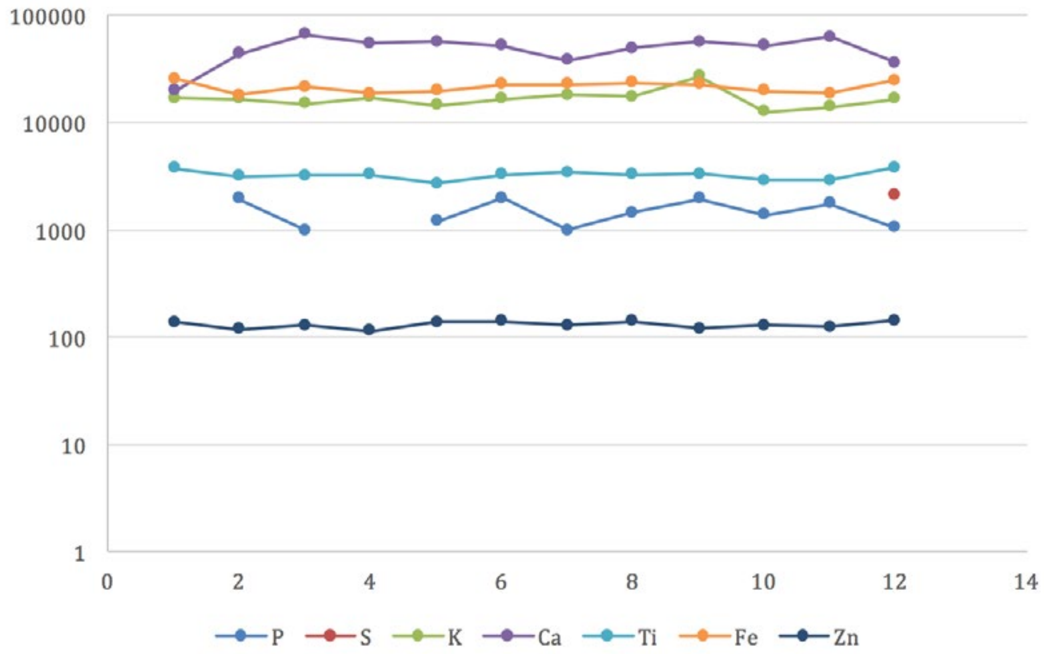


Figure 6.11. Transect pEW1, XRF results

General soils-vegetation correlation analysis

In order to confirm if and how soils underlying the circular grass patches differ in composition, additional correlation tests considered the type of vegetation corded at each sample location along the other survey transects. Using a coarse system of categorisation, defining locations as either 'patch', 'non-patch, grassy', 'non-patch, sparse' and 'bare', there was no indication that particular grass cover types are associated with particular soil compositions.

6.2.4 2010 excavation units

I took samples at 5 cm intervals along the block/column samples obtained from excavation unit walls during the 2010 season; the same blocks prepared for micromorphological thin section analysis, as discussed later. Units were excavated along a northerly transect from the southern part of the site, with unit A/10 located around 20 m north of the patches surveyed in transect pEW1. Unit B/10 is positioned 10 m north of A/10, with D/10 30 m beyond.

Soil pH

All samples from A/10 showed greater alkalinity than samples from either of the other

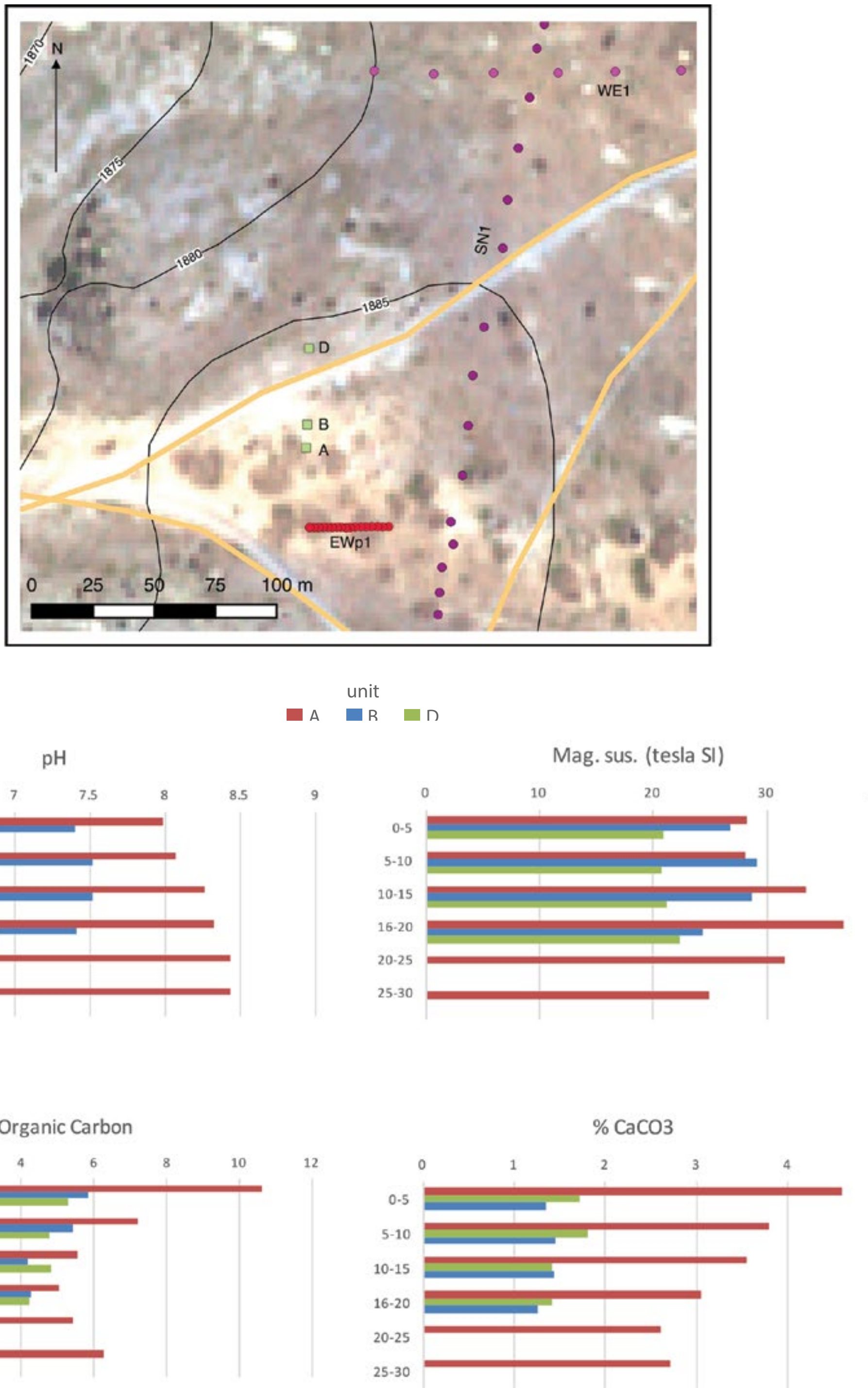


Figure 6.12. pH, MS, CaCO3 and org. C data, column samples from 2010 excavation units

two units, and gradually increase with depth. Levels of 8-8.5 are comparable with those observed for the peaks of transects SN1 and WE1. pH in unit B/10 is not so elevated, but remains higher than D/10, for which levels are comparable to control samples taken beyond the perimeter of the site.

Magnetic susceptibility

Units A/10 and B/10 show very similar MS readings in the upper deposits, whereas the deepest samples from units B/10 and D/10 are comparable and A/10 shows a marked increase. This peak at 15-25 cm then drops away to, at 25-30 cm, return to a similar level to readings seen in B and D. Samples were not taken at this depth for B and D.

Organic carbon %

Organic carbon is a considerably greater component in samples from the top layers of unit A/10, where its concentration is around double that seen in units B/10 and D/10, between which there is little variation. Unit A/10 levels, however, return to something approaching those of B/10 and D/10 below around 10 cm.

Calcium Carbonate $CaCO_3$

As with organic carbon, $CaCO_3$ is significantly higher in unit A/10, almost three times the levels observed in B/10 and D/10 in the topsoil samples. The latter are more or less consistent throughout their respective soil profiles, while unit A/10 shows a steady decline. However, the deepest samples from unit A/10 still carry a $CaCO_3$ component twice that of the other units.

Spherulites (analysis by Jon Cogdale)

Faecal spherulites in unit A/10 show an increase from the topsoil with depth, peaking in the 10-15 cm samples, there is then a steep decline to levels below those noted in the topsoil. Ratios of small : very small spherulites in the upper levels are comparable with those expected for cattle dung deposits (J. Cogdale pers. comm.), while VS-dominated ratios observed at lower levels might be explained by the ease of which these smallest spherulites might percolate down the soil profile.

X-Ray Fluorescence

XRF data from the excavation units indicates clear differences in the composition of deposits. Unit A/10, located close to the post-hole features observed in unit A/2004, shows significant enrichment of P, Ca, Mn, and Zn in the uppermost soils, levels of which decline at a fairly even rate into the lowest, natural deposits. In fact, P only registers in samples above 20 cm depth. Conversely, other elements including S, K, Ti, Ni and Rb, are most concentrated towards the base of the profile.

Unit B/10 shows similar concentrations of P, Ca, Mn and Zn in the surface and upper-

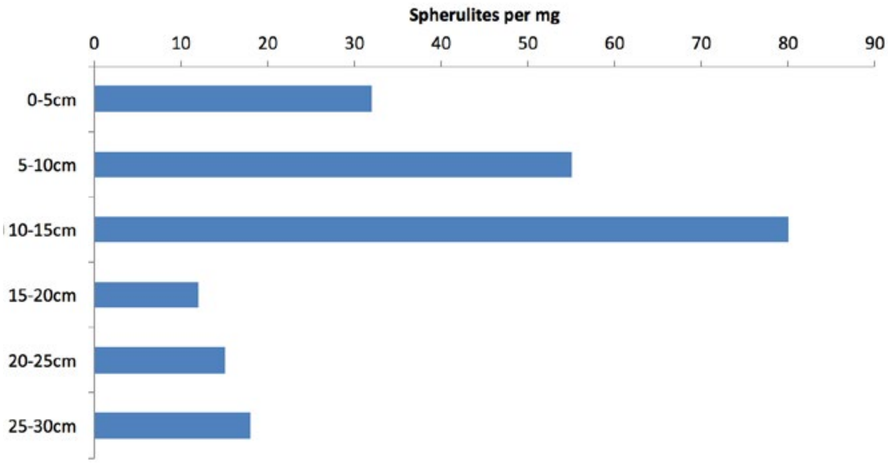


Figure 6.13. Faecal spherulites from unit A (2010) (courtesy of J. Cogdale)

Table 6.1. Faecal spherulites from unit A (2010) (courtesy of J. Cogdale)

Depth	Spherulites /mg	Very Small (%)	Small (%)	Ratio VS:S
0-5cm	32	62%	38%	1.6
5-10cm	55	66%	34%	1.9
10-15cm	80	86%	14%	6.3
15-20cm	12	70%	30%	2.3
20-25cm	15	92%	8%	11
25-30cm	18	92%	8%	12

middle deposits as in A/10. This unit also shows the pattern of S, K, Ti, Ni and Rb enrichment lower down. Notably, though, the B/10 profile is shallower (max. 20 cm deep) and the P, Ca, etc-enriched deposits are restricted to the top 10 cm, while in A/10 these extend to c. 20 cm. This fits with the excavators' idea that B/10 was located towards the edge of an area of distinct ashy deposits, while A/10 was more central. Unit D/10, in contrast, shows fairly consistent levels for all variables throughout the c.20 cm profile, though there is a slight, even decrease in Mn, which may indicate that this pattern in the other two units may reflect natural vertical translocation processes. These levels are broadly similar to the lowest, natural deposits in units A/10 and B/10. There is, therefore, nothing to suggest that more than one type of deposit is present at unit D/10, while at least two are evident at the other two locations.

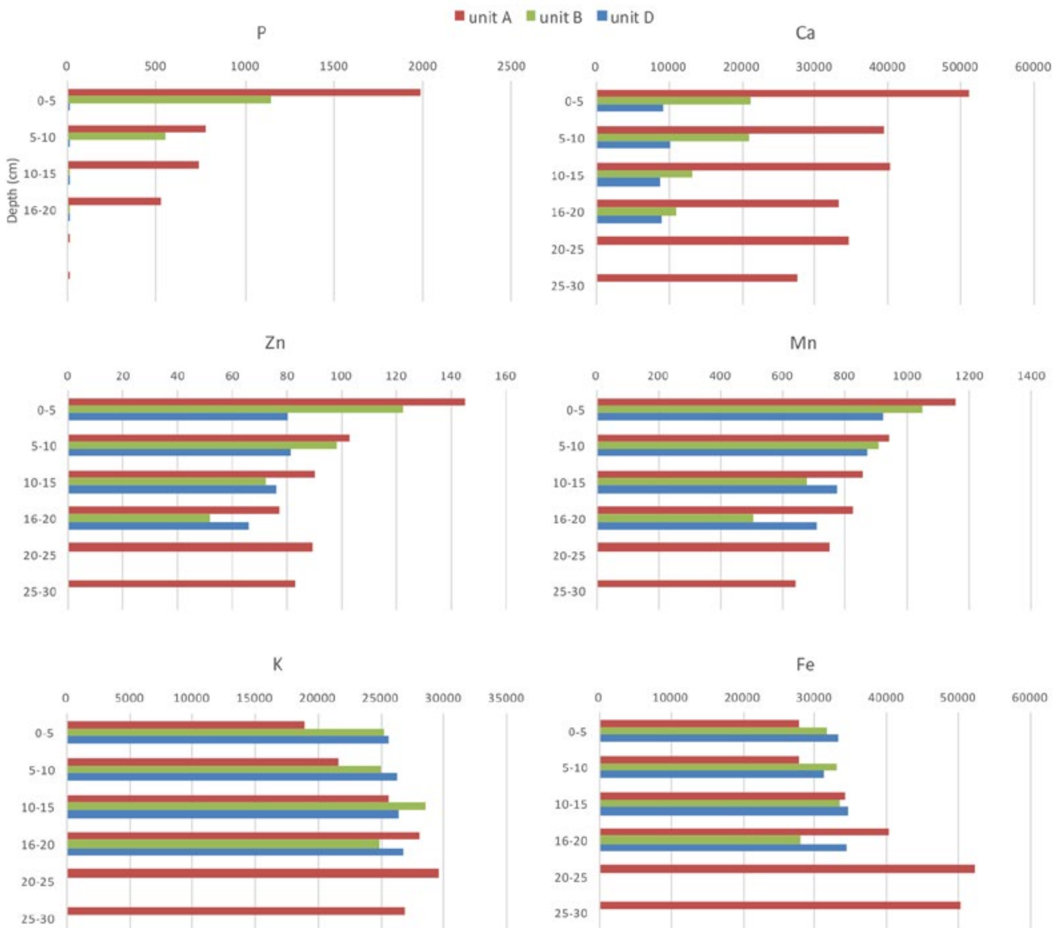


Figure 6.14. XRF data (selected elements) from 2010 unit column samples

6.3 Soil Micromorphology

Thin sections were manufactured from the three column samples collected from excavation units A, B and D and mentioned earlier with regard to my sub-sampling for bulk anlayses; four, three and three 50x75 mm slides pertain to each unit, respectively. The table below summarises the observations made.

A number of observations can be made on the basis of the micromorphological records outlined above. The most pressing of these is that the soils at Maili Sita have been and continue to be subject to comprehensive bioturbation by soil microfauna, likely *Marcotermes spp.*, the effects of which have been documented on Lolldaiga (Qandelihle 2010) and savannah environments more generally (Fox-Dobbs et al. 2010; Jungerius et al. 1999). This is perhaps unsurprising given the numbers of termite mounds, active and relict, visible across the site and the surrounding area; indeed, termites are a constant presence across the semi-arid landscapes of eastern Africa and are a factor in site formation that archaeologists are forced to consider (McBrearty 1990). Second, and following directly from the above,

Table 6.2. Summary table of micromorphological observations (O. Boles)

UNIT A **Depth (mm)** (thin section)	**Microstructure**	**Bioturbation**	**Coarse fraction (c:f ratio)**	**Mineral grain size**	**Voids (%)**	**Fine fraction (colour PPL)**	**Charcoal (grain size)**	**Bone**	**Calcite**	**Spherulites**	**Phytoliths**	**Organics**	**Pedofeatures**
0-75 (ms/a/i/1)	Homogeneous Complex, granular excre-mental, apedal	+++	95:4:1 Q:FS:M sa, u (70:30)	cSd-sP	CP (30) Ch (10)	ud(s)	++ (f)	-	MCv	++	-	++	Excremental infilling of voids, micropan clay coatings of larger quartz grains
75-150 (ms/a/i/2)	Homogeneous Complex massive/granular (10:90) excremental, Weakly developed sub-angu-lar blocks	++	95:4:1 Q:FS:M sa, u (30:70)	fSd-cSd	CP (40) Ch (10)	ud(s)	++ (f)	-	MCv RC	+++	+	+	Dusty micropan clay coating of quartz grains, low clay in groundmass, freq. ver-miforms, dense, well-defined infilling of channel with clayey silt (possible slaking of org.-rich layer above), few spherical phosphate nodules
150-225 (ms/a/ii/1)	Homogeneous Complex massive/granular (10:90) excremental, Weakly developed sub-angu-lar blocks	++	95:4:1 Q:FS:M sa, u (40:60)	fSd-mSd	CP (20) Ch (10)	ud(s)	+++ (f) (2x cSd)	+ (2x cSd)	MCct RC	+	-	-	Freq. typic clay coating of quartz grains, high limpidity, few spherical phosphate nodules
225-300 (ms/a/ii/2)	Homogeneous Complex massive/granular (25:75) excremental	+	80:15:5 Q:FS:M sa, u (50:50)	fSd-mSd	CP (15) Ch (10)	ud(s)	+	-	MCv	-	-	-	Some clay rich nodules, rare infilling of channels with excremental pellets

UNIT B **Depth (mm)** thin section	**Microstructure**	**Bioturbation**	**Coarse fraction (c:f ratio)**	**Mineral grain size**	**Voids (%)**	**Fine fraction**	**Charcoal (grain size)**	**Bone**	**Calcite**	**Spherulites**	**Phytoliths**	**Organics**	**Pedofeatures**
0-70 ms/b/1	a) top 25 mm, horizontal striations, organic rich, massive/granular, apedal	++	90:8:2 Q:FS:M sr, u (30:70)	cSt-cSd	CP (30-80)	ud(s)	+++ (f)	(-)	rCal	(-)	(-)	++	Horizontal striations of 1-3 mm, clear boundaries
	b) below 25 mm, Homogeneous Complex, granular Excremental, some weakly developed sub-angular blockly peds		95:4:1 Q:FS:M sa, u (30:70)	fSd-cSd	CP (20) Ch (10)	ud(s)	++ (f)	(-)	rCal MCv	(-)	(-)	++	Rare micropan and typic clay coating of mineral grains
70-140 ms/b/2	Homogeneous Complex massive/granular (10:90) excremental, apedal	+++	80:15:5 Q:FS:M sa, u (60:40)	fSd-cSd	CP (20) Ch (10)	ud	+ (f)	(-)	MCv	(-)	(-)	+	Some excremental infilling of voids, micropan clay coatings of coarse grains (more common with depth)

UNIT D **Depth (mm)** thin section	**Microstructure**	**Bioturbation**	**Coarse fraction (c:f ratio)**	**Mineral grain size**	**Voids (%)**	**Fine fraction**	**Charcoal (grain size)**	**Bone**	**Calcite**	**Spherulites**	**Phytoliths**	**Organics**	**Pedofeatures**
0-70 ms/d/1	Homogeneous Complex, massive/granular (5:95) excremental	++	85:10:5 Q:FS:M sr, u (50:50)	cSt-cSd	CP (10) Ch (20)	ud	+ (f)	(-)	rCal	(-)	+	++	Significant organic staining of fine fraction, some micropan clay coatings of larger grains
70-140 ms/d/2	Homogeneous Complex massive/granular (10:90) excremental, apedal	++	80:15:5 Q:FS:M sa, u (60:40)	fSd-cSd	CP (20) Ch (10)	ud(s)	(-)	(-)	(-)	(-)	(-)	+	Single very iron-rich clay nodule with very clear boundaries and similar composition to major fabric, common infilling of voids, less organic staining than above
140-190 ms/d/3	Homogeneous Complex massive/granular (10:90) excremental, apedal	+	80:15:5 Q:FS:M sa, u (50:50)	fSt-sP	CP (5) C (10)	ud(s)	(-)	(-)	(-)	(-)	(-)	(-)	Very rare micropan coatings of coarse grains, some excremental infilling of voids

Abbreviations: *coarse fraction:* Q = quartz, fs = feldspar, m = mica, sa = sub-angular, sr = sub-rounded, u = unsorted; *grain size*: fSd fine sand, mSd = medium sand, cSd = coarse sand, cSt = coarse silt, sP = small pebble; *voids*: CP = complex packing void, Ch = channel; *micromass*: ud = undifferentiated, (s) = high order speckling; *charcoal* etc: (f) = flecking, (-) = absent; *calcite:* MCv = micritic calcite in voids, MCct = micritic coating of mineral grains, RC = rhomboidal crystals, rCal = root calcification is that very few micromorphological features such micro-strata and evidence of ped formation are evident in the samples considered; if present at all, such features may well be obscured by the activity of soil microfauna. Only a single instance of microstratigraphy is recorded, in the uppermost part of unit B/10 (slide ms/b/1). However, there is general uniformity between the striations and little additional information from which to infer origin. There is a subtle difference in the soil fabrics of the upper and lower portions of the sample in question, and the striated area appears to be composed differently to the rest of the soil profile, suggestive of translocation from elsewhere. This fits well with Payton's (2005:54) observation of thin, loose wash layers overlying weakly developed topsoils.

A third observation – or set of observations – concerns the differences between the units sampled. While there are strong similarities in mineral compositions across the units – all samples show compositions of quartz, feldspar (mainly plagioclase) and mica consistent with soils derived from the kinds of granite and migmatite base geology that characterises the Lolldaiga Hills (Hackman et al. 1989) – and the fine fractions have been subject to similarly dramatic bioturbation, samples from unit A/10 show a number of features that are absent or much reduced in those from the other two units. Although present in B/10, charcoal is most clearly and frequently observed in unit A/10, where it ranges from flecking, which accounts for up to 5 % of the total soil fabric, to sand-sized fragments. These larger fragments were particularly easily identifiable as charcoal as opposed to manganese or other opaque particles, with which micro-fragments can be confused in thin section (M. Arroyo-Kalin, pers. comm. 2014), due to their visible cellular structure. Interestingly, charcoal is most frequently observed in samples pertaining to the middle of the A/10 profile, which may suggest either that there has been some additional soil accumulation above the levels at which the charcoal was originally deposited, or that processes of bioturbation and/or illuviation have caused a downward translocation of charcoal microfragments. Charcoal is completely absent in unit D/10.

Calcium carbonate accumulations are much more frequent and extensive in A/10 than the other units, and in the middle samples sometimes take the form of rhomboidal crystals that may be linked to plant ash (Canti 2003). The relative distribution of these features throughout the soil profile is similar to the patterns noted for total $CaCO_3$ content, as tested for via loss-on-ignition and outlined above, with the mid-level slides (ms/a/i/2 and ms/a/ii/1) showing the highest concentrations of carbonate pedofeatures. As with the observation that charcoal appears to be concentrated at sub-surface levels, this may be a function of bioturbation causing downwards translocation.

A/10 is also the only unit observed to contain micro-fragments of bone, of which there are several instances recorded in the middle part of the profile (ms/a/i/2 and ms/a/ii/1).

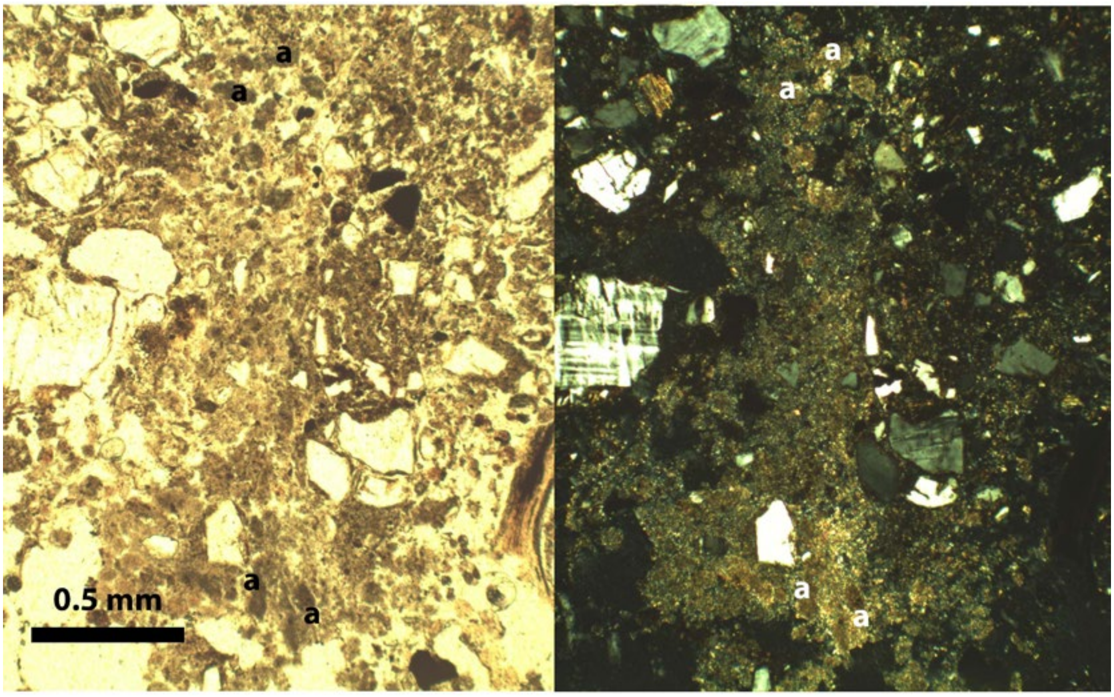


Figure 6.16. calcium carbonate accumulation with rhomboidal crystals (a), slide ms/a/i/2, x50, PPL & XPL (O. Boles)

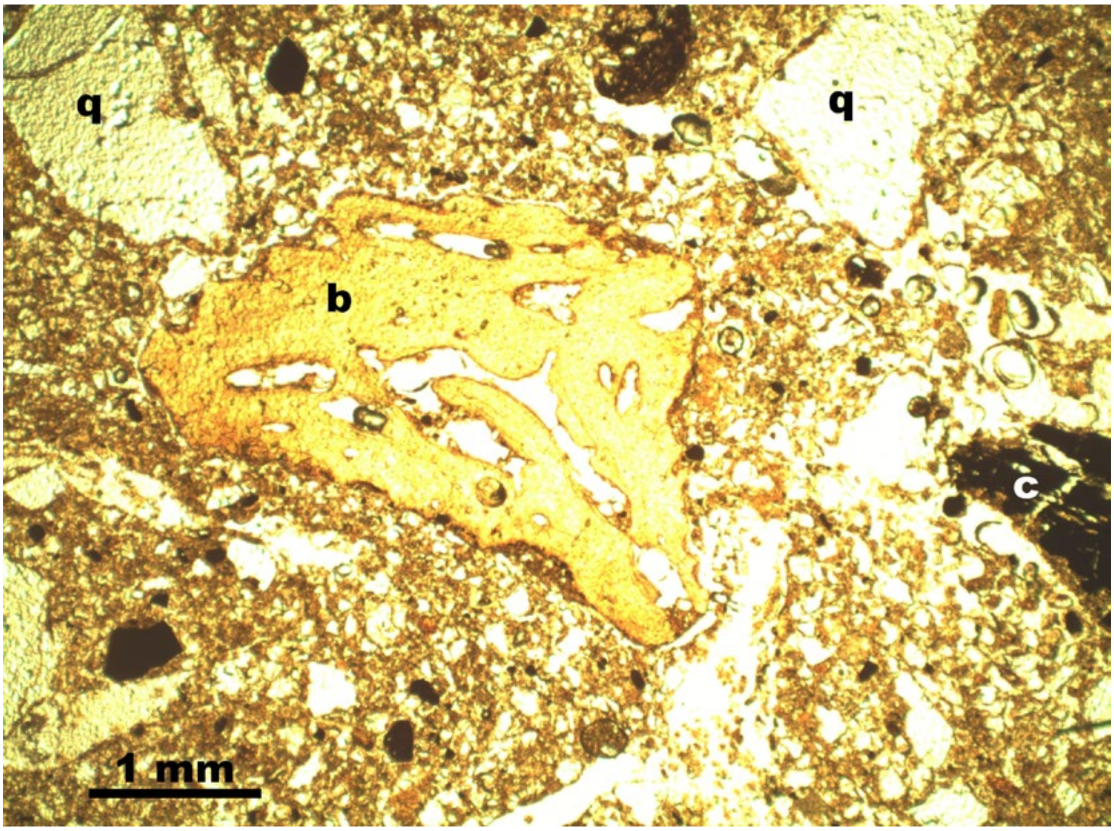


Figure 6.15. bone fragment (b) and partial view of charcoal fragment (c) in granular fabric with unsorted quartz (q), slide ms/a/ii/1, x25, PPL (O. Boles)

In addition, these samples contain the highest densities of faecal spherulites; spherulites are present in varying densities throughout the A/10 profile, in a comparable pattern to the specific spherulite data outlined above (analysis undertaken by J. Cogdale) as well as in very low concentrations in unit B/10. Faecal spherulites may also account for the high-order speckling of the b-fabric throughout A/10 and, to a lesser extent, in the upper levels of B/10 (c.f. Shahack-Gross *et al* 2002; 2003). As with charcoal, neither spherulites nor speckling were observed in D/10, and it seems that this unit contains no anthropogenic introductions. A/10 also contains rare authigenic calcium-phosphate nodules in the central part of the profile. These were not identified in the samples from units B/10 and D/10.

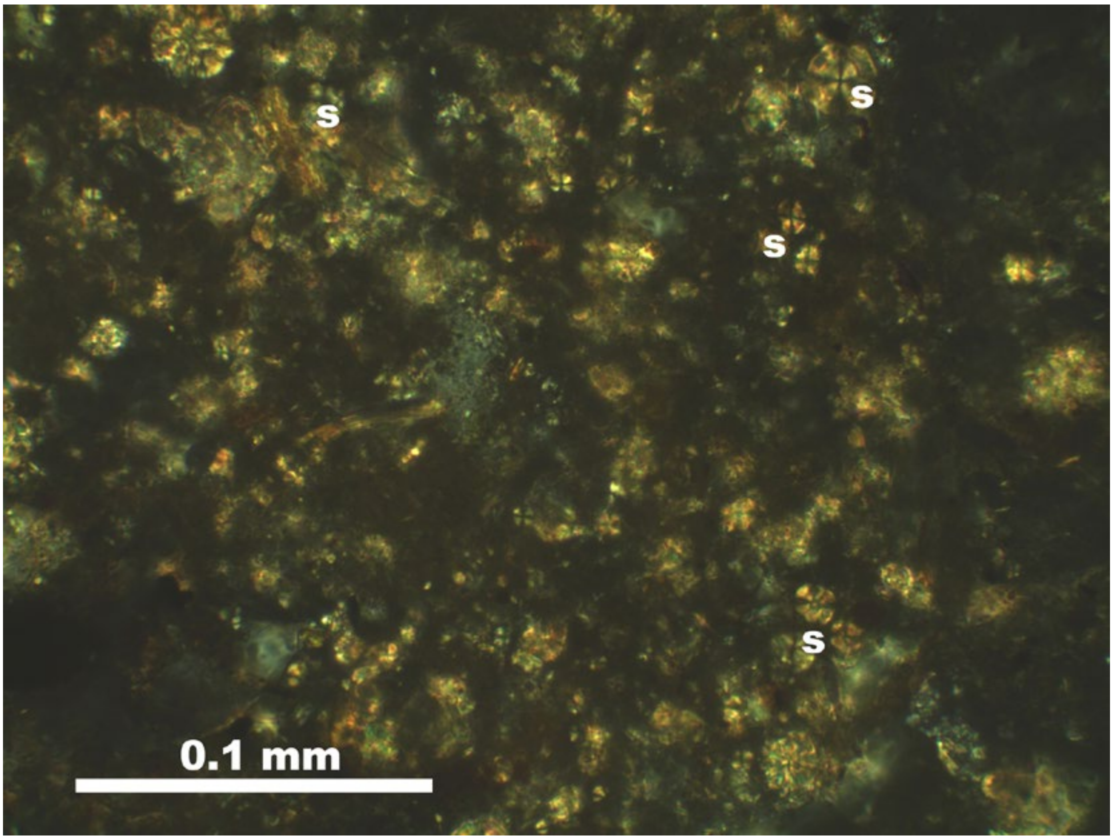


Figure 6.17. Faecal spherulites (note cross-pattern, see Canti 1998) slide ms/a/i/2, frame width 0.3mm, XPL (O. Boles)

6.4 Discussion

There are strong positive correlations between certain variables across all the samples from Maili Sita (site transects, patch transect, excavation units), which, if grouped together, exhibit negative correlation with other variables. At the level of individual samples cases, there appears to be two broad categories of deposit: soils that contain high levels of organic C, $CaCO_3$, P, Mn, Zn and Ca, are of basic pH (c. 8) and are comprised of a high proportion of fine sand particles (hereafter referred to as 'group 1' deposits); a second group can be made up of soils of slightly lower, neutral pH (6.5-7.5), with a higher clay content, magnetic susceptibility and levels of, for instance, K and Fe (group 2). In terms of the samples from the excavation units, the former can be equated with the upper and middle deposits of unit A/10 and the upper deposits in unit B/10, while the lower parts of those profiles, and all of unit D/10 can be equated with group 2. Consequently, high charcoal and ash content and faecal spherulites can be added as features of group 1, based on the associated micromorphological descriptions of these deposits.

Given their distributions along the transects and vertical concentrations in the sediment profile, group 2 deposits can be considered, in a general sense, to be natural, of similar composition and structure to off-site, regional control samples. Group 1 on the other hand, appears largely derived from the by-products of human occupation: primarily degraded dung, mixed with ash. The environmental conditions at Maili Sita are not suited to the survival of organic-rich dung remains, which in desiccated (di Lernia 2001; Rosen et al. 2005) or waterlogged environments (Rasmussen 1993) can be remarkably well-preserved; for instance, Rasmussen (1993) has been able to differentiate between individual sheep and goat faecal pellets at the 4300 BC site of Egolzwil 3 in Switzerland. Instead, at sites where conditions are neither anoxic or consistently dry, the organic component of dung

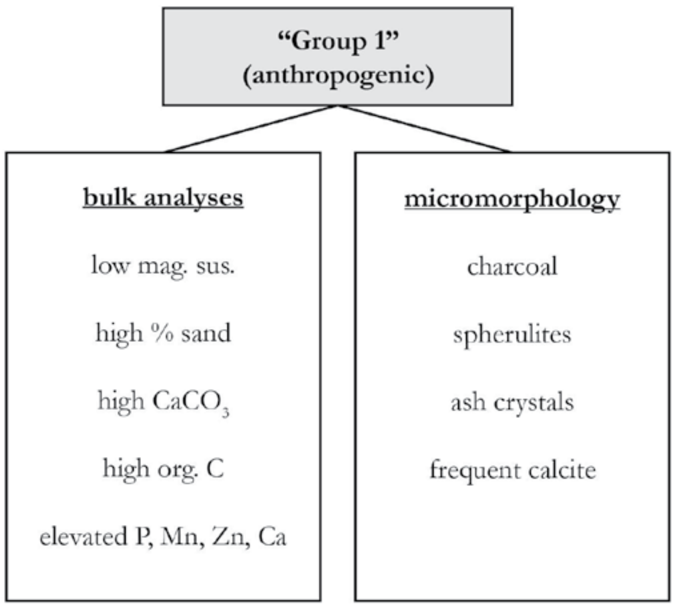


Figure 6.18. Indicators of group 1 'anthropogenic' deposits

degrades quickly and completely, leaving the kind of light grey-brown deposits (Shahack-Gross 2011) seen in the group 1 samples at Maili Sita.

The presence of concentrations of faecal spherulites, albeit at much lower densities than were observed in Shahack-Gross' ethnoarchaeological studies (Shahack-Gross et al. 2003), or have been recorded at enclosed cave sites (Brochier et al. 1992) is a principal indicator that the group 1 deposits are largely comprised of dung (Canti 1997; Canti 1998; Shahack-Gross et al. 2003; Lancelotti & Madella 2012). While it should be remembered that spherulites are less likely to survive in acidic conditions (Canti 1999), such that their depletion would be expected in group 2 soils, samples from the excavation unit A/10 – where pH is seen to be fairly consistent throughout the profile, and which was subject to quantified spherulite analysis – yielded much higher densities of spherulites in the upper, group 1 levels (J. Cogdale, pers. comm. 2015). While there is no direct evidence (e.g. spherulites) that the northern, southern and eastern areas of group 1 soils are indeed comprised of a comparable dung content to the A/10 deposits, I would argue that such an inference can be reasonably made based on close similarities in other measures linked to dung, such as high phosphorus content (Augustine 2003; Muchiru et al. 2009; Macphail et al. 2004). Equally, phosphorus levels can be enriched by the presence of microscopic bone fragments of the kind observed in the sub-surface deposits at unit A/10 (Provan 1971; Shahack-Gross 2011), though further investigations (e.g. SEM) would be needed to confirm such an origin. There were, however, a number of calcium-phosphate nodules recorded in the group 1 deposits from unit A/10 that may well be composed of authigenic dahllite, attributed by Shahack-Gross *et al.* (2003; 2004; 2005) to the degradation of organic component of dung. This process releases phosphate into the soil which is thought to react with calcium carbonate present in the sediment – and perhaps complemented by the addition of plant ash – to form the authigenic mineral dahllite (carbonated apatite; Shahack-Gross *et al.* 2005:1424).

None of the soil thin sections preserved the kinds of microlaminations that have elsewhere been cited as unequivocal evidence for the trampling of dung within livestock enclosures leading to parallel orientation of fibres, orientations which can be preserved in phytolith distributions well-after organic degradation (Macphail et al. 1997; Shahack-Gross et al. 2003). However, it would be highly unlikely for such features to survive the intense bioturbation that has clearly affected soils across Maili Sita, as discussed below. Furthermore, and as alluded to in chapter three, the test of Shahack-Gross' methodology on archaeological deposits at Sugenya, southern Kenya, only recorded clear microlaminations on samples at around 60 cm depth, much deeper than the dung deposits at Maili Sita and below the

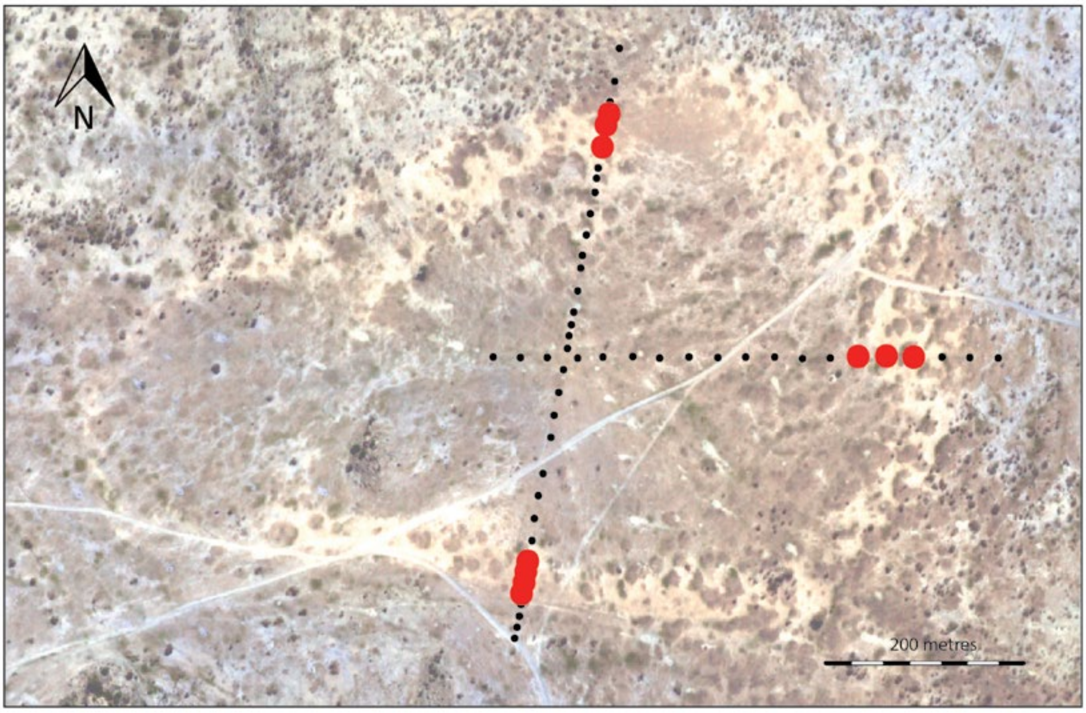


Figure 6.19. 'Group 1' sample locations on Worldview-2 image of Maili Sita. Note the pale 'ring' within which these deposits are restricted.

limits of intensive biological activity. Bioturbative processes may also account for the more general lack of dense phytolith accumulations that one might expect given the apparent density of the dung deposits. Phytoliths become increasingly soluble in alkaline conditions, such that preservation can be compromised in soils above pH 8-8.5 over archaeological timescales (Cabanes et al. 2011), levels commensurate with the group 1 deposits.

Rhomboidal calcite crystals and charcoal particles signify the presence of ash in the group one deposits (Wattez & Courty 1987; Canti 2003), though there is no stratigraphic indication of discrete depositional episodes, as one might expect in a contained refuse pit (c.f. Shahack-Gross et al. 2004). The release of calcium oxalate crystals from burnt plant material (Franceschi & Horner 1980) may also explain the considerably higher levels of total Ca observed in group 1 deposits than in those of the group 2 regional soils; unburnt calcium oxalates – i.e. those that might enter the soil profile from the degradation of unburnt organic material – are palatable to bacteria and rarely preserve (Garvie 2003). In addition, the presence of large amounts of carbonate derived from ash is likely to have contributed to the elevated pH of group 1 deposits (ULERY et al. 1993; Demeyer et al. 2001), and consequently the possible dissolution of phytoliths discussed above (Cabanes et al. 2011). In contrast to Payton's (2005) data, which depicts an increase in exchangeable K at the northern and southern ends of the site, my own XRF analysis – which measures total K – showed a marked reduction in these areas. This disparity does, however, offer further indication of the presence of ash at these locations; ash is known to increase

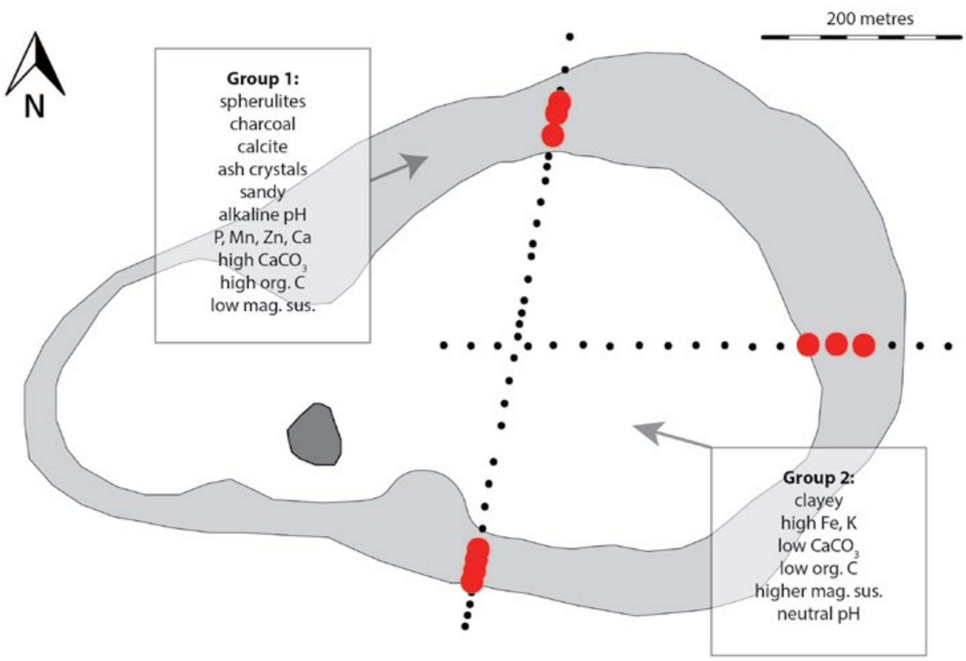


Figure 6.20. Soil group indicators and distribution and based on the extent of the pale 'ring'

both cation concentrations in soils and the risk of K leaching (Demeyer et al. 2001), with the latter accounting for the gradual increase in total K with depth seen in the unit A/10 samples. Elevated exchangeable K, Ca, Mg and Na cations are observed in Payton's records for the northern and southern 'peaks', which I would argue can be included in the 'group 1' category.

There is clearly a link between the group 1 deposits and the pale areas visible in the satellite image, as shown in Figure 6.19. I would argue that these deposits are anthropogenic, with high contents of degraded dung and ash that could only have resulted from sustained human occupation. Group 2 samples, on the other hand, show no sign of anthropogenic input, with samples from the centre of the site almost indistinguishable from those nominal off-site samples from the northern, southern and eastern ends of the transects. It therefore seems logical to assume that occupation was focussed within these areas. Figure 6.19 (see also Figure 6.20) clearly shows the pale deposits encircling the Maili Sita col; that the deposits appear continuous and homogeneous, yet there being no obvious explanation for their absence in the centre of the site, may indicate accumulation over a single sustained period. If this were so, the settlement, or at least the livestock enclosures, must have been broadly circular with 'bomas', refuse areas and burning locations tightly clustered within a ring, between 50 and 100 metres wide and c. 350 metres in diameter, that encircles and encompasses the col.

The vegetation survey shows no clear correlation between the two sediment groups and either certain plant species or animal dung. There is, however, a clear distinction between the species represented within the perceived limits of the archaeological site and that beyond the limits of the ring formed by the group 1 deposits. As would be expected at a glade site, woody species are largely excluded in favour of grass taxa. The precise nature of species representation, however, differs slightly from that noted at nearby Mpala Ranch (Muchiru et al. 2009; Veblen 2012). Interestingly, *Cynodon plechtostachyus* has been seen to dominate species composition at abandoned bomas at Mpala after 5-20 years, yet at Maili Sita it is *Cynodon dachtylon* that predominates, with *C. plechtostachyus* becoming more common with increasing tree cover. Furthermore, ecologists at Mpala describe *P. stramineum* as being restricted to glade edges, and while this pattern is replicated at Maili Sita, the species is also present across the glade by way of the patches.

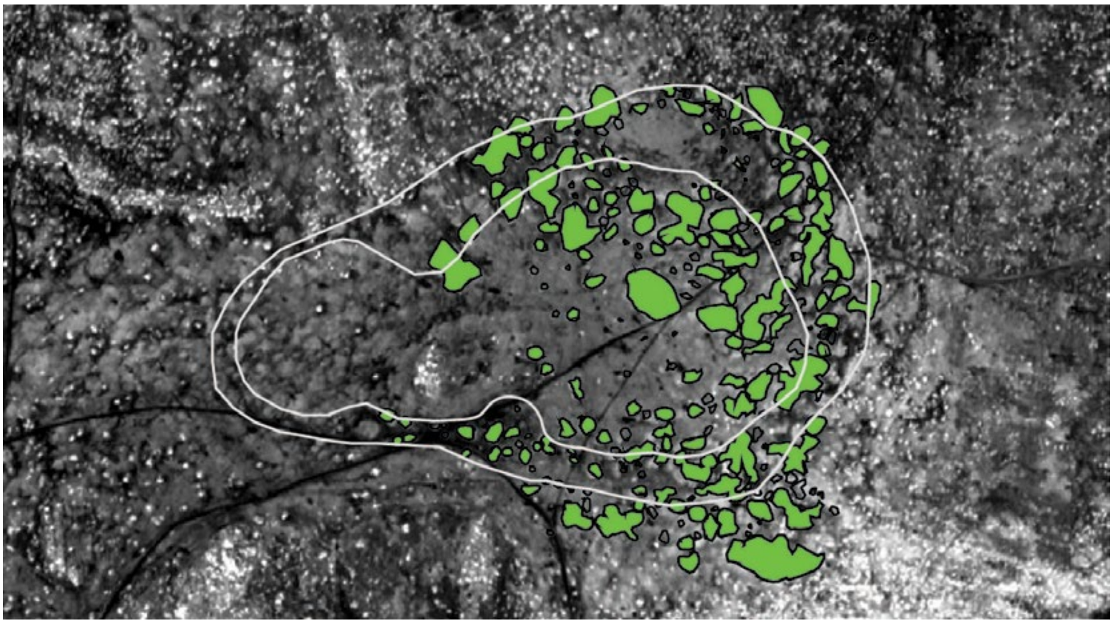


Figure 6.21. SAVI with group 1 soil distribution outlined and patches mapped by 2010 survey team

There is little clear correlation between patch location and the physical properties of soils observed in the 2015 transect survey, however, this may be a function of sampling strategy, with points not falling with patches. Furthermore, a soil-adjusted vegetation index (SAVI; Huete 1988; Zhang et al. 2009) compiled from multispectral Worldview-2 imagery, overlain with the patch distribution mapped during the 2010 field season, shows firstly that patches are not restricted to the 'group 1' areas, being relatively evenly distributed across the col (Figure 6.21). The SAVI process has been developed from the more-common Normalised Difference Vegetation Index (NDVI), itself based on the premise that photosynthetic absorption of light by plants leads to low reflectance of visible light wavelengths, particularly reds, while near infra-red (NIR) wavelengths show high reflectance (M. J. F.

Fowler & Y. M. Fowler 2005). NDVIs assess the ratio between NIR and visible light (red, R) bands on a pixel-by-pixel basis across a given region of interest, using the following formula (Price 1993):

$$NDVI = (NIR- R) / (NIR + R)$$

An image is produced with higher (lighter) or lower (darker) pixel values corresponding to how much light is reflected; heavily vegetated regions yield greater reflectance values than less cover or bare soil, and the technique has been widely used in vegetation mapping, with one particularly useful application being the estimation of plant health or developmental stage, based on the level of photosynthesis observed (Tucker et al. 1985). The above formula, however, fails to account for the influence of background soil on reflectance, though darker soil substrates have been shown to inflate vegetation index values (Huete 1988). The SAVI formula (ibid), by contrast, includes an *L* value, a constant between 0 and 1 calculated based on land-cover, which for the Lolldaiga Hills is relatively low.

$$SAVI = (NIR – R) / (NIR + R + L) \times (1 + L)$$

It is clear from the vegetation indices that the 'ring' of group 1 deposits stands out largely due to a lack of grass coverage except in those areas defined as patches, with the latter clearly visible in the SAVI as pale, circular features, while the ring is very dark. That the patches do not appear to be associated with the distribution of anthropogenic deposits, yet are present atop the col in greater densities than elsewhere in the area, is suggestive of some alternative origin than the link with discrete enclosure locations posited by previous investigators (Payton 2005; Lane 2011). As with the severe bioturbation noted in the soil micromorphology and discussed above, the effects of termite activity might offer some explanation and are worth considering in some depth. There are clear similarities between the impacts of termites and livestock enclosures on soil chemical properties; for example, elevations in pH, electrical conductivity, Ca, Mg and exchangeable K have been observed at both abandoned bomas and within and around termite mounds (Okullo & Moe 2011; Joseph et al. 2013; Muchiru et al. 2009; Augustine 2003), and both have been shown to alter local ecologies, and impact on broader landscapes in ways that are visible and persistent (Reid & Ellis 1995; Bonachela et al. 2015; Dangerfield et al. 1998). Just as nutrients become concentrated at *boma* sites through processes of faecal deposition by livestock, termite ingestion and excretion of soil material – geophagy – from the wider savannah in order to extract nutrients concentrates certain elements within mounds; it is often the same nutrients that are redistributed, with C, P and N among the most common (Brauman 2000; Sarcinelli et al. 2009). These effects are felt over a relatively wide area, considering that the mounds rarely appear more than a few metres in diameter on the surface; the systems of interconnected subterranean passages Interestingly, some authors have argued that frequencies of mounds are particularly high within glades related to former *bomas* (Veblen 2008), while there are local traditions from across Africa that link termites with fertility, and therefore indicate favourable locations for both farming and herding (Fairhead & Leach 2003). Either way, there appears to be associations between boma sites and termite mounds that extend beyond the geochemical; there are visible similarities in the residual landscape signatures of both features, such as those observed by Bonachela et al. (2015) in northern Tanzania (Figure 6.22), and the same authors use infra-red imagery to show improved vegetation productivity at both in relation to the surrounding savannah.

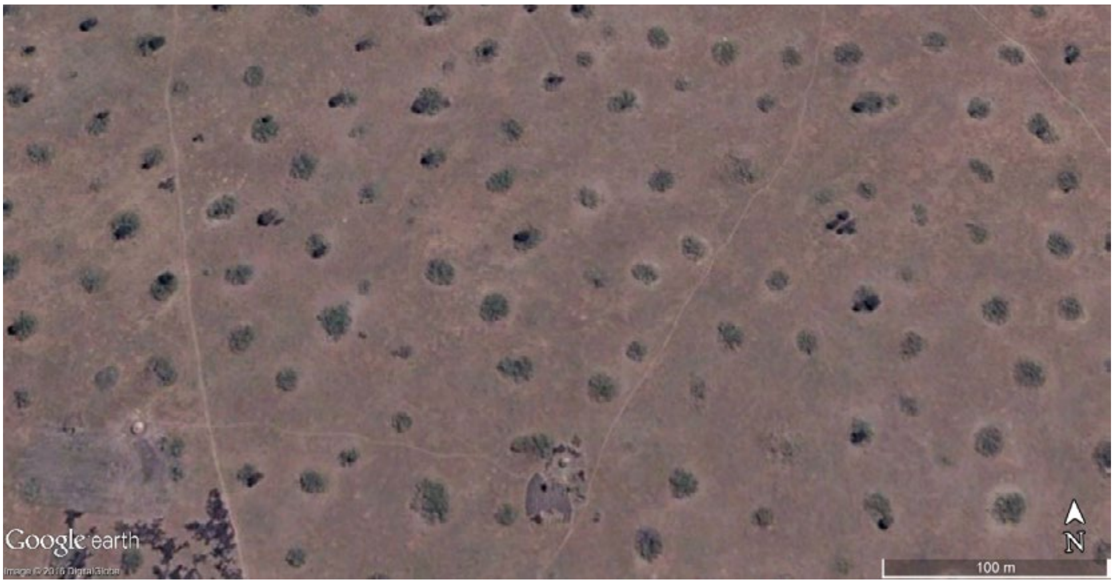


Figure 6.22. Presumed termite mound sites in northern Tanzania (36 M N 9857115.44 E 652613.81), observed by Bonachela et al (2015:727), ©GoogleEarth

The patches associated with mounds arguably resemble those at Maili Sita (Figure 6.23), and certainly there are termites present on and around the site. Indeed, *Pennisetum stramineum* has been shown to favour termitaria, perhaps due to nitrogen-enrichment (Riginos et al. 2009; Okullo & Moe 2011; see also Sarcinelli et al. 2009)not grazing, is the main determinant of spatial variation in savanna herbaceous vegetation. This tallies with the aforementioned preponderance of *P. stramineum* close to the boles of *Acacia* trees beyond the glade edge, at least in part a function of the nitrogen-fixing capacities of these species – the capacity to assimilate atmospheric N, thus compensating for N-poor soil environments - with N subsequently disseminated into local soils via the root network (Riginos et al. 2009; Fox-Dobbs et al. 2010). Given that mounds can encompass a basal area of as much as 50 square-metres (Dangerfield et al. 1998), the *P. stramineum* patches at Maili Sita could conceivably be relics of termite activity. Considerable weight is added to this correlation by the chemistry data from the 2004 survey when viewed in light of

Figure 6.23. South across Maili Sita, note circular patches in foreground

my own, recent findings. Payton's (2005) analysis of soils along a transect between two of the patches shows that only elevated exchangeable K – another potential effect of termite mound-building (Kaschuk et al. 2006) – could be robustly linked with the longer grass. While, as Payton (2005) contends, this pattern could be consistent with degraded enclosure deposits (Saunders 2012; Veblen 2012), one would expect similarly inflated pH, P, and organic C in samples relating to boma contexts. I have been unable to ascertain exactly which patches were sampled for Payton's analysis, though as the pH values he records are commensurate with my own samples from the central part of the site (and beyond the glade perimeter), I would argue that these relate to 'group 2', 'natural' deposits. Furthermore, my own sampling along a transect between two patches happened to fall within the group 1 area at the south of the site, and returned results that were relatively homogeneous. Given that, as described above, many of the compositional attributes of termite mounds are comparable with those of boma deposits, this is perhaps unsurprising, with the two effectively cancelling each other out, geochemically-speaking. On this basis, I propose that the patches are a consequence of processes distinct from those instituted by the anthropogenic deposits, and most likely mark the locations of degraded termite mounds, itself a phenomenon with ecological links to pastoralism, as will be explored in later chapters.

6.5 Summary

The data presented above indicates dense deposits of dung and ash towards the northern, southern and eastern limits of the grassy col at Maili Sita. This is in agreement with earlier investigators' descriptions of where archaeological material was most concentrated; for instance, the apparent refuse dumps observed at unit J/2010 and BA/2004 are located in the eastern and northern areas, respectively, while the post-hole complex at unit A/2004 was found close to southern peak in my own data. Samples from the centre of the col, at least in terms of transect coverage, are of broadly similar composition to control samples from beyond the perceived limits of the archaeological site. When this data is considered against satellite imagery of the Maili Sita col, a ring of pale deposits, slightly extended to the west and appearing to encircle the archaeological site, shows near-perfect correspondence with these concentrations of dung, ash and general refuse.

Figure 6.24. Western slopes of Maili Sita ridge, looking northwest, termite mounds in foreground with others visible beyond

My analysis, however, was unable to confirm Payton's (2005) assertion that the circular grass patches are relics of former livestock enclosures; intensive sampling between two of these features showed no significant variation in any of the variables tested. While the analysis did show that the entire transect EWp1 was located atop deposits rich in dung and ash, in instances where sample locations along the main survey transects (SN1 and WE1) fell within patch features outside of the observed limits of the ashy-dung deposits, results were similar to neighbouring non-patch samples. Comparison with Payton's (2005) earlier survey data, suggests that these features may be distinct from both the 'group 1' occupation deposits and the 'natural' 'group 2' soils, and thus are a function of a third process: termite mounds. The Maili Sita ridge is shown to be effectively lacking in woody vegetation, with tree species present immediately beyond the limits of the archaeological site. Instead, nutrient-rich grasses such as *Cynodon plechtostachyus* predominate, with *Pennisetum stramineum* present in those discrete patches interpreted as inactive termite mounds. The latter is, however, present in greater concentrations around the perimeter of the site, where woody species begin to reappear. Dung associated with a number of herbivorous mammals, from small grazers to large browsers like elephant and giraffe, though no obvious patterning could be determined as to where each species was focussed (i.e. glade edge, centre, close to patches, etc).

It is clear, then, that the occupation of Maili Sita has exerted a visible impact on the local landscape, the archaeological and ecological implications of which will be addressed later. Before exploring these issues, however, the following chapter considers Maili Sita within its wider geographical context, whereby I seek to determine whether the patterns described above might be replicated elsewhere. If so, the aforementioned implications of this research may be more widely applicable.

7

Regional Survey

Figure 7.1. Ring features in southern Laikipia (Google Earth)

This chapter develops the idea that Maili Sita took the form of a large-ringed settlement and the extent to which such an interpretation would represent an anomaly, in the context of the wider region and cultural landscape. I consider my findings, discussed in the previous two chapters, in light of those of previous investigations (e.g. Lane 2005). Specifically, I draw comparisons with the other major site investigated by Lane and colleagues – Maasai Plains – and suggest that the two settlements might be linked. Furthermore, I present the results of a survey of Laikipia District conducted using Google Earth, and assess whether the pattern is replicated elsewhere. I use this data to begin constructing a regional narrative for pastoralist presence in Laikipia during the second millennium AD, a theme I will develop in my concluding discussion chapters.

7.1 Arrangement

Previous investigations emphasised a link between Maili Sita and the Laikipiak, who occupied the plateau prior to the inter-sectional Iloikop Wars of the nineteenth century (e.g. Lane 2011). This association, discussed in my introductory chapters, is forged primarily on the strength of oral historical accounts of the Laikipiak being the dominant group in the region prior to their defeat and replacement by an alliance of Purko and Kisongo Maasai sections, and on the basis of a material culture assemblage suggestive of Maa-speaking pastoralists, most particularly in the form of Kisima ceramics (see Siiriainen

1984). Cultural and economic identities during this period, however, appear to have been considerably more flexible than those of modern populations (Waller 1979; Spear 1993), at least insomuch as these are professed – the examples of the Mukogodo Maasai ethnic manipulation and the osmotic Samburu-Dorobo relationship described in my introductory chapters (see for example Cronk 1989; Spencer 1965) clearly contradict the superficially-rigid tribal divisions implied in earlier ethnographic accounts (e.g. Jacobs 1965) and, arguably, propagated today in the self-serving political arena (Bratton & Kimenyi 2008).

This hypothesis is largely based on the formal arrangement of the site, as inferred from the distribution of anthropogenic deposits. In summary, the grassy col on which Maili Sita is located is encircled by a ring of fine, pale sediment, analysis of which suggests a high content of degraded ash and dung commensurate with the residues and refuse of pastoralist settlement. Importantly, these deposits are broadly homogeneous, exhibiting very similar chemical and physical properties, while deposits within the ring show near identical composition to the 'natural' regional soils without. Furthermore, archaeological material – ceramics, lithics and faunal remains – appears mainly, though not exclusively, concentrated in excavation and survey units sited within these anthropogenic soils, such as unit A/04, the only excavated unit to yield evidence of built structures. The coherence of these deposits, which form a well-defined, almost-unbroken ring around the ridgetop, and that the isotope data obtained from cattle teeth point to perennial rather than occasional (ceremonial) or seasonal occupation, suggests that this ring reflects the original layout of the site: enclosures, refuse areas and domestic structures positioned around the edge of a largely empty central area. Of additional importance is the scale of the site, which at almost 500 metres across is larger than any ethnographically-recorded pastoralist settlement in eastern Africa, and second only to the Maasai Plains site (see chapter four) in the archaeological record-book. While this form resembles the *il-manyatta* and *lorora* constructed by the Maasai and Samburu for their age-set graduations, not only do these sites today rarely exceed a hundred metres in diameter but the practice of keeping cattle in the centre would be expected to be marked by elevated soil nutrient content linked to dung.

Before discussing possible alternatives to *manyatta*-like occupation, or the historical implications presented by the data from Maili Sita, I would like to move briefly away from the site and consider the wider Laikipia Plateau, namely by examining other features visible in satellite imagery obtained using Google Earth. A scan of the plateau and its surrounding lowlands, as was undertaken casually during this research process, reveals a number of features that bear comparison with Maili Sita (Figure 7.2) and, perhaps even more closely, with Maasai Plains. Indeed, some of these features might be thought of as 'missing links'

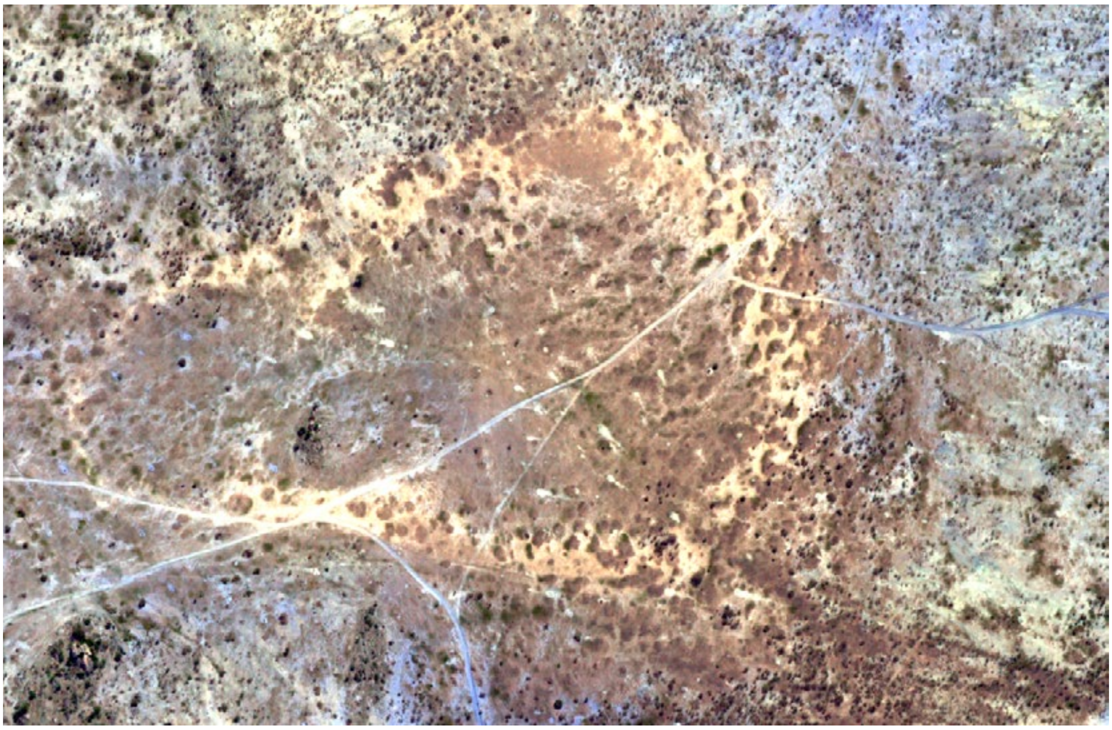


Figure 7.2. Maili Sita, Worldview-2 image

between these two recognised sites. Essentially, these images appear to show large circular distributions of anomalous soil or vegetation patterns. Though many are small enough as to fairly clearly represent the remains of relatively-recently abandoned pastoralist settlements, a number are upwards of 300 metres and several over 500 metres across. One of these larger features lies close to Lolldaiga within land belonging to the Makurian community of Mukogodo Maasai. Permission to visit the location was obtained during the last week of fieldwork at Lolldaiga, and it is worth offering a detailed description of what can be observed both on the ground and using Google Earth. It should be noted that previous examinations of remote sensing imagery from Laikipia (e.g. Causey and Lane 2005; Ogotu 2005; Causey 2008), though considerably more extensive than my own opportunistic Google Earth survey, failed to identify these sites. I therefore did not consider such a survey to be necessary earlier in the research process, though with hindsight this would have been beneficial in designing my sampling strategy at Maili Sita.

7.1.1 Makurian Fence

The site, which I have been calling 'Makurian Fence', though it has yet to be formally registered, is centred on 37 N 290400 E 37615 N, and lies around 100 metres from the northern fence of the Lolldaiga Hills Ranch. It was identified using Google Earth based on formal similarities with Maili Sita; specifically, the site appears as a broadly-circular ring of very pale deposits 400-500 metres in diameter (15.5 ha), set within reddish-brown surroundings (Figure 7.3). In slight contrast to Maili Sita though, wherein the pale areas form a continuous, homogeneous ring, at Makurian Fence it is possible to discern small discrete circular patches arranged around the perimeter. These patches are between five and 20 metres across and are frequently slightly darker towards the centre.

Similarities with Maili Sita continue at ground-level; Makurian Fence occupies a comparable position in the landscape, atop a gently-sloping grass-covered hill. It is notably distinct from the dense tree and shrub cover of the surrounding area, which consists primarily of the more shrub-like *Acacia mellifera* as opposed to the *Acacia drepanolobium* that dominates the footslopes and valleys of the Lolldaigas to the south and comprises the vast majority of the tree-cover around Maili Sita. The understory of these bushland areas is similar to that across the LHR and beyond, with stands of *Pennisetum stramineum*, *Harpachne schimperi* and *Digitaria milanjiana* and various shrub and forb species. The site itself is characterised by open grassland, predominantly *Cynodon plechtostachyus* and occasional small diffuse areas of *Pennisetum stramineum,* with *Pentonesia* spp., *Solanum incanum* and *Ipomoea* spp. also present. There are also occasional instances of *Opuntia dilenii* ('prickly pear'), which – based on the amount of faeces in the area – cause the site to be a popular feeding ground for baboons. Grass cover ranges from lush patches with diffuse boundaries to more heavily denuded areas. The lack of grass cover in these areas and the frequency of coarse sand and granular material above a crusted surface suggests that sheet erosion has been an issue in the recent past. It may be possible to tentatively claim that such denudation is most common around

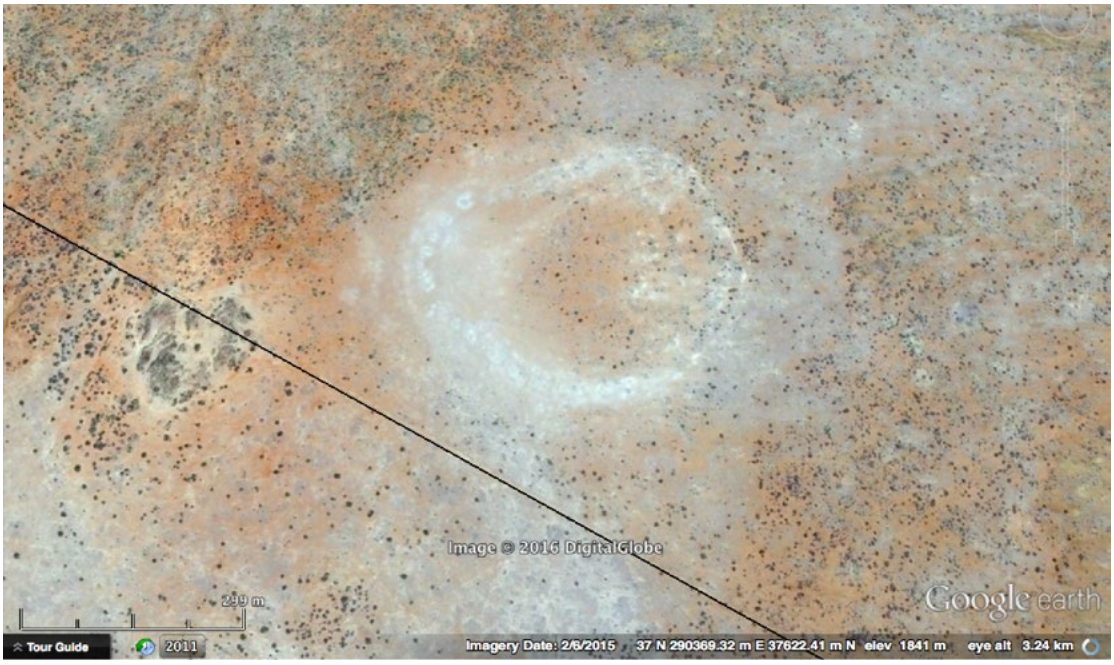


Figure 7.3. Makurian Fence, and the northern fence-line of LHR, Google Earth.

the perimeter of the site, in the vicinity of the pale deposits visible in the satellite imagery, though more intensive and systematic survey work is required to substantiate this.

Archaeological material is scattered across the site, particularly in and around the denuded areas, though this may be a function of greater visibility where grass cover is reduced. Due to stipulations in the Kenyan research permit for the project, material could not be collected and preliminary observations had to be made in the field. Surface finds were almost identical to those recorded at Maili Sita, with ceramics dominated by Kisima ware with its diagnostic raised ridge and impressed-notch decoration (figure Figure 7.4), and obsidian flakes and *outils* écaillés. There were also a few instances of faunal bone, though besides a single caprine mandible revealed by erosion within one of the bare areas, this was all surface material and cannot be reliably linked to past occupation. Finally, a number of small pieces (<5cm) of iron slag were found across the site, which though insufficient to suggest smelting in the immediate confines of the site, may point to metallurgical activity having been undertaken relatively nearby, as with the industry at Maili Sita. Essentially, then, the material culture present at Makurian Fence suggests a Pastoral Iron Age occupation more or less coeval with that at Maili Sita and Maasai Plains, thus provisionally dating the site to the mid-to-late second millennium AD.

Figure 7.4. Examples of pottery and iron slag observed at Makurian Fence, the four sherds in the front row are all variants of Kisima ware

As described in chapter four, the northern plains of LHR receive considerably less annual rainfall than the hillier southern and central parts. The Google Earth image presented in Figure 7.3 and used in the initial identification of the site was taken in February 2015 at the height of the dry season (and, according to LHR staff, following a particularly poor rainy season), which may account for the lack of grass cover suggested by the intense reddish-brown and grey colour of the local terrain. Indeed, when the site was visited in January 2016, recent rains had ensured that vegetation across the region was at its peak. Intense grazing may be an additional factor in the drastic fluctuations in land cover at Makurian Fence, with Mukogodo livestock present in much higher densities than on the other side of the fence in LHR – again, as mentioned in chapter four, the owners of LHR allow the local Maasai controlled access to certain areas and water-sources during periods of drought – with corresponding impacts on vegetation quality. These effects are especially dramatic in open grassy areas such as the archaeological site; ASTER satellite imagery (Figure 7.5) showing the northern boundary of LHR clearly shows the difference in vegetation density on either side of the fence, with the site showing particularly low coverage.

It is possible that the lower rainfall experienced around Makurian Fence may account for the survival of the individual patches of pale, likely dung-rich, deposits around the perimeter of the site, though denudation seemingly caused by sheet erosion appears to suggest otherwise. More relevant than lower rainfall to the survival of these features may be the lack of termite mounds visible within the site or in the surrounding bushland. In my earlier discussion of soil dynamics at Maili Sita (chapter six), I argued that not only might soil fauna be responsible for the formation of the circular grass patches – another notable absence at Makurian Fence – but that termites are the likely cause of the severe bioturbation observed in thin section, the action of which has prevented the survival of the kinds of microstratigraphic evidence for livestock enclosures advocated by Shahack-Gross et al. (2003; 2004; 2008). It seems reasonable, therefore, to hypothesise that Makurian Fence represents a similar settlement to Maili Sita, but that the archaeological deposits have been subject to much reduced taphonomic disruption at the hands of soil fauna. While, it is clearly problematic to assume that the two sites were occupied by the culturally-related communities based purely on perceived similarities in the satellite imagery, I would contend that the presence of effectively-identical material culture and therefore-assumed social and temporal link, as well as basic formal similarity (in terms of size and shape) seen in no other recorded site except perhaps Maasai Plains, which itself is of a similar date and exhibits a similar artefactual complex, makes this a reasonable supposition.

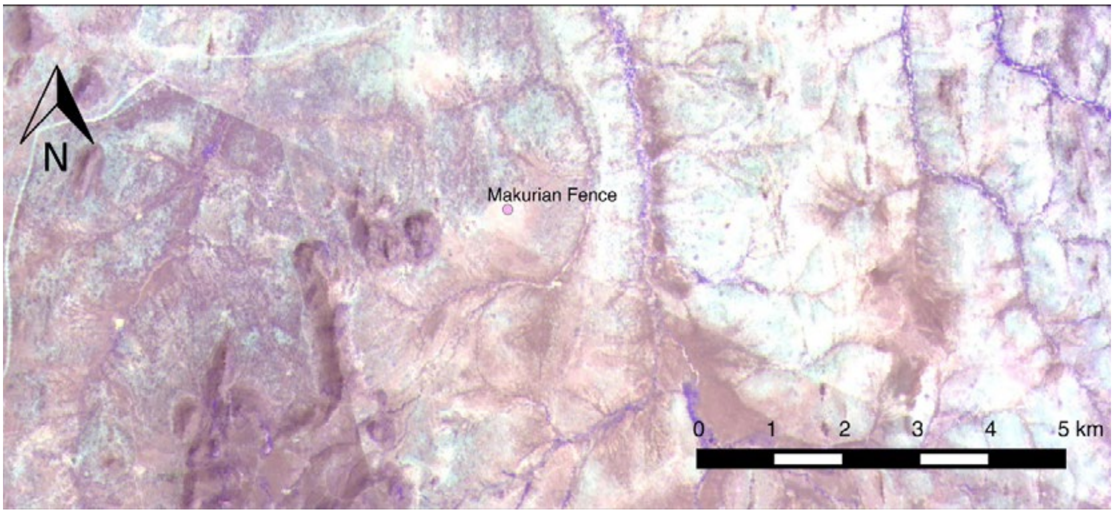


Figure 7.5. Northern LHR and Makurian Group Ranch, ASTER image, note change in vegetation (grass) density along fence line, implying degradation north of LHR

7.1.2 Ethnographic comparisons

The extent to which the anthropogenic deposits at Maili Sita have been affected by post-depositional forces such as soil fauna and erosive colluvial action clearly affects our ability to understand the original form of the settlement. This problem applies principally to the vertical stratigraphy, which besides a few ashy horizons in the excavated units and evidence for sheet erosion of topsoil contexts is effectively absent across the site, but also to horizontal distributions. If, however, Makurian Fence is taken as an acceptable analogue, it may be possible to comment on what that horizontal deposition may have originally looked like. I mentioned earlier the relatively small, circular areas of pale sediments that encircle Makurian Fence, which can be reasonably assumed to be formed of degraded dung, either in the form of direct enclosure deposits or as refuse mounds, in the manner of those at Maasai Plains and observed at contemporary Samburu homesteads (see figure 5 in Lane 2011:19). Based on the size and distribution of these features at Makurian Fence, I would posit that the former is more likely. Added weight is lent to this assumption if one looks to examples of modern pastoralist settlement in the region. Specifically, I want to highlight a location identified during the same survey of Google Earth imagery from Laikipia and its environs as that during which Makurian Fence was first noted.

Figure 7.6 shows an apparently-occupied settlement in the lowlands just beneath the eastern escarpment of the Laikipia Plateau (37 N 294590 E 68466 N), around 30 kilometres north of LHR and 50 kilometres northwest of Isiolo, an area now generally inhabited by a southern section of the Borana, a group originating in southern Ethiopia and who are today found there and in central northern Kenya (Dahl 1979), just beyond the usual southern limit of

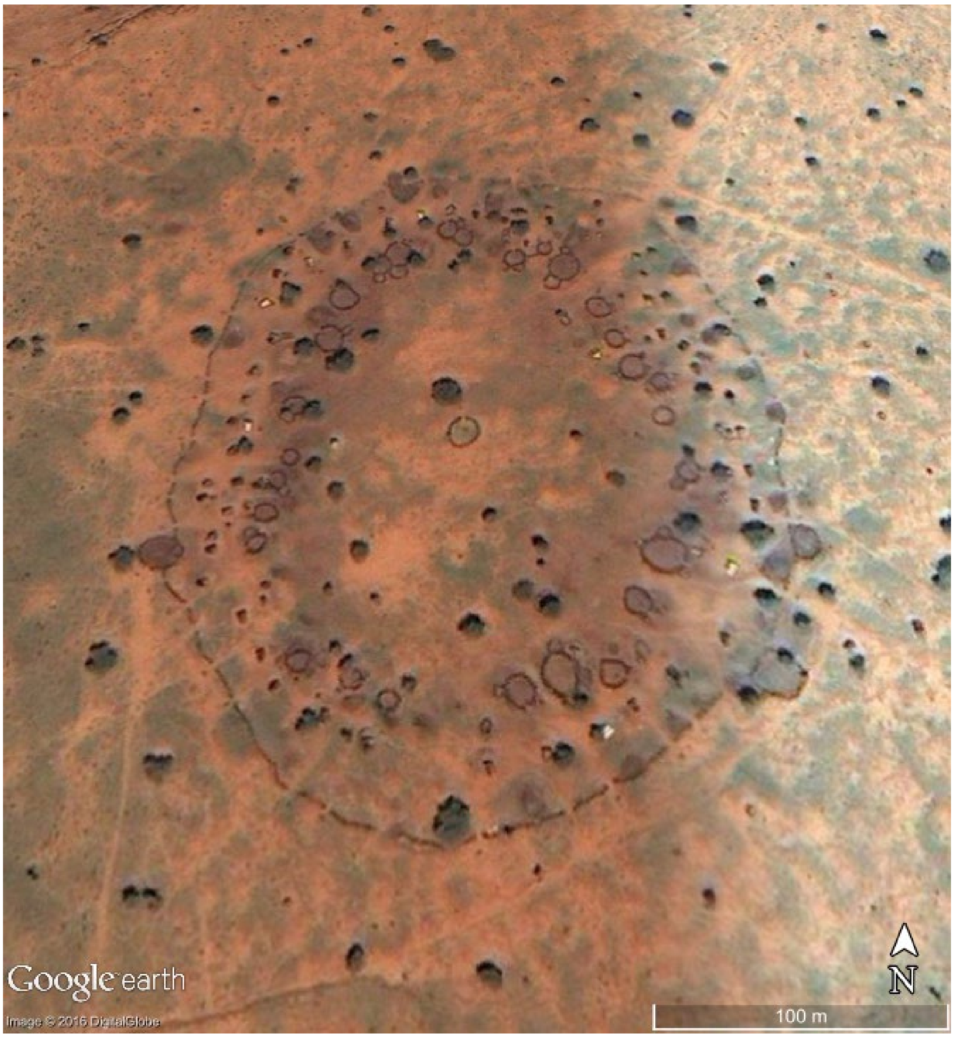


Figure 7.6. REN1, Rendille-esque site east of Laikipia

Samburu territory (Spencer 1965). Unfortunately, the site is remote and fairly inaccessible and was not identified in time to arrange a visit for ground observation, though significant information can be gleaned from the available imagery. The most immediately obvious features are the circular livestock enclosures that form a large ring, over 300 metres across (6.1 ha), around the perimeter of the settlement, identifiable as such by darkened soil due to the accumulation of dung. The enclosure complexes are generally composed of a single large corral, up to 20 metres across, many of which are adjoined by smaller pens, perhaps to house either young animals or small stock. Beyond the enclosure ring there appears to be a ring of buildings, probably houses, outside which there is a perimeter fence broken by numerous gateways: it is possible to count at least 41. The central part of the settlement is completely empty except for a single enclosure, though neither this pen nor the surrounding central compound has any of the dark staining that would indicate consistent use as a corral. Indeed, soils within the centre of the site are barely distinct from those outside the perimeter fence, as is grass cover with the exception of a few bare patches. It is worth noting also that within the main ring of enclosures are unfenced dark areas that may point to the relocation of animal pens within the settlement to avoid excessive dung build-up. Equally, it is possible that these are produced by adult cattle, not themselves corralled, but which stay close to their penned offspring. It is difficult to assess the topographic setting of the site based on imagery alone, however its situation at the confluence of two river channels is suggestive of slightly-raised ground.

The side-by-side images in Figure 7.7 clearly show parallels between the modern site, which I will hereafter refer to as REN1, and Makurian Fence. Most pertinent, perhaps, are the ring of enclosures – in terms of both form and scale – and the virtually-unaffected central areas. Strangely, given its location within their usual territory, REN1 does not resemble a typical Borana settlement, which usually comprise a semi-circle of houses facing away from the prevailing wind toward a central corral (Dahl 1979), yet there are parallels with the Samburu *lorora*, essentially the equivalent of the Maasai *manyatta*, which host the ceremonial gatherings associated with age-set graduations (Spencer 1965; Figure 7.8) and are occupied for around six months (Grillo 2012). The basic layout of *lorora* certainly echoes that of REN1 and Makurian Fence, with respect to the outer ring of houses and enclosures, and though the examples chronicled by Spencer (1965) are considerably smaller (c. 50 m dia.), Pavitt (1991) suggests that some of the largest *lorora* can host 200 families. This information, however, seems to be unsubstantiated at present.

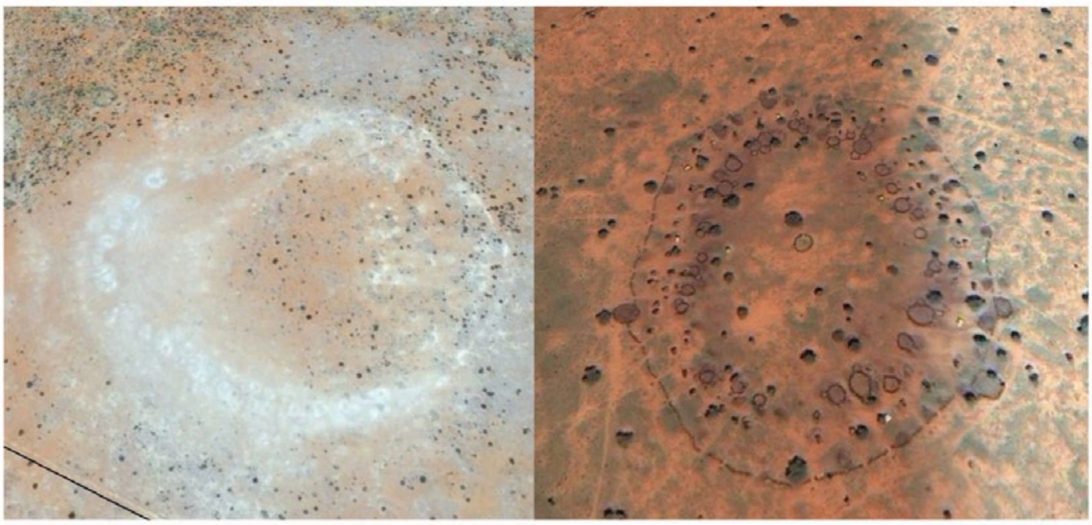


Figure 7.7. Makurian Fence (left) and REN1 (right), GoogleEarth

REN1 also bears comparison with the principal settlements constructed by Rendille communities further north, as described by Spencer (1973) in his ethnographic comparison of Rendille and Samburu society and how they interact. His sketch of one such settlement (1973:21), reproduced here (Figure 7.9), shows a ring of houses with clusters of adjoined

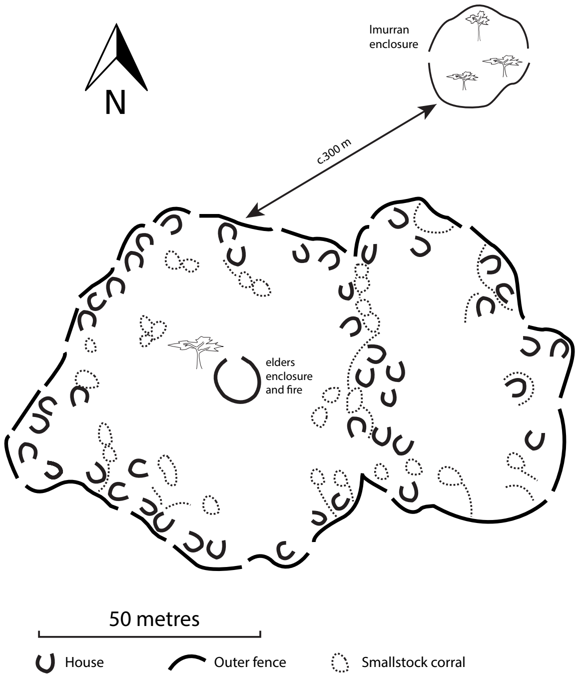


Figure 7.8. Samburu lorora, redrawn from Spencer 1965:92

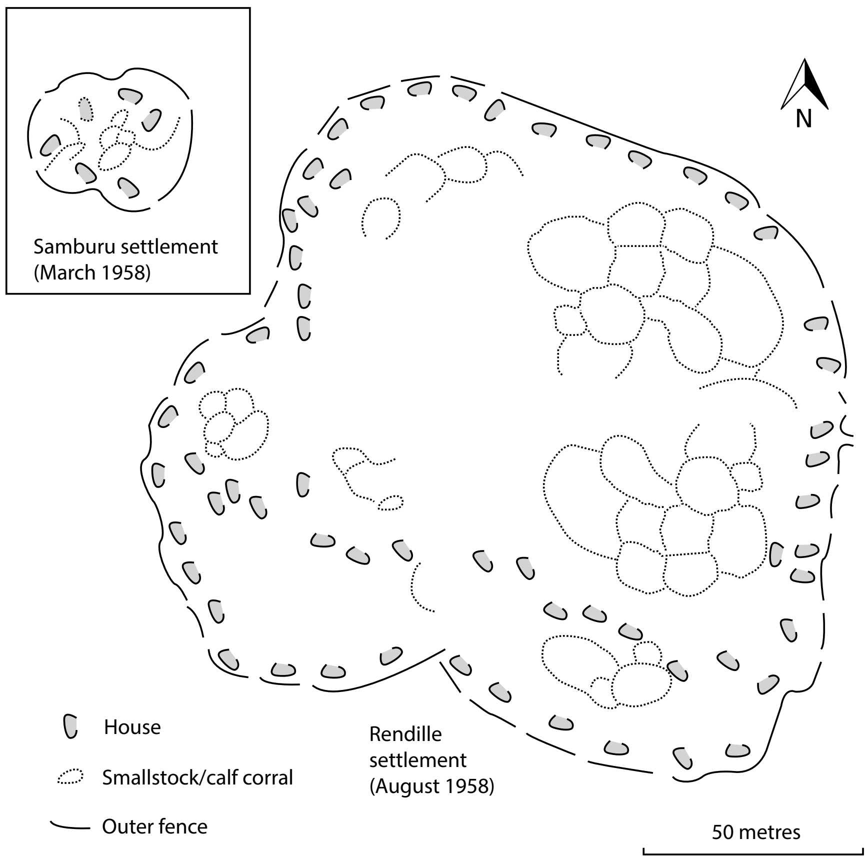


Figure 7.9. Rendille and Samburu settlements observed in 1958, redrawn from Spencer 1973:21

enclosures enclosing a large open area in the centre. What is particularly striking about Spencer's sketch is the scale; the settlement is recorded as being nearly 200 metres across. Also important is the additional, outer series of houses in the southwest corner, which marks an extension to the settlement by late-comers. As with REN1, numerous gateways puncture the outer fence of the settlement. While Spencer's description does not match exactly with the form of REN1 or, apparently, Makurian Fence, other Rendille settlements to be found on Google Earth do bear greater resemblance. Figure 7.10 shows one such location, in the arid plains of the Chalbi Desert, around 50 kilometres northwest of Marsabit in the modern Rendille heartland. Within what appears to be a fairly ineffectual perimeter fence, with numerous gates and gaps, a distinctive ring of round houses is visible around clusters of enclosures and an open centre. The enclosures here, though, are arranged in a more coherent ring than depicted in Spencer's diagram. The scale too is slightly closer to that of REN1 and Makurian Fence, up to 300 metres across at its widest point. Lastly, it is worth noting the remains of abandoned settlements in the vicinity; the remains of two such locations are visible in Figure 7.10, while Figure 7.11 shows the density of the whole settlement cluster in this remote corner of the desert, with over 40 sites visible. While it is obviously impossible to speculate on how old these abandoned sites are, given the aridity of the region – the Rendille occupy one of the driest parts of Kenya – it is unsurprising that occupation residues should survive for long periods.

Figure 7.10. Rendille settlement, north of Marsabit. Note degraded remains of abandoned settlements to east and northeast (Google Earth)

Figure 7.11. Cluster of Rendille settlements, occupied and abandoned, in the eastern Chalbi desert, north of Marsabit (Google Earth)

7.2 A regional phenomenon?

The notion of Maili Sita being a large, ringed settlement urges comparison with the site at Maasai Plains (Figure 7.12). Links have already been made between the material culture of the two sites, with respect to the Kisima-dominated ceramic assemblage and preponderance of obsidian outils écaillés, though Maasai Plains may be substantially older (1315-1616 cal. AD, Beta-189982, 2 sigma, IntCal13; Reimer et al. 2013). The ringed dung-ash features at Maasai Plains, recognised since the site was first documented, do conform to slightly different patterns to either Maili Sita or Makurian Fence, with ash middens seen in excavation to have accumulated gradually through multiple deposition events. This would be in keeping with the kinds of household refuse dumps seen at modern Samburu homesteads, for instance (Lane 2011). Furthermore, that there are multiple, concentric

Figure 7.12. Maasai Plains - the main site is the set of concentric rings on the left of the image, but note others extending to northeast, Google Earth

rings may indicate multiple occupations. At Makurian Fence, in contrast, the clarity with which the individual circular features – be they corrals or refuse dumps – are visible in the satellite imagery is suggestive of a single occupation. At Maili Sita, neither satellite imagery, excavation or soil survey has been able to identify individual depositions, and the ring of occupation refuse appears as a single amorphous entity. Moreover, and as discussed in chapter six, I am sceptical that the circular grass patches have any direct link to enclosure locations, and instead more likely relate to termite activity.

While the three sites cannot, therefore, be assumed to have served the same function, I would contend that enough formal similarities (i.e. size and shape) and material associations exist to imply some kind of link between their inhabitants. Furthermore, expansion of the Google Earth survey that led to the recognition of Makurian Fence and REN-1 reveals that this phenomenon – large, ringed settlements, distinct from those generally constructed in the area today (REN-1 being a notable exception) – may be widespread across the Laikipia Plateau.

7.2.1 Method

On returning from fieldwork in early 2016, I undertook a preliminary survey of Laikipia District using Google Earth, with a view towards identifying features resembling large, ringed settlements. Full (100 %) coverage was ensured by systematic scanning of the imagery, at an altitude of five kilometres. I decided that this scale was appropriate for recognising features of sufficient size – a diameter of more than 200 metres was taken as a principal criterion – while ensuring efficiency in the process of scanning a large area (c. 9000 km2). Observed features were marked, and approximate dimensions recorded, with the site-area calculated using the 'measure polygon' function in Google Earth; for clusters of sites, the area of the largest 'ring' was recorded. Qualitative description was also made, including observations of the local environment – i.e. grassland, woodland, cultivated, degraded, etc. – whether or not the feature was isolated or whether multiple 'rings' were visible, and any evidence for the presence of modern pastoralists (i.e. nearby bomas). I also noted the presence or absence of nearby water sources, including seasonal river channels, and approximate position within the district and proximity to other features not within an immediate cluster. Sites were categorised according to their basic form or appearance. Features were also classified by whether they appeared isolated (i.e. single sites), as part of a cluster of overlapping features, or as having close neighbours; the latter was based on whether additional features could be seen within the c. 9km2 field of view within which the survey was carried out.

It is worth reiterating that Google Earth imagery is inconsistent in its coverage and resolution. On beginning this research project, the coverage was such that this kind of survey would not have been possible. While reasonably high resolution imagery is now available for almost the entire plateau, besides a few small areas of cloud interference, there are areas where lower image resolution makes features harder to spot. The images have also been obtained by the satellites at different times, with some areas having not been photographed since the early 2000s. Where the data exists, Google Earth has the capacity to provide time-series imagery for a given area, and does not always default to the most recent. As a result, sites that were not visible in my original survey were subsequently noted during later unsystematic scanning of the older imagery. Furthermore, imagery has been obtained at different points during the year; my own work at Maili Sita, such as the 2016 vegetation survey, has shown how drastically the environment changes between the wet and dry seasons, and it seems likely that some seasonal bias has affected whether sites were identified in this survey. It is difficult at this stage, however, to know whether this bias favours areas with dry season or wet season imagery, or how it might be affected by general ecological variation across the plateau. This issue is sometimes compounded by recent human activity; much of the area is now cultivated, particularly in the southern half of Laikipia District and north towards Leroghi, activity which appears to have expanded rapidly during the last ten-to-fifteen years. While ploughing, for example, may not always completely obscure earlier features – one might expect soil nutrient 'hotspots' to still be visible, as in aerial photography from other parts of the world – the effects of farming activity could be expected to bias observed-site distributions in favour of uncultivated areas.

7.2.2 Results

Thirty-four locations were identified during the survey as possible ring sites (Figure 7.13). Sizes range from 2.4 to 40.7 hectares, with a mean of 12.5 ha. A range of environments is represented, from healthy grassland in the southern part, forest/woodland in the west and arid scrubland in the centre and north. The appearance of the site seems to correlate with the general environment (p=0.766): sites in grassland environments mostly appear as continuous rings of darker grass, with little visible evidence of enclosure locations (e.g. sites a,; in more arid areas, where grass cover is reduced, sites generally appear as rings of pale soil with pale circular patches arranged more or less regularly around the perimeter; sites in wooded areas, by contrast, appear as thin bare rings against the surrounding canopy, often as parallel lines either side of a ring of trees (n, p, q, r, s). The latter show dense woody vegetation in the centre of the rings while others are grassy or otherwise more sparsely vegetated. Notably, all sites (except perhaps v, which appears bare within) show a basic continuity in vegetation type and density between their central areas and the surrounding landscape. Following this observation, there is little immediate evidence that these sites exist as glades, with their edges clearly defined by a change towards greater tree- and shrub-cover. Equally, it might be noted that there is frequently a pattern wherein a change of vegetation occurs up to several hundred metres beyond the observed site perimeter (a, b, c, d, f, g, h, aj), arguably also the case for Maili Sita, most visibly at its western edge. While for most locations this occurs as an increase in tree cover, grass in and around site k appear more degraded beyond the site, or cluster thereof. Such a pattern is particularly apparent in the context of clustered sites, such as c, f, g and h, which appear as dense collections of 'rings' within a grassland setting, beyond which tree cover is considerably thicker.

Distance from water source varied between 0.1 to 3.5 km, with an average of 1.2 km, well-within the maximum ranges for daily watering of cattle and smallstock discussed in chapter 3. It should be noted, however, that the Google Earth survey was unable to account for seasonal changes in water availability, though given that the Ewaso N'yiro and its major tributaries (e.g. the Timau) represent the only perennial flowing water in Laikipia today, one can assume that these minor streams could provide water only during and following the rainy season. Nor was the survey able to account for historical inconsistencies in the location and direction of seasonal channels; the suddenness and impact of the rains when they do arrive is such that channels easily shift, as evidenced by the frequency of defunct stream beds in the Lolldaiga Hills (pers. obs.).

The majority of sites are located in the western part of Laikipia, within 20 kilometres of the escarpment ¬that drops down into the Rift Valley towards Lakes Bogoria and Baringo, in a vague band reaching from the footslopes of the Aberdares in the south to the northern reaches of the Leroghi Plateau. Besides site n, none are found in the flat, arid central plains, and this one exception lies less than a kilometre from the Ewaso N'yiro river system. Sites are very rare in the eastern part of the plateau, and besides the cluster of Maili Sita, Makurian Fence and site l, which lie within 4 kilometres of each other, only one other location was observed – the isolated and ephemeral, site m. There is little clear clustering of sites within these areas, although sites f, g, and h and sites o, p, q, r and s are relatively close to each other. The latter group are set within the densely wooded surroundings of what is now the Ol Ari Nyiro Ranch – indeed, site s was recorded in a 2013 reconnaissance

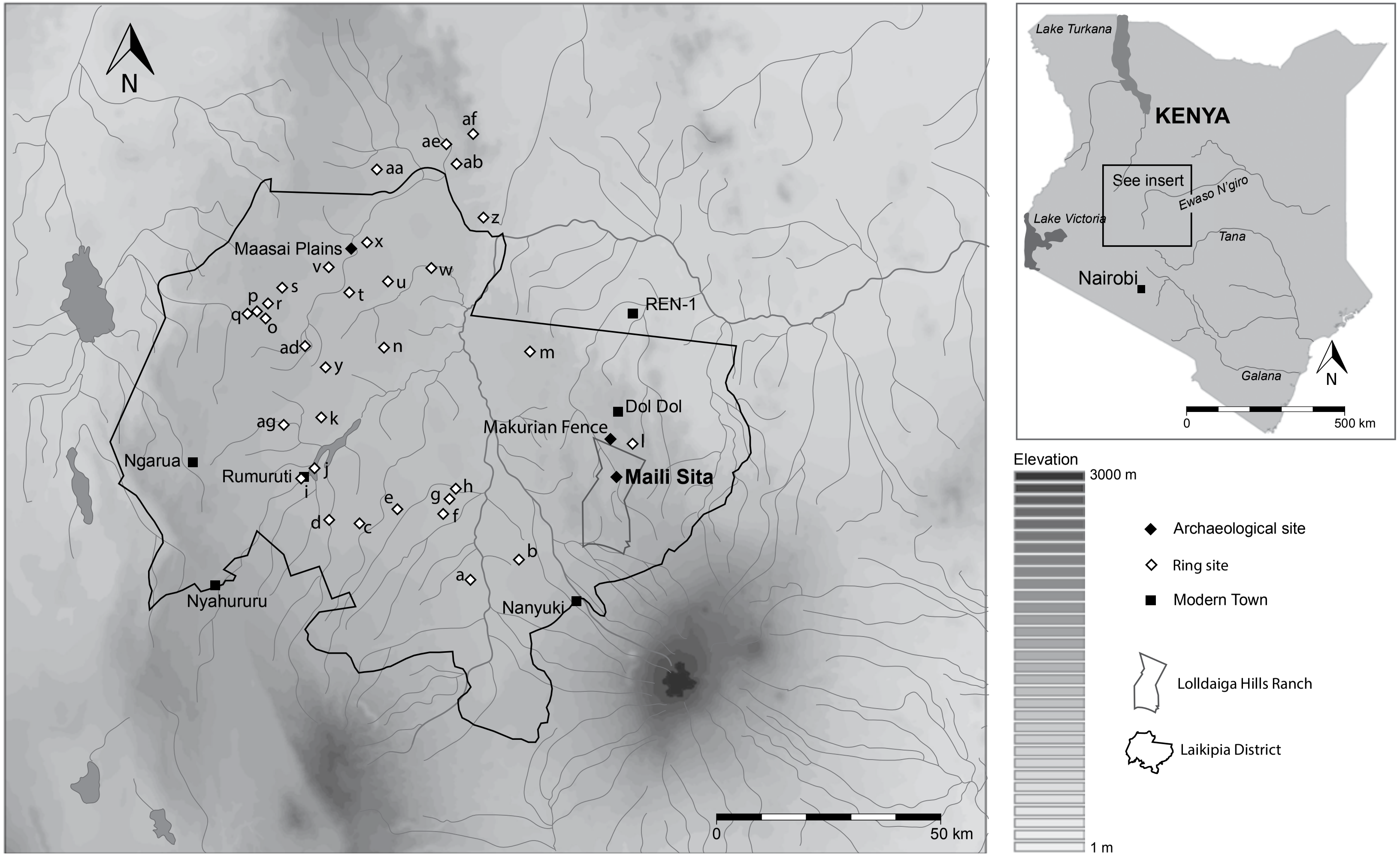
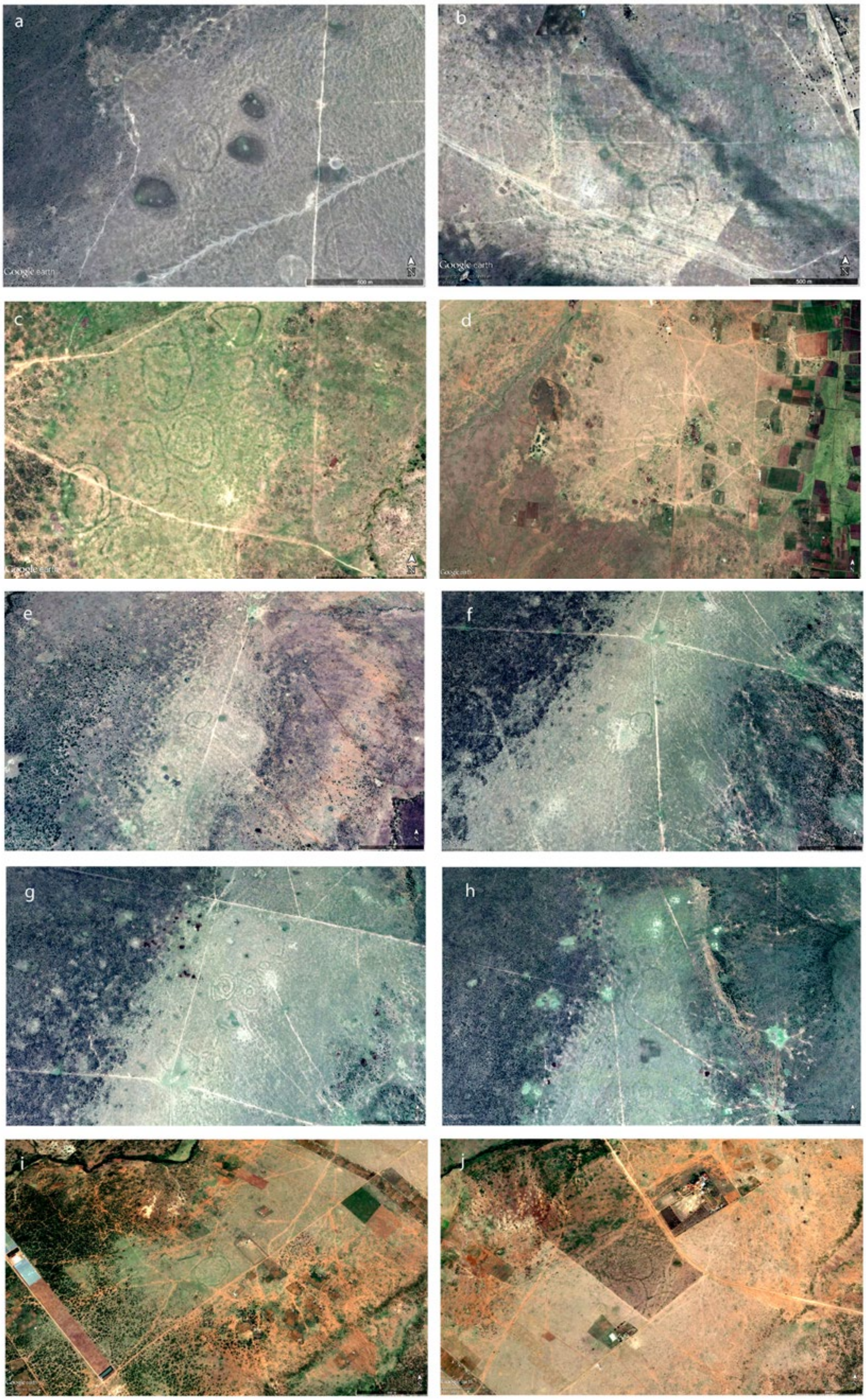


Figure 7.13. Distribution of ring sites and other important locations around Laikipia. The extent of the plateau and surrounding highlands is visible as darker shading indicating higher elevation (map based on 'FIGURE 1' in Lane 2011:14)

Site	Easting	Northing	Area (Ha)	Environment	Climate	Description	Water (km)	Closest neighbour (km)	type	clustering
a	262190	5452	5.1	grassy	v	single continuous grassy ring, two or three others visible nearby,	2.2	10.8	1	3
b	272066	10640	7.2	grassy	v	single, faint but continuous grassy ring, two or three others visible nearby (c.50 m away)	3.5	10.8	1	3
c	237530	15928	8.9	grassy	iv	multiple grassy rings, dense cluster, 10+ features, some overlap and size variation, some possibly concentric rings	1.4	6.9	1	2
d	230746	16425	2.4	grassy	iv	faint grassy ring, continuous, single, one smaller feature nearby (50m)	0.7	6.9	1	3
e	245682	19586	2.5	grassy	v	single continuous grassy ring, isolated	1.5	8.8	1	1
f	255691	19005	3.1	grassy	v	single grassy ring, isolated, but cluster (g) 1.4km north	2	1.4	1	1
g	256316	20616	4.7	grassy	v	concentric grassy rings (2), cluster (7), faint individual bomas like Makurian Fence, north of f, south of h	2.5	1.4	2	2
h	257181	22940	18.7	grassy	v	single continuous grassy ring, 2 smaller and more faint to south (c.400m)	2.1	2.3	1	3
i	224224	24820	5.4	grassy	iv	single continuous grassy ring, close to cultivated area	1.1	2.8	1	1
j	226554	26886	7.3	grassy scrub	iv	cluster of grassy rings (6?), broken, near cultivated land but degraded	1.4	2.8	1	2
k	226843	38122	10.7	grassy scrub	v	continous, single, cluster (5), cultivation nearby	1.5	3.4	1	2
l	295526	36395	27.5	woody scrub	v	ring outline in shrubby vegetation, close to MF	1.6	4.6	5	1
m	272347	55601	31.8	bare scrub	v	pale ring (soil), large, isolated, some individual bomas possibly visible	0.7	25.1	4	1
n	239935	54182	7.2	grassy scrub	v	single broken ring, slightly elongated, faint bomas	0.4	14.7	2	1
o	212417	59240	8.2	light woody	v	dense ring of trees with smaller rings and darker soil within	2.5	1.1	3	1
p	211364	60161	4.9	dense woody	v	dense continuous ring of trees and bare ground, elongated shape, three in main cluster with 1 c.1km southwest	0.6	1.1	3	3
q	209533	60334	24.1	dense woody	v	two large rings (300m apart) of bare ground with single line of trees (resemble train-tracks). dense vegetation within	0.7	1.5	3	3
r	213865	61151	10.2	woody	v	single ring of trees, slighlty broken, train-tracks, woody within, near-by cultivation	2.5	2.1	3	1
s	216390	66406	12.4	woody	v	single ring of trees, slightly broken, train-tracks, woody within	1.8	5.6	3	1

t	231200	66154	32.5	woody scrub	vi	faint ring of paler soil and trees, continuous, similar feature 700 m south	0.1	7.3	3	1
u	239961	69342	9	bare	vi	very faint ring of pale soil, possible extension on east side, close to mud pans (black cotton?)	2.1	10	4	1
v	226308	71626	17.4	woody scrub	vi	ring of pale soil, some trees, bare within	0.4	7.2	3	1
w	249491	72256	2.9	scrub	vi	pale soil, possible discrete bomas, similar feature 500m north	0.6	10.1	2	3
x	234120	77589	10.8	grassy scrub	vi	2 concentric rings, pale soil and shrubs, discrete bomas visible, 2km south of Maasai Plains	0.4	2.3	2	1
y	227523	49171	19.6	scrub	v	dark ring with pale boma patches, almost complete	1.1	9	2	1
z	260225	84391	9.7	grassy scrub	(vi)	circular patch of pale soil, possible faint rings	0.5	15.3	5	1
aa	235731	94627	21.2	grassy scrub	(v)	various concentric but muddled rings of dark soil, bomas discernible, nearby cultivation and bomas, hilltop	2.1	13.3	2	2
ab	253368	96607	13.2	grassy scrub	(vi)	ring of pale boma patches, possible extension on west side, or two sites overlapping	0.1	2.1	2	2
ac	255623	96313	7.4	grassy scrub	(vi)	train-track rings of pale boma sediments, slightly elongated	0.6	2.3	2	1
ad	222882	53786	40.7	scrub	v	large ring of pale boma patches, partly lined with shrubs in southwest corner, nearby cultivation	0.9	6.3	2	1
ae	251135	101238	11.1	grassy scrub	(v)	faint pale sediment patches, with darker semi-continuous incomplete inner ring,	0.1	3.7	2	1
af	257024	104586	8.8	grassy scrub	(vi)	ring and patches of pale sediment, complete ring, nearby small-scale cultivation	0.9	8.7	2	1
ag	219654	36431	6.3	scrub	iv	rings of darker sediment, outer continuous, inner broken, some pale patching around perimeter, nearby cultivation	0.4	3.9	2	1

Table 7.1. Sites identified in Google Earth survey.; Climate' zones based on Mizutani 2002, see Figure 7.15; 'Type' column: 1 - grassy ring; 2 - boma patches; 3- wooded rings; 4 - pale soil ring; 5 - general circular, no internal features; 'Clustering': 1 - isolated; 2 - mulitple, overlapping rings; 3 - nearby, non-overlapping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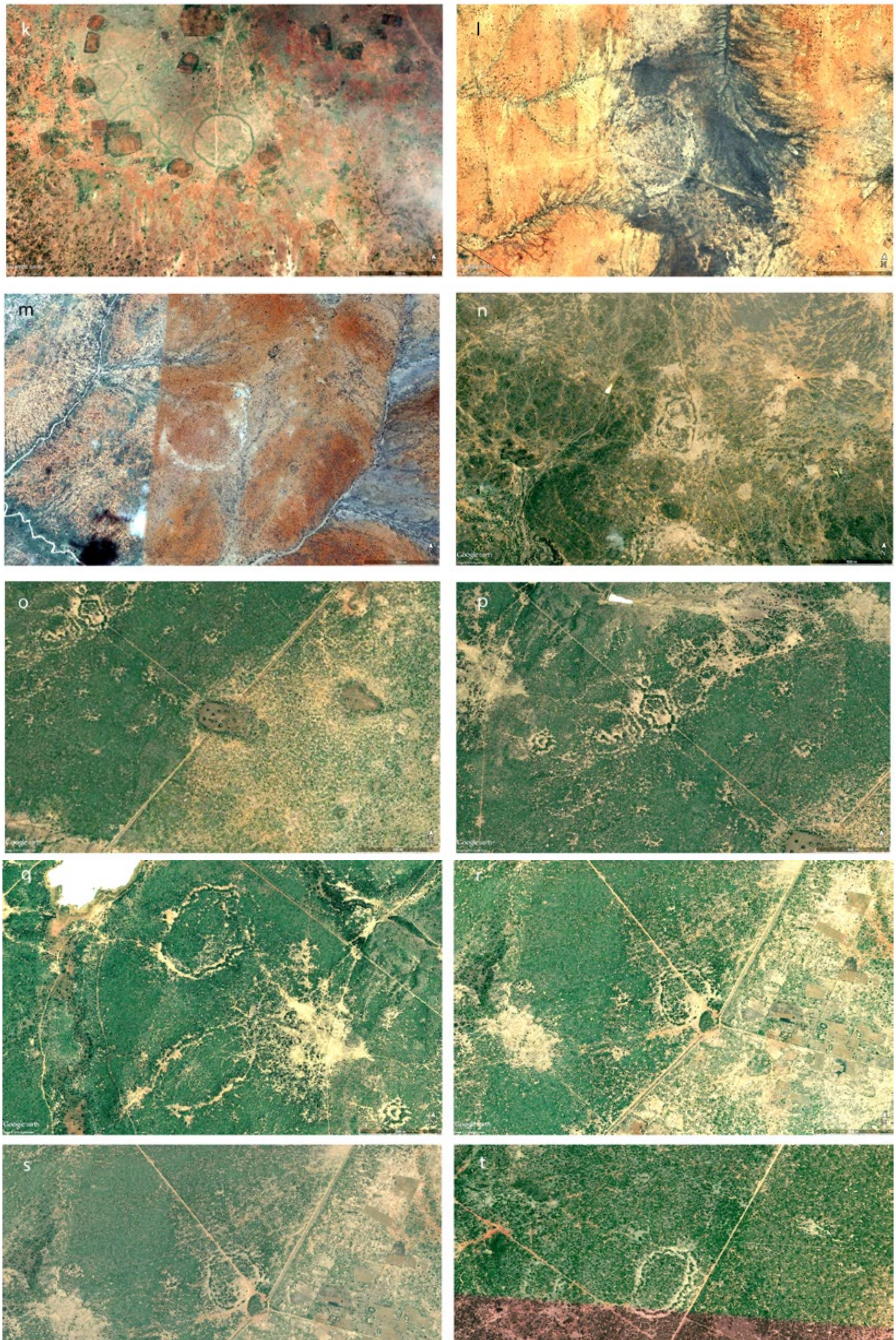
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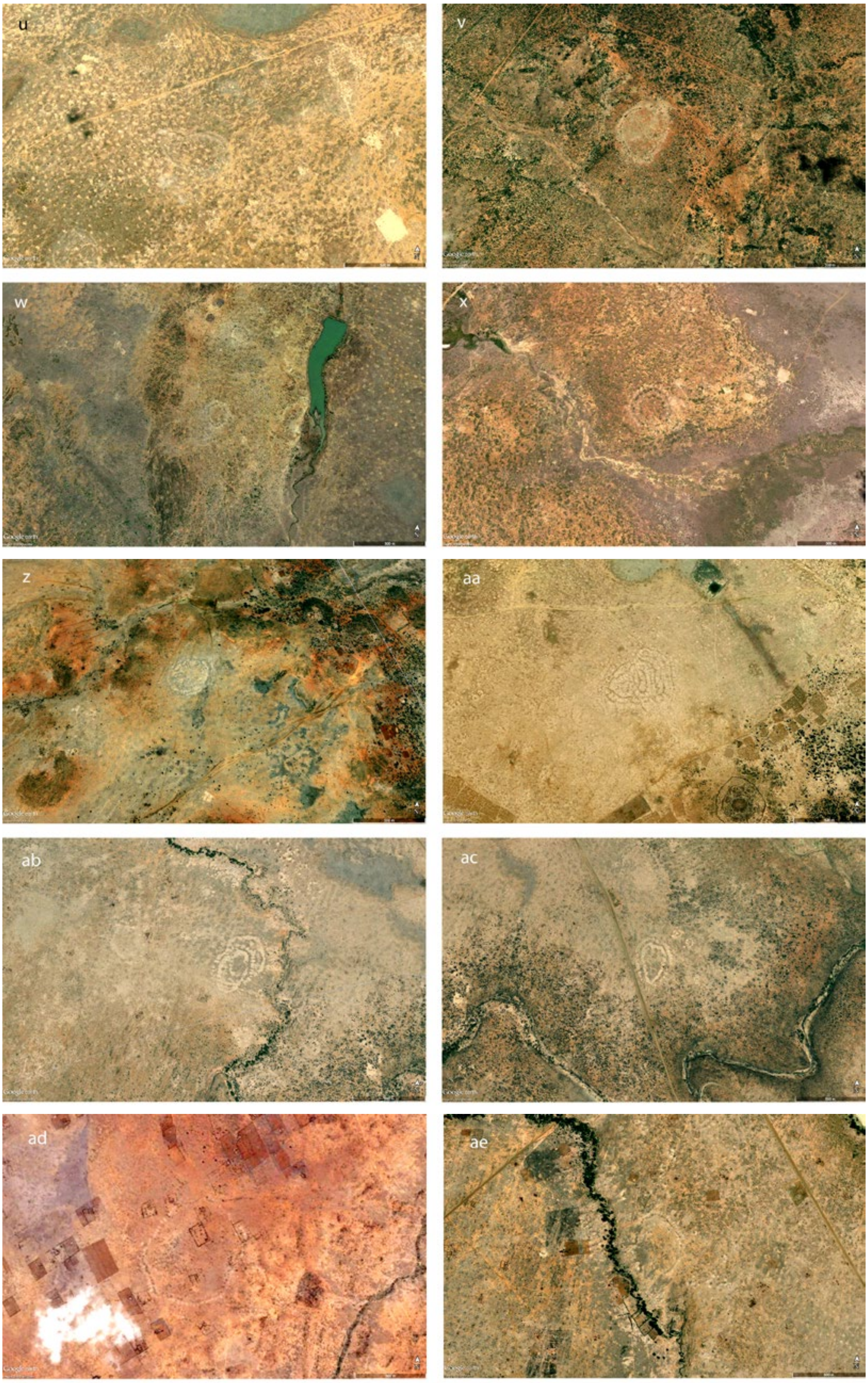
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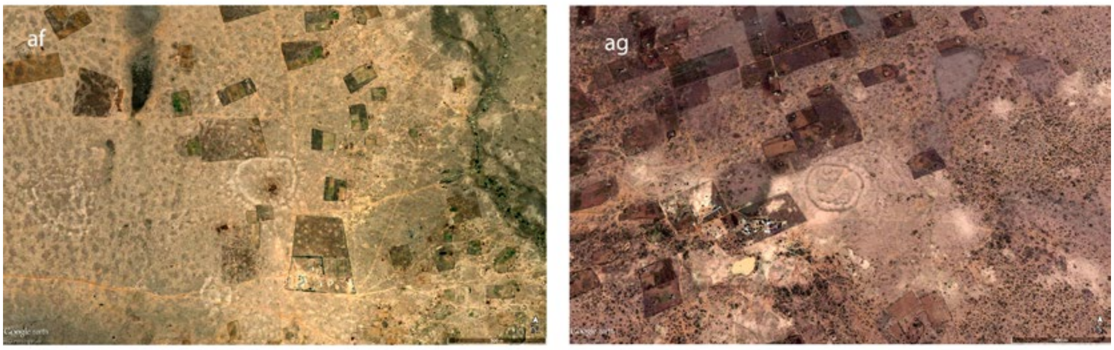

Figure 7.14. (a-ag) Large ring sites around Laikipia Plateau, Google Earth imagery at 5km altitude, screen area is around 4km². Enlarged images are provided in the Appendices.

survey of the ranch by Lahr and Foley (n.d.), more of which later – while the former are set within a large expanse of grassland, possibly a large glade.

Sites are set within a range of ecological contexts. Based on my own observations of the satellite imagery, nine (a, b, c, d, e, f, g, h, i) are set within relatively lush grassland, four (p, q, r, s) within forested areas while the remainder lie within scrubland of varying density. According to the varying climatic zones in Laikipia, as observed by Mizutani (2002), the most sites lie within the semi-humid (IV) to semi-arid (V) bands that dominate the central and southwestern parts of the district (Figure 7.15). This is pattern is not exclusive, however, and at least five sites (t, u, v, w, x) are located in the arid (VI) north/

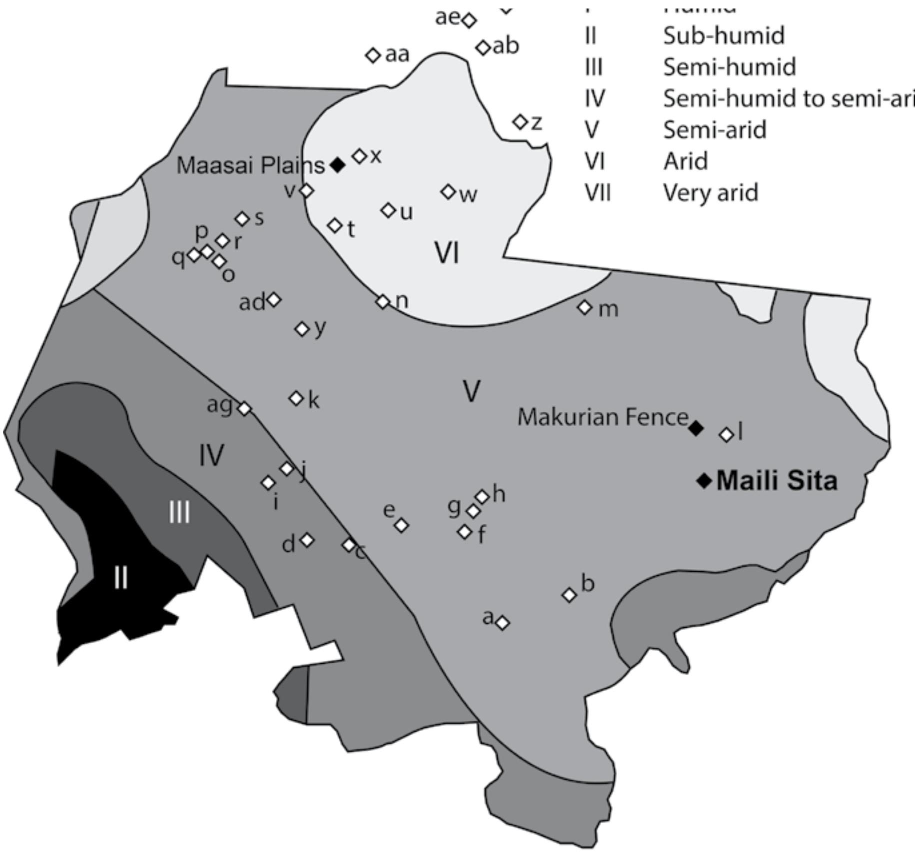

Figure 7.15. Ring-site distribution between climatic zones in Laikipia District (prepared by O. Boles, climate data from Mizutani 2002)

northeast. Five more (z, aa, ab, ae, af) lie north of the administrative district and therefore beyond the limits of the available climatic data, but might safely be assumed to lie within or close to the arid zone, given the regional trend towards drier conditions further north. Land-cover/use data for the district, obtained from the Mpala Research Centre (mpala.org 2017), shows the preponderance of agricultural activity in southern Laikipia (figure ????); this and the high density of broadleaf forest in the southwest broadly correlates with the higher humidity in these areas. Grassland, some of which is wooded, dominates much of central and northern parts. The land-cover data is too coarse and mixed to be usefully compared with individual site locations, though a high frequency of grassland locations might be provisionally noted. With reference to this land-cover information, however, it may be worth reiterating that no sites were observed in the centre of the plateau, where the landscape is characterised by closed shrubland and wooded grassland.

7.3 Discussion

There is no clear correlation between any of the variables observed in this preliminary survey. While it may be observed that the most common site-forms differ between the north, west and south – rings of enclosure patches, forest rings and grassy circles, respectively – at this stage it is difficult to know whether this reflects variation in original construction or function of the site. Indeed, it could be that visible distinctions stem from the different environmental conditions and commensurate taphonomic pressures found across the plateau. Equally, given that 'types' are not always restricted to particular regions or ecological zones, there would be reason to suspect fundamental differences in these sites' original form. Without secure dating, we cannot know whether or not those sites where internal features like enclosure-patches are more clearly recognisable than those at neighbouring locations are simply more recent examples. I am therefore inclined to suggest that some sites are manifest as rings of trees while others as rings of grass due, at least in part, to local ecological context; in a heavily wooded area, as in western Laikipia, sites will clearly have a different functional ecology to those within open grassland. Such a pattern echoes my discussion in chapter three of the different glade ecologies noted in Laikipia (e.g. Muchiru et al. 2009; Porensky et al. 2013) compared with Turkana (e.g. Reid & Ellis 1995) and southern Africa (e.g. Blackmore et al. 1990).

At the same time, while intra-regional variation in taphonomic pressures must surely have had some effect on the modern condition of these sites, the apparent integrity of the excavated contexts at Maasai Plains and the clarity of internal structure at some of the newly-identified sites, most particularly Makurian Fence, make it unlikely that post-depositional change is the sole drivers of variability. Considering the greater age of Maasai Plains compared to Maili Sita, one possibility is that these changes in form reflect temporal differences between the two. Both sites have yielded Kisima ceramics, and these too are of slightly different sub-styles, with Maili Sita exhibiting apparently a slightly later variant (Lane 2013). It is therefore possible that a similar pattern holds for the settlements themselves. Clearly, though, this point can only be speculative without considerably more detailed investigation, at the very least to better determine the character of material remains and, ideally, a comprehensive programme of absolute dating.

All sites fall well within the 10-12 mile limit suggested by Dahl and Hjort (1976) for distance from a settlement to a water source, based on maximum daily travel for cattle. Indeed, the greatest distance observed here was just 3.5 kilometres. However, mostly these water sources were generally streams and rivers that may only be seasonally available. As Google Earth imagery is derived from data obtained throughout the year, it has not been possible to ascertain whether river beds appearing to contain water are perennial or temporary resources. As described in chapter four, the only reliable perennial surface water in Laikipia – excepting reservoirs created by modern damming activity, as in the Lolldaiga Hills – is offered by the Ewaso N'yiro and its major tributaries. Thus, my argument in chapter five that Maili Sita is likely to represent more seasonal occupation is supported by that site's proximity to the perennial Timau River. While Maasai Plains (and site x and possibly u, from this survey) may be similarly well-resourced by the swamp at Loitigon Vlei, it is harder to assess the positions of the other sites. Sites f, g, h, n, w and z do lie within ten kilometres or so of the main Ewaso channel, and thus could be expected to support year-round settlement; whether or not similar patterns could be ascribed to the remaining sites requires more detailed hydrological data than presently available.

Likewise, there is no clear pattern to the location of sites relative to each other. There are several possible clusters - such as sites f, g and h, and sites o, p, q and r – wherein features are less than two kilometres apart, as well locations (e.g c, g) where multiple 'rings' overlap, apparently in palimpsests of upwards of ten settlements, unlikely to be contemporaneous. It may be notable that these two examples are fund in the wetter, grassy southern part of Laikipia, where conditions are less hostile. Seemingly-significant river channels can be observed nearby – g is 2.5 kilometres from the main Ewaso channel – and it is possible that these locations were somehow desirable and so regularly re-occupied.

While the driving factors behind the specific situation of each site remain unclear, when their wider distribution is considered, there is a striking preponderance for locations close to the margins of the highland plateau. These areas tend to offer distinct environmental conditions, being much more heavily vegetated and often with more varied topography than the plateau itself. For example, the now-cultivated areas in the south lie close to the heavily-wooded foothills of Mt Kenya and the Aberdares, while dense forests are also found at Mukogodo to the east – near Maili Sita and Makurian Fence – and Leroghi to the north. Ancient cedar woodland is also found in the hills around Ol Ari Nyiro Ranch close to the western Rift Valley escarpment (Taiti 1992). Also striking is the scarcity of site observed in the central part of the plateau (n being a possible exception), yet those areas are perhaps best-resourced in terms of water access by the Ewaso N'yiro. As described previously, and accorded greater focus in the following chapter, these peripheral areas are associated with other economic groups, and offer a distinct array of resources from those in the plains. It may well be, therefore, that pastoralists positioned their settlements so as to maintain access to these environments, resources and people.

7.4 Summary

This consideration of the wider archaeological landscape of Laikipia indicates that Maili Sita, rather than an isolated phenomenon, may be part of a regionally-bound culture of large, ringed, pastoralist settlements that, based on its co-occurrence at Maasai Plains and Makurian Fence, is linked to the Kisima ceramic tradition. Based on the available dates and known contexts for Kisima ware outlined in chapter four, one implication is that this phenomenon dates to the middle centuries of the second millennium AD. The form of these sites, particularly those where patching around the perimeter appears to denote the locations of former livestock enclosures, is highly evocative of the modern settlements constructed by the Rendille as well as the lorora ceremonial sites built by the Samburu, albeit at a much larger scale than anything seen today.

While the results of the survey presented here are clearly provisional and many of the questions raised might only be addressed via a more intensive programme of remote sensing analysis coupled with concerted ground-truthing, my observations may be significant; the presence of a hereto-undescribed regionally-bound settlement pattern dating to a period in which cultural identities and economic systems were being to coalesce into their modern forms certainly warrants further consideration. The following chapter considers these ethno-historical implications and speculates as to the role of Laikipia in the development of identities like Samburu, Rendille and Maasai.

8

Congregation and Assimilation

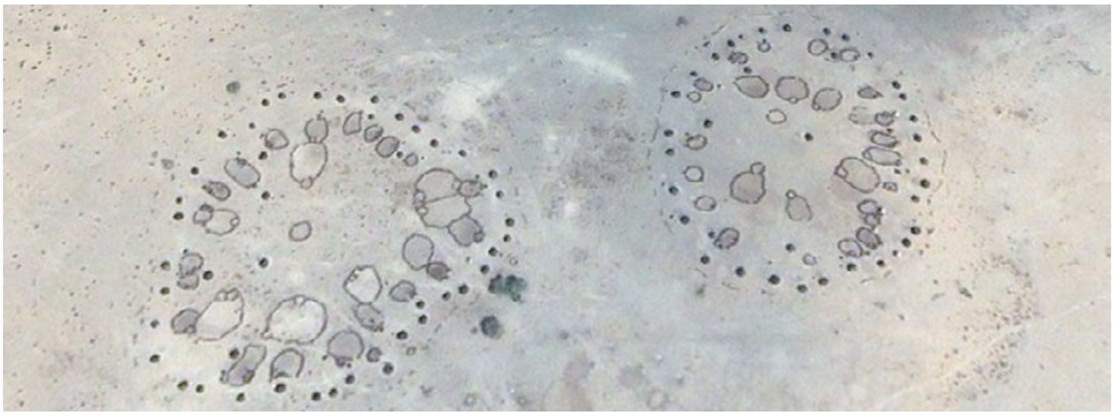

Figure 8.1. Rendille settlements in the southern Chalbi Desert (Google Earth)

This, the first of two chapters that draw together and discuss the implications of this research project, focusses on the social-historical implications of my data. I position the occupation of Maili Sita within the broader milieu of diverse economies and identities in and around the Laikipia Plateau and central Rift Valley during the middle of the last millennium. I will argue that the settlement landscape of second-millennium Laikipia, as described in the previous chapter, is reflective of patterns of communication, congregation and exchange reflective of the region's role as an incubator for the strongly-defined cultural identities that would emerge over the following centuries.

8.1 Reconstructing Ethno-histories

The following paragraphs present an in-depth consideration of oral traditions and linguistic data as these relate to the formation, movement and contacts of the key groups present in and around Laikipia during the mid-second millennium AD. Important questions surround the identity of the Laikipiak, their link with Kisima ceramics, the notion that Maa-speakers have dominated the plateau since their southward dispersal from western Turkana and the extent to which ethnic identities like 'Maasai', 'Samburu' and 'Rendille' were somehow fully-formed by this time. In the scenario presented below, the notion of direct continuity between Maa-speaking Rift Valley Nilotes and the Laikipiak is tempered by the influence of Cushitic-speakers like the Rendille, already established in central Kenya. I propose that

Maili Sita and the other 'ring sites' depict a key moment in the history of eastern African pastoralism, a period when savannah economies were characterised by the networks and links they maintained prior to the ethnic division, dispersal and antagonism that followed. I begin by situating the available radiocarbon dates for Maili Sita in the context of traditional histories, or at least the few that go back far enough.

8.1.1 Radiocarbon dates and oral traditions

As described in chapter four, the available radiocarbon dates for Maili Sita are rather vague, coinciding with a fluctuation of the calibration curves (Reimer et al. 2013; Hogg et al. 2013) and exacerbated by typographical error[1]. The 1520-1808 cal. AD date for unit A/04 (IntCal13, 2-sigma, Beta-189981) and the post-1670 date for the iron smelting remains (Beta-212297) – which can only provisionally be considered contemporaneous with the main settlement – point to the site being occupied sometime between the sixteenth and eighteenth century. It may also be important to remember here that Maasai Plains is dated considerably earlier, most likely having been occupied during the fifteenth or sixteenth century. Equally, though, Maasai Plains and its environs clearly hosted multiple, not-necessarily-contemporaneous settlements, and there may have been more overlap with Maili Sita than the available radiocarbon dates appear to suggest.

The date for the main site at Maili Sita positions it, rather unfortunately, within one of the most enigmatic periods for central Kenyan pastoralism, an issue compounded by well-documented vagaries in radiocarbon calibrations with respect to the last three or four hundred years. As is hopefully clear from introductory chapters, there are conflicting views on when Maa-speakers – that may or may not have included the Laikipiak – moved out of the Rift Valley and when the subsequent splintering of groups like the Samburu and Il-Chamus and the consolidation of a 'Maasai' core might have occurred. Jacobs' (1972) reconstructions of oral traditions from the Narosura area, in the Narok highlands above the southern Maa escarpment of the Rift Valley, point to the arrival of the Il-Tatua in that area, having been replaced as the dominant group in Laikipia by the emergent Laikipiak. The precise date of this is unknown, though cross-comparison of age-set traditions and family genealogies relating to the *oloiboni*, the Maasai ritual leaders, point to a date prior to 1600 AD, and perhaps as early as 1400 AD. Jacobs' sources link the Il-Tatua – pastoralists

8.1. The Beta-189981 date of 240 ± 40 is mistakenly given in Causey 2010:116 as 200 ± 40, and re-printed in Lane 2011:102 and Iles & Lane 2015:392. This variation leads to the *terminus post quem* for the site being stated as post-1642 cal AD as opposed to the correct 1520-1808 cal. AD (2-sigma range, calibrated using the IntCal13 curve, Reimer et al. 2013).

who engaged in some cultivation, constructed piled stone burial cairns and, though having access to metal spearheads, were not iron-workers themselves – with Cushitic-speaking groups like the Somali, Rendille and Borana.

Jacobs (1972:82-3) goes on to say that the Il-Tatua were later driven out of the Narosura area around 1600 AD, again by a group which he links to the Laikipiak: the Iloogalala. In this narrative, the Iloogalala, along with the Laikipiak themselves, were 'separated from the main body of pastoral Masai [sic]' (1972:82; see also Lamprey & Waller 1990) during the earliest movements of Maa-speakers out of western Turkana. He suggests that these groups may have lived together on the Laikipia plateau, where they were in contact with 'Galla' communities (i.e. Oromo-speaking Cushites) with whom they developed shared traits. It is unclear from Jacobs' account, however, whether the Cushitic groups encountered were remnants of or related to the Il-Tatua that were eventually pushed out. In his description of Iloogalala economy, they are portrayed as pastoralists more concerned with livestock as a source of meat than of milk, and that some families diversified into agriculture and hunting (1972:83). He also highlights their adopted-practice of cairn burial, stating that the modern Maasai widely attribute such constructions to the Iloogalala, and their skills in iron production.

Based on Jacobs' descriptions, the Iloogalala or a closely-related group would appear to be a likely candidate for the occupiers of Maili Sita; the evidence for a broadly pastoral economy, though not completely exclusive of domestic crops (based on Mwiriri's unconfirmed reports of domestic taxa represented in pollen records from samples excavated in 2004; see chapter four), with nearby cairn burials, and extensive iron working reflects many of the traits he describes. The dates are also partly appropriate, with the Iloogalala moving onto the Laikipia Plateau sometime during the fifteenth or sixteenth century. However, it is also said that the Iloogalala, and perhaps the Laikipiak too, were highly mobile, rarely stationary long enough for the foundation of homesteads (Siiriainen 1984). Furthermore, settlements tended to be situated in steep, highland areas and were small, isolated and easily defensible; this is clearly at odds with the open setting and demonstrably long-term occupation of Maili Sita.

8.1.2 Linguistic evidence

Two core linguistic clusters are associated with the spread of herding: initially, hunter-gatherers preceded the arrival of Southern Cushite herders from southern Ethiopia in the third millennium BC; Southern Nilotic speaking herders then arrived in the Central Rift Valley from southern Sudan in the late-second or early-first millennium BC; speakers of Eastern Nilotic languages, from which Maa is derived, moved down into western Turkana during the first millennium AD, at a similar time to southward incursions as far as Mt Kenya by Eastern Cushitic herder-farmers, from whom the Yaaku language spoken by the Mukogodo was acquired.

Eastern Nilotes, then, moved into the region between Lake Turkana and the Karamoja area of northeast Uganda where they encountered and interacted with Eastern Cushites – perhaps the progenitors of the Dassanetch and Elmolo (Sobania 1980) – acquiring shared traits like clan structuring, age-set organisation and, probably, iron working (ibid; Sommer & Vossen 1993). This interaction may have reached as far as the Rift Valley highlands of central and southern Kenya and included the agro-pastoral Sirikwa (Lamphear 1986). Based on glottochronological reconstruction, there was a split into South Maa and North Maa at some point between the thirteenth and sixteenth century (Sommer & Vossen 1993), with speakers of the former continuing to expand southwards, forming the foundation for the modern Maasai, while the latter, of which Samburu and Il-Chamus are the principal modern dialects, established themselves to the north in the area around Lake Baringo and the Leroghi Plateau, and even as far as southern Turkana (Sobania 1980). This split may be at the root of the Maasai-Iloikop distinction, which according to Galaty (1982; 1993) arose out of the centre-periphery dialectic that itself developed as Maa-speakers moved out of the Rift Valley.

Another interesting element in this narrative is that the Parakuyo Maasai of northern Tanzania are also considered to be Iloikop and, though South Maa speakers, share at least 21 words with Samburu, words that are not present in the vocabulary of any of the Maasai sections whose territory lies between (Sommer & Vossen 1993:34-5). This may be a relic of interaction prior to the North-South split, or it may reflect later processes of mobility; the Parakuyo are also referred to as *Iloogolala*, linking them with the homonymous group referred to in Jacobs' (1972) oral histories (see above). Moreover, the Loitai Maasai of the Loita Hills around Narosura – where Jacobs' Iloogalala are said to have settled on leaving Laikipiak – share vocabulary with the Parakuyo; indeed, the two are the most closely-linked of the South Maa dialects (Sommer & Vossen 1993). This correspondence in itself is not a novel suggestion, and the Parakuyo are well known to have settled in Loita *en route* to their modern homeland south of Mt Kilimanjaro (e.g. Galaty 1993). However, the prospect that they may have come down from Laikipia, perhaps moving across the highlands southwest of Mt Kenya – a largely under-investigated area from an archaeological perspective – thus circumventing much of the Purko-Kisongo core around Lakes Nakuru and Elmenteita, is an intriguing one, remembering here that Jacobs' oral histories point to this occurring before 1600 AD, a timeframe seemingly confirmed by Sommer and Vossen's (1993:35) estimation of a 200-year spell in the Loita Hills, based on the degree of dialectic divergence between Parakuyo and Loitai.

A further implication of this, and one that various commentators have suggested, is that the Laikipiak were also 'Iloikop' (e.g. Weatherby 1967; Waller 1979), part of the same process of expansion as the Samburu and, seemingly, the Parakuyo. Indeed, while it has been proposed that Kore, spoken by purported descendants of the Laikipiak living on Lamu Island, represents a third variant of Maa (Heine & Vossen 1979), it has also been noted that the dialect bears lexical and phonological comparison with North Maa (Sommer & Vossen 1993:30). This lends weight to the assertion by Spencer (1973:151) that the Samburu consider themselves – and perhaps, by extension, the Il-Chamus – and the Laikipiak to been a single entity for some time after the initial Maa split. By this measure, these groups may only have diverged sometime before the early-nineteenth century, by which time the Il-Chamus had split from the Samburu and early-European accounts describe strong ethnic distinctions between the Maasai and the Iloikop (Krapf 1854).

Prior to the nineteenth century, the Laikipiak-Samburu-Il Chamus nexus may have been, as Sobania (1980:83) puts it, "only a loose confederation of clans whose unity was still to be fashioned by their coming experiences". These experiences may have included, perhaps foremost, the *Laparanat* droughts that remain well-remembered in Samburu traditions; Anderson (2016), based on unpublished work by Waller and Sobania (cited in Anderson 2016) drawing attention to the shared time-depth of age-generation systems among herders in the northern Rift Valley, suggests that environmental catastrophe may have triggered a 're-making of [ethnic] identity'. He argues that at least eleven traditions from across eastern Africa describe a period of severe and extended drought around the turn of the nineteenth century (see also Webster 1979). Such an event (or series of events) is supported by various paleoenvironmental records depicting extreme lake-level low-stands in the early nineteenth century, with a return to more humid conditions around 1830 (Nicholson 1998; Bessems et al. 2008; Kiage & Liu 2009). This closely coincides with earliest remembered age sets of the Maasai, the Samburu, the Il-Chamus and, importantly in the context of this dissertation, the Rendille. Furthermore, the early nineteenth century also saw the end of the Sirikwa (Sutton 1993), and the 1830s heralded the first of the Iloikop Wars; Anderson's hypothesis is that drought caused the disruption of the broad social connections between [North] Maa-speakers and their Eastern Cushitic neighbours, yet that it was climatic amelioration and subsequent struggle for pastoral resources, manifest in conflict, that encouraged the construction of defined 'ethnic' boundaries based on territory and subsistence. Lamprey and Waller skirted the edge of this theory, making the important point that, 'if a community undergoes a period of dissolution and restructuring, such as to alter its composition and identity, it is unlikely that the emergent community will assimilate the old corpus of tradition…in which [it] has no *collective* part and therefore, no direct concern' (1990:19, my emphasis).

8.2 Discussion

So where does this leave the occupation of Maili Sita? I will first summarise the primary points of evidence, beginning with Maili Sita itself. As discussed in the first part of this chapter, the site bears comparison in terms of form both with the main settlements of the modern Rendille and the Samburu *lorora*. However, the enamel isotope data presented in chapter five, albeit based on a small sample population, points to semi-permanent occupation rather than the short-term ceremonial congregation associated with the latter. Kisima ware, which dominates the ceramic assemblage, has links with both the Samburu – through the (unfortunately) un-provenanced ethnographic collections of the National Museum of Kenya – and the Cushitic-speakers said by Jacobs' (cited in Siiriäinen 1984:66) to have produced it. The faunal assemblage is dominated by cattle and small stock, with no evidence for the presence of the camels one would expect to find at a Rendille homestead. There is tentative evidence for domestic crops, though whether these were cultivated at Maili Sita or obtained through exchange networks is unclear. Iron working was undertaken beyond the main settlement, and other groups with diverse technological practices operated in the area, though the possibility of contemporaneity remains open. The cairns, though undated, are strongly reminiscent of Cushitic practices, and, if not contemporary with the main occupation – which is plausible given the other potential indicators of Cushitic presence in the region (e.g. Kisima ware) – may have been related to an earlier Il-Tatua population.

How, then, is this archaeological record situated with respect to the reconstructions of population history outlined earlier? My thoughts on the possible events are as follows: the Southern Cushitic-speaking Il-Tatua seem to have moved south from Laikipia – leaving the Yaaku language as a relic of their presence – around 1400, or perhaps earlier, and been replaced in that region by an amorphous North Maa-speaking population from the west, a population which included the forebears of the Samburu, Il-Chamus, Laikipiak and Iloogalala. While the as-yet indistinct Il-Chamus remained around Lake Baringo, the 'Samburu' occupied the Leroghi Plateau. At a similar time, Eastern Cushitic populations – perhaps descended from Schlee's (1985) PRS culture that had been present in the northern lowlands for some time – had pushed into the highlands. These groups, linguistic ancestors of the Rendille, were primarily cattle-keepers (Schlee 1989:39) and were therefore not in direct resource competition with the cattle-keeping Maa. At some stage, likely during the sixteenth century, the Iloogolala moved south to the Loita area, where their proximity to incumbent South Maa populations – the 'Maasai' core – encouraged their almost-total conversion to that dialect. Back in Laikipia, there remained a kind of proto-Samburu-Laikipiak-Rendille conglomeration alongside Yaaku hunter-gatherers, and the sixteenth to eighteenth centuries were characterised by inter-ethnic contact, exchange and osmosis of the kind that fostered the emergence of the Ariaal, who came to bridge the Samburu and Rendille (see Fratkin 1991). This period of relative cordiality was disrupted by the *laparanat* droughts, after which ethnic distinctions emerge. While the Laikipiak, given their prominence in the reliable post-1800 histories and colonial records, were comprised of those herders who occupied the main Laikipia Plateau, the Samburu were formed of those left in Leroghi and the lowlands west of Maralal and Mt Marsabit, their current homeland. While economic differentiation facilitated a mutually-beneficial relationship with the Rendille, who with their camel-focussed economy were able to move further north into the arid Chalbi desert, the Samburu and Laikipiak were left in direct competition for grazing resources, hence the reputation of the latter in Samburu traditions as raiders (Sobania 1993).

Essentially, then, Maili Sita and, by extension, Maasai Plains, Makurian Fence and the other large-ring-sites observed across the plateau, exhibit material and formal characteristics linking them with a number of different groups. Moreover, the reconstructed ethno-histories for the region point to the Laikipia and Leroghi Plateaux being host to a broader, perhaps ethnically-undifferentiated population out of which sub-groups like the Laikipiak, Samburu and Rendille would ultimately emerge. These sites may therefore be emblematic of this shared or mixed identity, which saw communities engaged in diverse subsistence practices and linked by wide ranging networks of exchange involving material culture like iron and pottery as well as subsistence resources and social principles like age-sets and circumcision.

The scale of the sites provides another interesting point of discussion, and I would like to think for a moment about the various ideas surrounding the congregation of otherwise-dispersed people in large centres; that is not to say that the occupants of Maili Sita were usually dispersed, but rather that the pastoralist lifestyle clearly entails a degree of mobility, and is not predisposed to urbanisation or other large-scale aggregation. McCabe (2004), in his discussion of the political ecology and stock-raiding activities of the Turkana, describes temporary congregations in large moveable settlements or clusters thereof, known as *arum-rum*, as a common response to inter-ethnic conflict. The Turkana consider such congregations to be undesirable, with the greater numbers of cattle present in the settlement requiring that individual herders travel greater distances in search of pasture. During the wet season, when grazing is plentiful, aggregated settlements known as *adakars* are formed, sometimes containing up to 3000 people in a 10 square-kilometre area. While the physical location of Maili Sita, atop an open area of higher ground with views over the surrounding landscape is perhaps appropriate as a defensive position, given that such a setting is frequently favoured by pastoralists across eastern Africa (Western & Dunne 1979), as well as the evidence for the period of occupation being one of relative stability, I would be reluctant to concede that the large-site phenomenon is linked solely to security issues. With reference again to the isotope data, nor would I expect a seasonal, *adakar*-type occupation. Moreover, were the form of Maili Sita and the other sites – which, it should be remembered, are spread across a considerable area – related to conflict, the opportunity to strengthen communal bonds and reinforce shared identities amid stressful external pressures may have encouraged the use of material culture style to create and signal different dimensions of personal and group identity (Larick 1986a; Larick 1986b); given the apparent uniformity of the material culture observed at the three sites thus far investigated, the notion of identity reinforcement through deliberate cultural differentiation may not be sustainable. Instead, I am more inclined towards Spencer's (1973:20) reasoning for the large size of modern Rendille villages, that the strength of consensus opinion made possible by large gatherings aids community cohesion in an essentially heterarchical society, proposing that any economic arguments are 'rationalisations of this essentially social choice'. Following this argument, it may be that the founding of large settlements contributed to the ability of pre-nineteenth century populations to engage in these economically and culturally symbiotic interrelationships within a diverse ethno-linguistic mosaic.

This is not to suggest that this settlement pattern in mid-second-millennium Laikipia was driven solely by social factors, and, as with any discussion of pastoralism, ecology must be considered. I have mentioned already (chapter four) that the eastern African climate during the middle centuries of the last millennium was initially characterised by drier conditions than today, during the Medieval Warm Period (c.AD 1000-1270), while the subsequent Little Ice Age (c.1270-1850) was broadly wetter but with the region experiencing spells of extreme aridity (c. AD 1380-1420, 1560-1620 and 1760-1840; Verschuren et al. 2000). Based on the available dating evidence from Maili Sita (1520-1808 cal. AD) and Maasai Plains (1315-1616 cal. AD), it is impossible to conclude whether the sites were occupied during drier or wetter spells, and reasoned arguments can be made for population aggregation being a response to either. For example, McCabe's (2004) description of the Turkana cited above includes communities gathering together as security against raiding, instances of which have been seen to increase in inverse proportion to rainfall (e.g. Homer-Dixon 1999; Gray et al. 2003). Moreover, the Acholi of northwestern Uganda explicitly site drought and the need to share meagre resources during times of stress, as being central to the consolidation of their ethnic identity (A. Reid, pers. comm. 2015). Equally, McCabe (2004:53-4) observed wetter conditions to encourage congregated settlement among the Turkana (i.e. the *adakars*), with surplus resources allowing people to come together for 'companionship and protection, for as long as the forage and water resources permit'. While the former aligns with Spencer's (1973) reasoning for the large size of Rendille settlements, the latter poses an intriguing contrast to an assumed causative link between famine and violence. Witsenburg and Adano (2009) make the important point that in parts of northern Kenya, at least, instances of raiding increase during the rainy season, with young men released from the intensive herding duties required when conditions are harsh and free to engage in these activities. Similarly, it has been noted that inter-ethnic community dialogue during drought has a moderating effect on conflict, indicating the importance of considering social and political context when attempting to explain the effects of environmental change (Linke et al. 2015).

Without dating evidence of sufficient resolution to specify whether Maili Sita was occupied during the drier or wetter periods defined by regional palaeoenvironmental proxies, or little way of inferring the extent to which security was a concern for its inhabitants, the rationale for such a large settlement is obscured. In the interests of addressing this important theme, though, a few additional points might be raised: firstly, the stable oxygen isotope data presented in chapter five suggests that the prevailing climate was not dramatically different from today, and perhaps unlikely to have been any drier given that the modern comparators – the teeth taken from modern Lolldaiga Hills Ranch stock – have ready access to water from the twentieth-century dams. The substantiation of this claim, however, will require data drawn from a much wider array of archaeological samples (c.f. Pearson & Grove 2013). Secondly, and linked to this point about access to water, is that the nearest perennial water source, the Timau River, at the southern end of the Lolldaiga Hills is over twenty-five kilometres away, well beyond the ten-to-fifteen kilometre limit for settlement-water source distance suggested by ethnographers (e.g. Dahl & Hjort 1976). Given that the Lolldaiga Hills receive more rainfall than much of the rest of Laikipia, and that the geoarchaeological and other isotope data suggests year-round occupation, one might imagine that the currently seasonal rivers that skirt the eastern and western flanks of the Maili Sita ridge flowed more consistently when the site was occupied. Third, assuming that the last of these arid spells, in the early nineteenth century, can be reliably linked to the *Laparanat* events that triggered the Maasai-Samburu consolidation (Anderson 2016) that may have marked the end of the Laikipia-bound, Kisima-using, large site phenomenon, it seems logical that the latter was manifest during amenable climatic conditions. Lastly, that Maasai Plains is located one kilometre from the Loitigon *Vlei* (swamp), a resource that might feasibly have supported large human populations during periods of higher precipitation, may further support the idea that these large sites were not a response to environmental stress. At the same time, given the complexity of the relationship between climate and conflict (e.g. Witsenburg & Adano 2009; Linke et al. 2015), neither can the influence of security concerns, perhaps partially driven by climate, be ruled out.

8.3 Summary

The preceding chapters have shown Maili Sita to be part of a previously un-documented settlement pattern, with sites of a form peculiar to the Laikipia region and specific to the middle centuries of the last millennium; this discussion has sought to contextualise this pattern with respect to the various groups that were either present-in or connected-to the area during this period, and speculated as to how these might relate to modern communities. The dynamics of how ethnic identities are constructed and perpetuated has been debated at length (e.g. Ranger 1983; 1993; Jones 1997; Spear 2003; various chapters in Richard and MacDonald 2015). As discussed early in this dissertation (chapter two), the opposing positions of the 'primordialist-instrumentalist' debate, that ethnicity identity is either innate or circumstantial, have given way to a more nuanced perspective whereby historical dimensions are recognised but not at the expense of mutability. Maili Sita and the Laikipia Plateau would seem to me to be synecdochic of this point as it concerns the history of African pastoralism; it is clear that the greater part of the last millennium was, in eastern Africa, characterised by various ethno-linguistic groups exchanging ideas, technologies, commodities and people, thus negotiating new identities which, though rooted in historical tradition, were as fluid and mobile as social and environmental conditions required them to be. The position of Laikipia at the apex of the frontier between two major ethno-linguistic clusters – the Nilotes and the Cushites – would perhaps have encouraged more intensive interaction than in most other parts of the region, and fostered the interrelationships that survive today, such as that of Samburu-Ariaal-Rendille. Subsequently, climatic upheaval sowed the seeds of division and the forging of antagonistic, semi-independent identities like 'Laikipiak' (see Anderson 2016). Kopytoff's (1987) notion of the Internal African Frontier may be salient here, whereby populations 'that nestle in the interstices between "normal" societies and ethnicities…' – i.e. societies with a historical, established common identity – '…[develop] a mish-mash of regional cultural traits' (1987:4). Thus,

> *'…the collective, "official" history that a society tells about itself may be unitary and straightforward. But that is belied by the individual histories [of its members] that show their ancestors coming from different areas and at different periods'* (Kopytoff 1987:5)

The details of Kopytoff's conceptualisation may not immediately apply in the context of Laikipia – he theorised in the context of the margins between major West African kingdoms and states, with peripheral differentiation seen as related to the diminution of hegemonic power with distance from the centre, with cultural remnants of indigenous populations being proportionately magnified. However, to return to Galaty's (1991; 1993) notion of a 'Maasai core' versus an 'Iloikop' periphery, and if we accept the linguistic evidence for a Cushitic presence in Laikipia prior to North Maa divergence, I would argue Kopytoff's framework offers an elegant hypothesis for how the occupants of Maili Sita came to be differentiated from their counterparts in the Rift Valley. Anderson's (2016) depiction of the cultural implications of environmental catastrophe, by contrast, offers an equally cohesive explanation of how nineteenth century circumstances were arrived at.

To return to my two key introductory themes – the key pastoralist dynamics of mobility and ecology – both have facilitated the kinds of interactions and physical, cultural and demographic exchange that have shaped historical trajectories. Different scales and forms of mobility are at play here: initial instigation of socio-economic change might be attributed to large-scale population, which though clearly not the sole means for cultural transmission, seems to have taken place on some level, as groups moved south from West Turkana (Nilotes/early-Maa) or from the Rift Valley into Laikipia and Leroghi (Samburu-Laikipiak); issues of security linked to resource availability (though not necessarily by way of 'cause-and-effect'), may have either forced or limited mobility and fostered population congregation and communication; herd mobility and broad grazing orbits are necessary for the exploitation of pastures in and around sites like Maili Sita, as well as to engage in trading relationships with farmers and hunters, for instance. It may be that itinerant artisans like blacksmiths were part of this mobile 'super-culture', allowing different groups access to metal technologies and helping disseminate ideas such as 'smiths as outsiders', the *il-kunono* for the Maasai; and individual mobility may have allowed people or households to move between settlements or even between economic communities in reaction to changing socio-political or environmental conditions. This last point carries with it the idea of mobile or fluid identity, that people can become associated with different 'ethnic' groups throughout the course of their lives; it is surely this capacity for adaptation in the face of changing physical and social landscapes that facilitated the cultural melange of pre-eighteenth century Kenya as much as any literal movement of people.

9

The archaeo- and socio-ecology of pastoralism

Figure 9.1. Cattle in the northerm Lolldaiga Hills

In this second phase of discussion and as a precursor to drawing my final conclusions, I look more closely at the second of those key dynamics: ecology. The following paragraphs discuss how the occupation of Maili Sita has impacted local ecodynamics and vice versa, and consider how my observations can contribute to archaeological approaches to pastoralist settlement. This is followed by a critique of how ecologists currently think about pastoralist settlements in their understandings of savannah dynamics, and how the results of this research project might force a reconsideration and expansion of the scope of these models. I then discuss how an appreciation of the economic value of glades, as imbued by these features' ecological significance, might be linked back to the kinds of social dynamics discussed in the previous chapter. Lastly, I consider the ramifications of modernity in pastoralist rangelands, and how changing ecologies and cultures today provide an effective, if possibly extreme, analogue to illustrate the centrality of ecology and mobility in the lives of past communities.

9.1 Archaeological implications

In chapter three I highlighted various archaeological approaches to African pastoralist settlements, and how their respective shortcomings these have hindered our comprehension of the historical trajectories of contemporary livestock-based societies. This methodological handicap has impacted all facets of archaeological enquiry, from essential questions as to the relative prominence of livestock versus other subsistence programmes, through to understandings of the formulation, exchange and evolution of ethnicities, traditions and cultural traits. While these latter points were discussed in the previous chapter, I hope that the approach I have taken at Maili Sita might prove widely applicable and help answer such questions as they pertain to other peoples, places and timeframes. Certainly, my results offer support to the kinds of ideas proposed by Cribb (1991; see also Chang & Koster 1986), for instance, which emphasise the value of understanding the spatial dynamics of pastoralist settlements, as a means to conceive and frame questions of cultural evolution and provide valuable context for material culture analysis.

One of the aims of my research has been to explore the application of the ideas advocated by Shahack-Gross and colleagues (2003; 2004; 2008; 2011). Their work having been based on ethnoarchaeological observation, it remains important to assess whether the 'smoking guns' that they identified – markers for the various specific spatial elements of pastoralist settlements in eastern Africa – retain relevance over longer timescales and under different environmental conditions. While the approaches I have taken and the techniques used at Maili Sita are sufficiently different from those used by Shahack-Gross *et al.* as to preclude direct comparison, and I therefore cannot claim to have fully interrogated the latter's archaeological potential, it is possible to make several observations. Foremost among these is that microstratigraphy visible in thin section as evidence for the corralling of livestock may be heavily dependent on the presence or absence of soil microfauna, such as termites. It is clear that Shahack-Gross's ethnographic subject-sites at Rombo (2003; 2004) and the archaeological test-case at Sugenya (2008) have experienced much less bioturbation than is in evidence at Maili Sita. It is impossible for me to say, based on available data, whether and in what densities termites are present at Rombo, and it may be that the impact of soil fauna observed at Maili Sita is linked to the greater period over which such taphonomies have had time to progress. At the same time, that microlaminations were recognised at Sugenya, a considerably older site than Maili Sita, confirms the somewhat-predictable theory that local ecological conditions are a primary determinant of the survival of micromorphological markers.

In the absence of structural indicators like soil microlamina, my recognition of degraded dung associated with the keeping of livestock at Maili Sita has relied on other markers. The presence of densely concentrated faecal spherulites, organic carbon, mineralogical enrichment (P, Ca, Mn) and elevated pH in my own data, and that these variables show close spatial correlations with the increases in soil nutrients observed during Payton's 2004 analyses, can be taken as strong evidence in this regard. Contrary to the expectations of Shahack-Gross et al. (2004), however, I have been unable to isolate patterns in the data that might relate to the individual elements of a settlement – for example, corrals as distinct from refuse pits, the location of gateways or house-floors – from which to draw reliable conclusions regarding the precise layout of Maili Sita. Indeed, the results are almost binary in the way that only anthropogenic versus non-anthropogenic deposits can be determined, with such homogeneity within these categories that I would question the potential benefits of conducting similar studies at any smaller sampling resolution, at least in environments where bioturbation is intense. This might be recognised in the first instance by the visibility of termite mounds on the surface. The possibility of exploring whether some of the spatially-manifest cultural particularities noted by numerous ethnographers of pastoralist communities (e.g. Herbich & Dietler 2007 on the relative locations of houses and enclosures in Luo communities; Kuper 1980; Huffman 1993, 2001 on the Central Cattle Pattern in southern Africa), is therefore limited. On the basis of my observations at Maili Sita, which admittedly are restricted to a single site, I am forced to conclude that complex definition of settlement layout at archaeological pastoralist sites in eastern Africa remains an exceptionally difficult proposition, and cannot claim that my work furthers the development of this field of enquiry beyond underlining the limitations of the techniques I have used. However, the most important aspect of my results concerns the scale of the site, and it is to these broader questions that my research might make a broader methodological contribution.

As discussed in the previous chapter, the large size and ringed-form of the anthropogenic deposits at Maili Sita and other sites in Laikipia, alongside various material cultural indicators, has informed my speculations regarding how interactions between distinct ethno-linguistic and economic communities might have influenced the formation of contemporary Kenyan cultural identities. Besides such local relevance, I would argue that these observations raise important questions regarding both how pastoralist sites should be approached by archaeologists and how ecologists perceive these sites as components of savannah ecosystems. Archaeological and even ethno-archaeological discussions of pastoralism and mobile economies more generally have tended to depict settlements as small and even insignificant; the language used in some, particularly older, descriptions of these sites – 'camp', 'hut', 'homestead' and 'village' (e.g. Robertshaw 1978; Simms 1988; Gifford & Behrensmeyer 1977; Kent 1992; Fisher & Strickland 1989)– seems to emphasise brevity and ephemerality, or even imply that such locations are somehow parochial or primitive. While this is far from an accusation that the writers cited above were in any way being intentionally patronising towards these communities, I would maintain that such language encourages certain assumptions about how and where pastoralists are expected to live. There are, of course, occasional descriptions of larger sites available – for instance, the ceremonial *manyatta* and *lorora* in the case of the Maasai and Samburu, respectively (e.g. Mbae 1990; Spencer 1965) – but these are implied as being exceptional and, again, temporary. These narrow expectations have filtered back into how the archaeology of pastoralism has been undertaken; with the exception of Maasai Plains and perhaps Lanet, I can think of no other archaeological site in eastern Africa with links to specialised pastoralism that has been excavated with the anticipation that it represents anything other than a single or palimpsest of single homestead-type occupations. Even these two exceptions may only have been singled out due to the large and clearly-visible mounds that distinguish them from the usual vague surface scatters of material culture.

Why there should be such myopia when it comes to the potential scale and function of pastoralist settlements is unclear, but it is surely in part a relic of long-held notions of nomadic simplicity and minimalism (e.g. Childe 1936). It may also be a function of the post-colonial marginalisation of herder communities, wherein these groups have been forced into resource-poor, peripheral environments where large populations cannot be supported (e.g. Homewood 1995; Brockington 1999). By this measure, the kinds of settlements documented by twentieth century ethnographers, in accounts that have influenced the way these sites are conceived of and approached by archaeologists, may be significantly different in form and function from the places people lived during more amenable periods in the past. Certainly my observations and speculations about Maili Sita being emblematic of a cultural or pan-cultural phenomenon wherein large and ethnically diverse populations were drawn together prior to social disintegration in the face of, firstly, environmental degradation (Anderson 2016) and, secondly, colonial land-appropriation and power-broking (e.g. Waller 2004; Hughes 2005), support a picture of pre-nineteenth century communication and congregation.

The approach I have used at Maili Sita may, I hope, be of some use in redressing this balance. The auger survey provided a relatively fast, straightforward and inexpensive way of defining the extent and composition of the occupation deposits across the col, and facilitated much broader coverage than would be realistic within an economically-comparable programme of test pitting, let alone open-area excavation. However, it is only when considered alongside the satellite imagery that the most important insights were gained, and the full extent of the anthropogenic deposits – in this case, dung, ash and other typically-pastoralist refuse – observed. These two approaches are, I would argue, inseparable in this kind of application: without the satellite imagery, the soil analysis points only to there being three areas of intense human activity with no discernible link between them besides similarity of composition; without the soil data, the imagery cannot define the anomalies visible therein (i.e. the 'ring'), or even distinguish between those of anthropogenic and natural origin. It must be conceded here that the widespread availability of high-resolution satellite imagery is a relatively recent development – Google Earth, for instance, was only released in 2005 – and earlier investigations clearly cannot, therefore, have had such easy access to the required level of spatial information. With the addition of faunal isotope data, albeit ideally with a richer corpus of data than that available at Maili Sita, it becomes possible to comment further on the kinds of herding strategies behind these physical manifestations, as well as the climatic and environmental contexts in which these strategies were enacted.

9.2 The ecology of Maili Sita

Ecologists and their studies fare little better than archaeology in considering the full range of ways that pastoralists have and continue to settle and exploit the savannah landscape. In my discussion of the ecological impacts of pastoralist settlements in chapter three, none of the studies cited considered anything more than the effects of single or clusters of enclosures, beyond perhaps implied differences in the seed content of dung in cattle and smallstock corrals (e.g. Reid & Ellis 1995). That is not to say that this narrow scope has gone wholly unacknowledged: Riginos et al. (2012:3), in their summary of the findings of the Kenya Long-term Exclosure Experiment (KLEE) at Mpala Research Centre, one of the main contributing studies to this field, explicitly recognise that pastoralism is not a single, static system but that the resources and strategies called upon by herders vary according to particular bio-physical, cultural and socio-economic conditions. Rather, there is an acceptance that these studies apply only to a specific and modern form of animal husbandry, wherein single species are kept within small isolated corrals, next to a single metal cabin for herders to sleep in, and the emphasis is placed on highlighting 'possible impacts'.

Unfortunately, such heavily-idealised models generate results that are arguably of limited use when it comes to trying to interpret ecological legacies at archaeological sites. It is all very well being able to point to glades containing material culture and infer the presence of an abandoned settlement, but such an approach says very little about the nature of that settlement or the particular ecological processes its inhabitants initiated and experienced. Arguably more problematic from an archaeological perspective, the strength and persistence of the scholarly association of glades with cattle corrals to the exclusion of other species (e.g. camels, smallstock, donkeys) may lead to erroneous assumptions that cattle are the principal factor behind the formation and endurance of all glades. In contrast, Causey (2008:358), with reference to Maasai Plains, speculates that the preservation of the grazing lawn environment might be due to the siting of smallstock pens around the perimeter of the settlement. He suggests that the accumulation of dung without the more intense trampling effects of heavy cattle might encourage an outer ring of prime grazing that, heavily used by wild animals, serves to protect grasses atop less stable, trampled soils within centrally-located cattle enclosures from tree and shrub encroachment. No other data (e.g. zooarchaeological analysis) is available to support or repudiate this hypothesis, however. Equally, there may be an issue over the focus on enclosures as the principal eco-dynamic components of herder settlements; refuse dumps might be expected to exert a similar influence on soil nutrient compositions, for example, and the number of houses/inhabitants and the length of the occupation would surely effect the amount of woody vegetation that is cleared for firewood.

Work at Maili Sita has been unable to differentiate individual activity areas and therefore comment on the specific ecological legacies of each element of a pastoralist settlement. Indeed, my opinion that the circular grass patches are relics of termite activity of other biological interference rather than markers of former boma locations could be seen as forcing a step backwards from this target. I would argue, though, that this project's greatest value as a contribution to savannah ecology (as an academic pursuit) is similar to its contribution to the archaeology of pastoralism: the recognition these sites can be much larger than and function differently to their modern counterparts. Just as many archaeological understandings of pastoralism are seemingly based on the notion that herder settlements are small, temporary and ephemeral, ecologists' models of savannah patch dynamics – the idea that ecosystem function is maintained through the dynamic relationship between heterogeneous components or areas created by disturbance, natural or otherwise (White & Pickett 1985) – are based on the assumption that herder settlements and the anthropogenic glades they create fall within certain size limits. Based on modern ethnography, these are unlikely to exceed 100 metres or so in diameter. Maili Sita, Maasai Plains and the other Laikipia sites discussed in this dissertation are considerably larger, and may therefore function very differently as ecological patches. It seems possible, for example, that such wide open spaces may be less desirable for grazing animals, with central areas being very exposed and offering little shelter from predators. While the dung survey undertaken at Maili Sita did not indicate any preference towards the edges of the site, other studies (e.g. Young et al. 1995) suggest that grazing intensity varies between glade edges and centres depending on species. Again, however, these investigations have only considered glades created by single cattle corrals of a purportedly 'standard' size; further work might usefully consider both size, number and distribution of enclosures, and the species' being corralled as important variables.

In some ways, however, Maili Sita does correspond well to the expectations raised by the ecologists. For instance, the presence of a broad grazing lawn comprised mainly of *Cynodon* spp. compares with the succession patterns observed under controlled conditions at Mpala Research Centre, where these species were seen to dominate boma sites within a few years of abandonment (Muchiru:2009cb; Veblen 2012). While there is slight variation in that these studies have *C. plechtostachyus* density reducing after several decades in favour of *Pennisetum stramineum* and other grasses prior to eventual recolonization by woody species, the observed pattern of *P. stramineum* being most prevalent around the glade edge is replicated at Maili Sita. Interestingly, Riginos et al. (2009) suggest that this concentration of *P. stramineum* around the perimeter of bomas might be linked to the nitrogen-fixing and fertilising effects of trees like *Acacia drepanolobium*, the dominant species around Maili Sita and across the northern Lolldaiga Hills, bolstered by enrichment through dung from grazing herbivores using glade-edge trees for shade. Termite activity is widely shown to have a similar or even more pronounced effect on soil nitrogen fixation (e.g. Fox-Dobbs et al. 2010; Okullo & Moe 2011; Rajeev & Sanjeev 2012), which, I would argue, further supports my association of the *P. stramineum* patches across the archaeological site with former termite mounds.

It has also been noted that termite densities are often significantly higher within glades than without, perhaps attracted by the heightened levels of organic matter and nutrients in dung, or even the scattering of bark and decomposing *Acacia* wood used in settlement fencing (Veblen 2008; K. Fox-Dobbs pers. comm. in Veblen 2008:33). This notion of termites as a commensal species at pastoralist settlements (see also Weissbrod 2013), and their proven role as 'ecosystem engineers' (Dangerfield et al. 1998), exemplifies how the occupation of Maili Sita may have affected ecological functioning across various scales: termites have added to soil nutrient levels already enriched by livestock dung and other occupation refuse; particular grass species (i.e. *P. stramineum*) colonise inactive mounds whereupon grazing herbivores are attracted; woody species succession is suppressed by grazing within the glade, though is perhaps most effective in preventing *Acacia* colonisation of those nitrogen-rich mounds most suited to tree recruitment; and finally, the concentration of termites and grazers within glades perpetuates these features as isolated patches. Thus, the overall productivity, spatial heterogeneity and beta-diversity of the savannah is improved.

9.3 Glades as resources

In improving productivity and biodiversity, glades have become valuable economic, as well as ecological, resources. I have mentioned previously how besides wild grazers being attracted to the rich pastures that glades offer, herders themselves have identified the link between certain preferred species and abandoned settlements; *Cynodon plechtostachyus,* as an example, is known to the Maasai as '*manyatta* grass' (Muchiru et al. 2009). It seems logical, therefore, to speculate that glade sites, as well as playing an ecological role with consequent but implicit economic benefits, might become imbued with acknowledged economic value as important and desirable grazing resources. Indeed, the value ascribed to these sites may be particularly acute given how practices of dispersed grazing and concentrated corralling have been seen to denude the wider savannah of soil nutrients, while glades become enriched (Augustine 2003). This idea bears comparison with the notion of 'landesque capital' raised in my discussion of *terras pretas* in Amazonia (chapter three), whereby occupation residues improved soil productivity, creating Dark Earth sites thought to be key to the domestication of staple crops and the support of large pre-Columbian populations (e.g. Heckenberger 2003; Arroyo-Kalin 2010; Fraser et al. 2011). While the concept of 'landesque capital' has usually been associated with deliberate landscape modifications that improve productivity such as agricultural terrace construction or investment in fertilisers (e.g. Leach 1999; various references in Håkansson & Widgren 2014), the arguments for its relevance to Dark Earths may also be applicable to glades. These are hinged partly on whether landscape modification that occurs incrementally and even unconsciously can be compared with that which occurs 'systematically' and deliberately (*sensu* Doolittle 1984). Although there is no record of herder settlements being initially founded with a conscious view towards improving local soil productivity, as has also proven difficult to recognise in Amazonia (Arroyo-Kalin 2016; see also Stump 2016 on the identification of 'indigenous knowledge' in the archaeological record), improvement appears to be recognised and value imbued post-hoc (e.g. Western & Dunne 1979; Muchiru et al 2009). I would suggest that it is the recognition of value and cause that distinguishes glades and Dark Earths from other forms of niche construction or anthropogenic landscape transformation (Laland & O'Brien 2010), where human activity effects enduring changes to the environment, altering the conditions experienced by subsequent generations.

This conceptualisation of glade sites as economic resources has potential implications for how pastoralist systems of power and social control might be constructed. Much has been written about gerontocracy in Maasai society, wherein the elder men maintain control of the main settlement and surrounding lands by sending the younger men, the *il-moran* warriors, to graze their herds in the peripheries of that community's sphere, while the young women remain behind (Spencer 1976; 1993; Hodgson 2000). This may be reflective of forms of ownership and control of production that while on the surface appear to be based on patriarchal control of women and livestock, may also be related to control of land, land with a capital value and which can only be acquired through that rigid system of age and gender-based hierarchy. Pastoralist access to land, as a subject, is often framed in terms of herders being excluded by sedentary 'owners', and notions of land ownership are almost seen as anathema to ideals of mobility, to the extent that pastoralist economics are generally discussed in terms of livestock. However, an interesting point might be raised here with regard to conceptualisations of boundaries; Cormack (2016) describes how colonial impositions of linear administrative divisions in land occupied by Dinka pastoralists in South Sudan are problematic in light of these communities' own concepts of territory and borders. In Cormack's model, and contra to the popular view of pastoralists as untethered wanderers (e.g. Schlee 2010), Dinka borders are conceived as 'galaxies', based on the control of individual, isolated points such as settlements, landmarks and key resources like wells, rather than fixed linear divisions. The notion of point-centred geography is not unique to the Dinka; a similar scenario is described by Turner (1999:108) for Fulani pastoralists in West Africa, in which access to pasture is 'governed by grazing radii around tenured points'. One might reasonably expect glades to function as such points by conceiving these landscape features partly as nodes around which mobility strategies are constructed, but also as places of implicit and explicit economic value that are integrated into pastoralist notions of territoriality.

As further implication of glades as 'tenured points', these features may be integral to the kinds of ethnic fluidity described in my initial discussion chapter. In contrast to linear borders, point-based territorial geographies allow for overlap and intermixing, with points or resources valued by one group either being distinct from those valued by another, or able to be shared through systems of usufruct, such as that documented by Barrow (1990). Notably, Barrow's study looked at access rights surrounding *Acacia tortilis* groves as sources of dry season fodder for Turkana pastoralists, *A. tortilis* being one of the most prominent recolonising species of abandoned settlements, due to its high seed-content in goat dung (Reid & Ellis 1995). For the Rendille and Samburu, for instance, the capacity to share territory may have facilitated the intensity of interaction that encouraged the formation of the Ariaal 'bridge culture' (Fratkin 1991). Whether or not this applies to Maili Sita cannot be presumed based on the available data, but it seems possible that the glade environments formed in the wake of settlement there or at other, similar sites in the region, were valued and used by disparate groups that became steadily and more closely linked.

9.4 Pastoralist Futures

Staying with this notion of the value of glades, as a final point of discussion I want to think about the implications of the themes and findings of this study with respect to the ongoing position of pastoralism in eastern Africa. A full discussion of the politics of land-use and conservation in the region is beyond the scope of this dissertation, yet it would be disingenuous to ignore the links between the subject of pastoralist ecologies and the current plight of herders in the region.

As tourism-led conservation and rampant urbanisation dominate regional land politics, the pattern of pastoralist marginalisation that began with the arrival of the British (see Hughes 2006) has continued, with herders being denied access to historic rangelands (e.g. Brockington 1999; 2002; Homewood et al. 2009). This has had severe consequences not only for the herders themselves – though the decline in the livestock economy has been considerable (Msoffe et al. 2011) – but also for the ecosystems they are forced out of. To return to that recurrent point made throughout this dissertation, regarding the ecological contribution made by herders through cycles of nutrient redistribution and the suppression of particular vegetation, the exclusion of pastoralists and the obstruction of these processes has tangibly impacted other elements of these environments, such as land productivity and wildlife density (e.g. Homewood 1995; Bhola et al. 2012); indeed, the very elements that many state-supported conservation efforts have prioritised have, in some instances, been adversely affected by a lack of foresight in the planning process (see also Ellis & Swift 1988). This widespread misunderstanding of the role played by herders is doubtless partially a reflection of the power of the overgrazing narrative (see Homewood & Rodgers 1987), and as such demonstrates the ongoing need for alternative perspectives to be given a platform. Much discussion has been afforded to the contribution archaeological and historical data might make towards developed understandings of landscape ecology and so-called 'sustainability', and the issues raised in the integration of diverse data (e.g. Stump 2010; Marchant & Lane 2014; Lane 2015; Stump 2013b; see also Dearing et al. 2010). In the case of this dissertation (see also Causey 2008), however, recognition of the complex ecological impacts of pastoralism and the timescales over which they operate – seasonal or short-term practices having legacies effects over centuries or longer – may be sufficient demonstration of this potential to warrant continued effort.

Besides ecological consequences, the division and reduction of pastoral rangelands and the diminution of the livestock economy is changing the nature of pastoralist identity. As this dissertation aims to have shown, herders' conceptualisations of ethnicity and kinship have, throughout their history in eastern Africa, been shaped by how they move through the landscape, encountering and communicating with distinct communities in order to negotiate a range of spatially- and temporally-variable ecologies. As land access becomes more restricted and its ownership more empowering, former specialist stock-keepers are turning to other economic strategies, and this turn towards sedentism is far-reaching in its effects on pastoralists' livelihoods, culture and health (see various references in Fratkin & Roth 2005). In keeping with previous chapters by taking the Maasai as an example, various studies highlight a trend towards cultivation, a decision that more often than being driven by economic necessity, appears to be a reflection of changing social norms (McCabe et al. 2010), norms that perpetuate the marginalisation of pastoralism. As the influence of elder community members whose personal identities are perhaps more invested in livestock and the specialist-ethos begins to retire, younger Maasai are more open to the prospect of using cattle to, for instance, pull a plough (O'Malley 2000).

9.5 Summary

Maili Sita and the other sites discussed in this dissertation demonstrate the historical time-depth behind the processes through which pastoralists have engaged and interacted with the savannah landscape, processes that have had lasting effects on these communities' cultural-evolutionary trajectories and the long-term ecological development of eastern African environments. This study has shown how occupation has effected lasting changes to soil composition and vegetation patterns at Maili Sita, changes that can be observed so as to reconstruct - in broad terms - the layout of the site. Further, through these impacts human activity appears to have influenced wildlife ecologies at a range of scales and trophic levels, from microfauna (e.g. termites) to grazing mammals. The other sites identified in my regional survey (chapter seven) indicate the geographical breadth of this influence, as well as bolstering my contention that ecological data can offer a useful proxy for archaeology. The edges of the Laikipia and Leroghi Plateaux, where these sites are most densely clustered, offer access both to pasture and to neighbouring communities occupying different environments and engaged in dissimilar subsistence regimes, thus fostering communication and exchange relationships. Histories of contact and assimilation between these groups under variable climatic, environmental and socio-political circumstances are reflected in the marks left on the landscape, with the scale of Maili Sita and others being both a cause and effect of how their inhabitants' experience these conditions.

However, just as the social and economic dimensions of pastoralist histories are known to be fluid and dynamic, we cannot assume that the ecological trajectories we are beginning to understand for short time periods – the twenty-year duration of the KLEE project, for instance (Riginos et al. 2012) – are relevant over century-scales, or longer. While Maili Sita certainly shares some features with more recently-formed glades, the potential long-term ecological influence of termites, for example, and the role of nutrient-enriched mounds within glades, is something that short-term studies have only hinted at (e.g. Veblen 2008). The capacity of pastoralists to transform savannah environments is now recognised, yet we are still working towards an understanding of the extent of those transformations. Moreover, as is clear from the responses of contemporary pastoral communities to externally-imposed changes to the environments they are able to inhabit, ecology exerts a similarly powerful influence on them.

10

Conclusions

Figure 10.1. Recently used corral locations in Lolldaiga Hill Ranch; after several new grass is beginning to come through; Maili Sita is visible along the far ridge, up and right of the Landrover

This dissertation has tried to develop an approach to the archaeology of pastoralist settlement that is explicitly constructed around two fundamental drivers of herders' daily experiences: mobility and ecology. In doing so, the definitions of both these terms have been somewhat broadened with respect to their general usage. 'Mobility' has been explored as both a literal process of movement, with herders moving around the savannah in response to combinations of environmental, political and cultural factors, but also as a social process whereby community and individual identities are both fluid and malleable. 'Ecology' is broadened along similar lines; climate and resource availability provide a broad structure within which pastoralist lifeways are enacted, but that those lifeways, moreover, institute long-term processes of ecological change. The human-environment interface is therefore interactive and – insomuch as much as it is mediated by political and cultural dimensions – reflexive: an understanding of one impossible without reference to the other.

10.1 Mobility and Ecology in Laikipia

My opening chapter introduced the central themes of this dissertation and posed four key research questions. These questions varied in their spatial and temporal focus, from specific concern with past human practices at Maili Sita to consideration of broader implications. I asked how mobility and herd management was structured at Maili Sita, sought to understand the direct and indirect residues and impacts of occupation, and questioned how the interface between these two lines of enquiry might facilitate a clearer understanding of who the inhabitants of Maili Sita were, how they lived, and how their actions have affected the social and physical environment of the Laikipia Plateau.

As made clear in chapter four, my investigations at Maili Sita have been predicated on extensive research undertaken under the auspices of various projects seeking to understand how eastern African landscapes have changed in response to past human interventions and environmental processes like climate change. These studies explored the historical ecology of the region, describing how environmental and social change is instigated by a variety of interwoven factors across a range of scales: the political upheaval of the late nineteenth and early twentieth century, when British colonialism brought news forms of social and geographical control, transformed land-use patterns across eastern Africa; equally, longer-term processes of economic development, such as the emergence of specialised pastoralism, have been linked with environmental change associated with the variable climate of the mid- to late-Holocene. As regards Maili Sita itself, however, these earlier undertakings were somewhat superficial in the conclusions they were able to draw, with no small degree of equifinality behind the observations that were made. For example, Payton's assertions that human activity was concentrated in the north and south portions of the col, based on anthropogenic soil-nutrient elevations, might be explained either by distinct seasonal (or otherwise separate) occupation, multiple contemporaneous settlements, or a pattern of intermittent, localised shifting of stock enclosures. Furthermore, issues with the resolution of absolute dates precluded the assembly of a robust temporal framework in which to position the archaeological record, and not even extensive excavation could provide strong spatial context. The work did, however, highlight the intensity with which the site and its environs were occupied and, in some instances (e.g. Iles and Martinon-Torres 2009; Iles and Lane 2015), suggest the kinds of complex social dynamics that my own findings would later support.

My first line of enquiry towards constructing a more comprehensive picture of the occupation at Maili Sita, drew on isotope analysis of tooth enamel obtained from the faunal assemblage excavated in 2004, as described in chapter five. Temporal variations in oxygen, carbon and strontium isotopes within enamel were assessed by sequential sampling along the tooth crown. Essentially, these isotopic signatures relate explicitly to factors such as climate, diet and underlying geology, respectively, and can therefore be used in concert to model herd management practices such as mobility patterns – as herds move between geological and ecological zones – and the climatic conditions – wet or dry season, for instance – under which these were constructed. By considering data drawn from the available archaeological samples against modern comparators drawn from local modern herds – the neighbouring Maasai community and Lolldaiga Hills Ranch stock – and with respect to hypothesised expectations for the various settlement practices that may have been instituted at Maili Sita, I was able to offer a refined, if provisional, assessment of how the site operated. Perhaps surprisingly, the isotope data depicted livestock management patterns more closely resembling those employed by the modern ranch than those of the modern Maasai. Herd mobility seems to have been restricted to the Lolldaiga Hills and the surrounding area rather than long-distance nomadism or seasonally structured transhumance. Such a pattern would be commensurate with a semi-permanent settlement, with little intra-annual exploitation of grazing resources further afield. Indeed, this seems reasonable given the relatively high rainfall and productive pasture available in the Lolldaiga Hills compared to much of the surrounding plateau.

Having established a picture of how the occupants of Maili Sita engaged with the wider landscape, I then turned to the site itself and questioned how human presence has affected long-term ecological processes, such as might cause visible alteration to the physical environment. One objective here was to examine whether ecological data relating to soils and vegetation could substitute for the scant archaeological remains recovered during earlier excavations and better elucidate the spatial organisation of the site. My approach was also designed to explore how pastoralist settlements might be implicated in the ecological functioning of savannah environments over longer time scales than those typically considered by ecologists. Using micromorphological and geochemical analysis of samples retrieved from across the Maili Sita col, I showed how occupation deposits comprised of degraded dung, ash and other refuse, were indeed concentrated in the northern and southern parts of the site, but also to the west. By viewing this data in relation to satellite imagery, I concluded that settlement at Maili Sita took the form of a broadly-circular ring that, at around 500 metres in diameter, encompassed the entire col. Towards the centre of this ring, no residues of human activity were identified, beyond sparse surface scatters of material culture.

Such an arrangement promotes comparison of Maili Sita with Maasai Plains, a site some 50 kilometres away in the northeast of Laikipia that was also investigated during the earlier programme of research. Though dating slightly earlier, Maasai Plains takes the form of concentric rings of dung and refuse deposits, and has yielded very similar material assemblages. Furthermore, using Google Earth imagery I identified numerous other sites in the region that share a comparable form; one of these, Makurian Fence, was located very close to Maili Sita and again yielded near-identical material culture, such as Kisima ceramics. I concluded that during the last millennium, Laikipia may have hosted a population of pastoralists with shared economic and cultural traits, but which was no longer recognisable as such by the time early-European records became available in the mid-nineteenth century: these were iron-using herders engaged in broad networks of trade and exchange with other stock-keepers, hunters, farmers, smiths and potters; most notably, these groups congregated in very large settlements, far exceeding those associated with the region today.

By comparing the form of Maili Sita and the other 'ring sites', and through a review of paleoenvironmental, historical and linguistic reconstructions, I speculated that this phenomenon may have been a manifestation of novel identities and social networks formed along the frontier between ethnically and culturally diverse populations; as Maa speakers expanded out of the Rift Valley, they met and associated with Cushitic groups originating in Ethiopia and Somalia, as well as autochthonous hunter-gatherers and, potentially, emergent Bantu farmers. That is not to say that these groups need be so sharply-defined; centuries of contact promoted cultural and demographic osmosis as people moved into new environments and experienced variable climatic and socio-political conditions. This was subsequently disrupted by the catastrophic droughts around the turn of the nineteenth century. Communities disbanded and resource competition encouraged economic specialisation and territorialism, with such differentiation laying the foundations for the tribalism and conflict documented by those first colonial ethnographers.

While I was unable to identify specific elements of the Maili Sita settlement, such as gateways and house floors, elements that would be vital for establishing how the site itself was organised and any associated socio-cultural significance, that the evidence points to occupation on such a large scale has considerable implications for how both ecologists and archaeologists think about pastoralists and their settlements. Both parties have been guilty of basing their views of how pastoralists live upon fairly narrow ethnographic analogies; Maili Sita and its ilk stand in clear contradiction to the notion of the parochial pastoralist homestead. Though ephemeral in terms of their structural remains, or lack thereof, these sites have left demonstrable and enduring marks on the landscape of central Kenya, the nature of which are specific to the practices of the inhabitants. It is widely accepted that the ecological histories of eastern African savannahs have developed with herders and their livestock as active participants, but in order to understand the present state and future prospects for these environments, we require a greater appreciation of the underlying social-historical variability behind their formation. In the closing paragraphs of the previous chapter, I argued that there is an inherent value to the effects of human presence in savannah ecosystems, both in terms of economics – i.e. the concentration of grazing resources in glades and the possibility that this has helped shape pastoralist institutions of land tenure – and in promoting biodiversity through landscape heterogeneity; thus, the obstruction and reduction of pastoral rangelands has far-reaching impacts.

10.2 Methodological Reflections

As has been described at length, the research design of this project sought to build on a fairly extensive corpus of earlier work both on the historical ecology of eastern African pastoralism and the prospects for using geoarchaeological data to provide spatial context at ephemeral sites. One of the difficulties I have faced, however, is how to balance the two. The method proposed by Shahack-Gross et al. (2003; 2004) would clearly benefit from explicit and rigorous testing in an array of archaeological circumstances, in order to properly explore the endurance of the proposed indicators across a range of depositional and post-depositional contexts. While my interest in this topic was piqued by the prospect of conducting such work, it became clear relatively quickly that Maili Sita would not be such an ideal case study. As must be a common problem with large-scope projects with numerous contributors, much of the existing data from Maili Sita, which would have been crucial for the augmentation of a high-resolution geoarchaeological survey, was difficult to coordinate. Many of the intended analyses remain unfinished or the data otherwise unavailable, and that which I was able to access is frequently inconsistent. For example, the Geographical Information Systems (GIS) generated by the 2004 and 2010 teams used different surveying equipment and software and much of the data was archived independently, with the result that unit locations and topographic information could not be cross-referenced. In addition, a number of the original contributors could not be contacted for assistance. This was a recurring issue, as will be discussed below.

Furthermore, it quickly became clear, particularly in light of the satellite imagery showing the 'ring', that Maili Sita did not fit the profile of the Maasai-esque homestead that was expected given its purported links with the Laikipiak. The scale of the site is such that it would have been beyond my means to undertake a geoarchaeological survey at sufficient resolution to examine spatial organisation in its entirety; I felt that it would be better aligned to the aims of the original investigators and my own developing research interests to gain a coarse but holistic perspective of the site than to dedicate my research to a targeted but potentially unfruitful examination of one part of it. This would also be more achievable given the lack of basic knowledge regarding where activity areas might likely be concentrated, not to mention the vagaries of the geoarchaeological method, it being unknown whether indicators would have survived at all. I believe that this decision has been vindicated by the results obtained, and I was still able to evaluate some aspects of Shahack-Gross' method, such as the potential identification of dung through soil thin section analysis. This had multiple benefits, as not only was I able to verify the presence of faecal spherulites and charcoal in the occupation deposits, and thus link them directly to corrals, but I could comment on the nature of soil bioturbation at the site and its implications for the endurance of microlaminations and other stratigraphic indicators.

Equally, I must concede that my approach was not perfectly designed to assess the ecology of the Maili Sita col. This might be attributed in part to my lack of prior training as an ecologist – indeed, both geoarchaeology and isotope analysis were new to me when I took on the project – but as with the obstacles Maili Sita poses to archaeological investigations, the scale of the site makes comprehensive understanding of its ecodynamics an optimistic proposition. I chose to focus on three elements in the ecosystem: soils, vegetation and wildlife. The latter was incidental and opportunistic, and only undertaken because my research assistant in the field, Julius Mwenda, enjoyed pointing out which species had produced the nearby dung as we were taking soil samples, he being more usually a wildlife guide. A better understanding of animal species distribution might require a broader sampling grid with multiple observations made over a given period. While I feel the soil and vegetation components were sufficient to address the questions I set out to ask, other questions remain to be asked. It would be interesting to know, for instance, how quickly vegetation degrades during the dry season, and how this affects wildlife densities. In addition, my discussion of the role of termites in the perpetuation of glades and the cycling of soil nutrients emphasised the benefits of a detailed understanding of the relationship between soil fauna and anthropogenic deposits.

The greatest difficulties I have faced concern the paucity of archaeological material available for analysis, and was particularly keenly felt with respect to my interest in enamel isotopes. This was intended to be a much more comprehensive study, involving analysis of a much larger range of samples. The dataset generated from zooarchaeological analysis of the faunal assemblage excavated in 2010 implied that I would have access to much more material, yet after extensive searching of museum store rooms and many attempts to contact the analyst, the assemblage could not be found. Having expended considerable efforts on research and learning the techniques involved, secured funding for the analysis, and integrated the data I expected to gather into my research objectives, I did not want to abandon this component entirely. Again, I hope that this decision has proved to be the correct one, as the data I did manage to obtain highlights its potential. Equally, an expanded isotope study would require various other criteria to be met; while the use of modern comparators as baselines works to some extent – and indeed in highlighting local strontium signatures is arguably superior to other methods, such the sampling of plant tissues – the comparison can really only be binary: local or non-local. In the absence of reliable biologically-available strontium distribution maps for the region, such as Coutu (2012) has begun to develop for eastern Africa more broadly, our capacity to know exactly where and how herders moved through the landscape is limited.

10.3 Prospects

This research is intended to contribute to ongoing discussion around the co-evolution of humans and landscapes, yet this contribution is clearly limited by my focus on a single site. It is clear that in order to understand pastoralist settlements as both ecological and archaeological phenomena, we must accept the near-limitless scope for variation, and, as with the most convincing supportive arguments for ethnoarchaeology, use detailed case studies as a means of explicating and exploring that variability. This point is well-illustrated in the comparison of Maili Sita with Makurian Fence (or, indeed, any of the other 'ring sites' in Laikipia); though the two locations are only a few kilometres apart and, based on similarities in form and surface material culture may have been occupied during a similar period by somehow-related populations, the two are ecologically distinct. Satellite imagery of Makurian Fence, for instance, suggests that the archaeological deposits may have been subject to far less post-depositional disruption, such that effected by termites, than those at Maili Sita. Moreover, that the former so closely resembles modern Rendille settlements is a considerable incentive for further investigation; should discrete depositions be preserved, the site would be an ideal candidate both for an extensive and targeted geoarchaeological survey and also an interesting counterpoint from which to explore why soil fauna are so unevenly distributed across a relatively small, and, in broad terms, environmentally-similar area.

Similarly, the other 'ring sites' could be very usefully explored so as to better define the phenomenon. This would necessarily involve a geoarchaeological component and an appreciation of whether, as I speculate in chapter seven, the rings were formed through the same processes but under different conditions, or whether human practices at Maasai Plains, for example, differed significantly from those at Maili Sita or Makurian Fence. It could also be useful to undertake a detailed interrogation of the material culture at these sites – and I include Maili Sita in this number, given that much of the data remains patchy – beginning, I would suggest, with the ceramics. Kisima ware clearly has a wide distribution and it would be an important first step to define its variability; Lane (2013) has previously noted that the examples from Maasai Plains and Maili Sita represent temporally-distinct variants, and a study encompassing sites across the region might illuminate exchange networks, particularly if it could incorporate a more concerted programme of dating and petrographic analysis. The latter, furthermore, might help to clarify where and by whom Kisima ware was produced, through the tracing of clay sources.

10.4 Final thoughts

Rates of socio-economic change in eastern Africa continue to accelerate as populations grow, particularly in urban areas. The industrialised agriculture and mass tourism to have emerged as the region has embraced globalisation have become the principal concerns of policy-makers as governments trying to feed those growing populations and improve national economies. Climate change is an increasingly prominent issue, and the effects of recent droughts across the Horn of Africa – said to be the worst in sixty years– are testament to the fragility of the region in the face of increasingly severe conditions.

Pastoralists and other mobile groups have been particularly affected by these changes. Reduction of historic rangelands and general economic marginalisation have seen pastoral production fall dramatically, with many of its practitioners moving to the cities or taking up farming. 'Authentic' pastoralists like the Maasai, so beloved by the glossy book publishers, are increasingly anachronistic, their livelihoods frequently based on their tourism-appeal rather than the actual income-generation afforded by specialised stock-keeping. That is not to say that these changes are necessarily for the worse; the aforementioned famine in Somalia, for instance, would likely have been far more devastating sixty years ago than today, with affected populations better placed to appeal for help from national governments and the international community.

The influence of socio-political and environmental factors in the daily lives of pastoralists is clearly neither recent or static. As I hope to have shown with respect to Maili Sita and pre-colonial Laikipia, and as implied by the earlier literature on the archaeology of the region, experiences are dictated through the ongoing dialogue between society and ecology, and negotiated through mobility and engagement with landscape. This is perhaps the key point I want to make in this dissertation, and one that has particular relevance, I would argue, in the modern world of borders and fences: it is social and physical mobility that allows herders to exist in the eastern African savannah, fulfilling their own needs and shaping their identities while making active and important ecological contributions; contributions that, unfortunately, are only becoming widely acknowledged in their absence.

Glossary

Alluviation	Process of sediment deposition by a body of water, such as by a river on its floodplain
Anthropocene	Proposed current geological epoch, during which human activity has become a driver of earth systems processes like climate
Anthropogenic soils (anthrosols)	Soil altered in their formation and character by the cumulative effects of human activities
Authigenic	Formed in-situ
Bao (mankala)	Game of some antiquity played across eastern Africa, involving moving pieces between lines of holes, often hollowed out of flat rock surfaces
b-fabric	difference between lowest and highest refractive index of a mineral, as visible as interference colours in soil micromass under **XPL** in thin section
Biotone (ecotone)	Transitional area between two distinct biological communities
Bioturbation	Processes of disturbance of soils by living organisms
Boma	KiSwahili word for livestock enclosure, often used erroneously as a general term for a pastoralist homestead
Congo Air Boundary (CAB)	Line along which warm, moist air from the Indian Ocean meets less humid, cooler air from the Atlantic, oriented north-to-south along the western side of the Rift Valley
Catena	Sequence of related soils along a topographic gradient
Cation Exchange Capacity (CEC)	Capacity of soil to hold **exchangeable cations**, linked to nutrient content and productivity
Luvisols	Soil in which clay has been **leached** from upper horizons due to eluviation by water, such as after heavy rain
Clay	Soil particles less than 2μm
Col	Low saddle along a ridge (geology)
Colluviation	Process of sediment deposition at the base of a hillslope
Cross-Polarised Light (XPL)	Light filtered to only vibrate in one direction, used in thin section microscopy

Diagenesis	Chemical, physical or biological change undergone after initial formation, can apply to sediments and bone
Edge effects	Ecological processes initiated at the boundary between two habitats
Eluviation	The transport of soil material from upper to lower horizons, occurs when water exceeds evaporation
Enamel Root Junction (ERJ)	The point where enamel meets cementum at the base of a tooth, also known as cervix
Enkang (Nkang)	Maasai (Samburu) homestead, made up of single household or multiple kinship-linked households
Erosion gully	Cut in the land surface caused by the channelling of water run-off
Eunoto	Maasai age-set graduation ceremony marking the transition of young **moran** warriors to seniority
Exchangeable Cations	Positively charged ions capable of transferring to negatively charged soil particle, enhancing soil nutrient content
Forr	Outlying camel herding camps around main Rendille **goob** settlement
Fractionation	Processes that affect the relative abundances of isotopes, such as evaporation (known as Raleigh Fractionation)
Glade	Clearing in savannah, generally lacking woody vegetation, formed on the sites of abandoned pastoralist settlements
Goob	Main Rendille settlement-type
Hypsodont	Teeth with high crowns and short roots
Illuviation	Deposition of soil material in lower from upper levels, removed through **eluviation**.
Isotope	Atoms of an element with the normal number of protons and electrons, but a different number of neutrons
Inter-Tropical Convergence Zone (ITCZ)	Atmospheric zone oscillating north-to-south over the equator, convergence of north and south trade winds, typically producing low atmospheric pressure, linked to rainfall regimes in eastern Africa

Kopje (inselberg)	Small, isolated hill in a flat landscape
Landesque capital	Investment of labour or resources in improving land productivity, with benefits that endure over generational scales, generally applied to agricultural terracing, for example
Landscape	Visible features of an area of land, including natural and man-made features, as perceived by human individuals and communities
Leaching	Transport of soil particles in solution between soil horizons
Legacy effects	Processes or landscape characteristics initiated by ecological events, including anthropogenic inputs and interventions
Lorora	Samburu ceremonial settlement, associated with age set graduations (similar to Maasai **manyatta**)
Magnetic susceptibility	Degree of magnetization of a material in response to an applied magnetic field
Manyatta	Maasai ceremonial settlement associated with age-set graduations (**Eunoto**), often applied erroneously to **enkang** or **boma**
Massive	Homogeneous soil structure lacking in internal differentiation and porosity
Microlaminations	Stratigraphic layers visible in micromorphological thin section
Microstructure	Soil composition in terms of particles, pores and aggregates, and their inter-relationships
Miocene	Geological epoch of the Tertiary, between the Oligocene and the Pliocene, c.23-5 million years ago
Minimum Number of Individuals (MNI)	Minimum possible number of individual animals represented within a zooarchaeological assemblage, based on elements represented
Moran (murran)	Maasai (Samburu) young male warriors, based on age set cycle
Number of Identified Specimens (NISP)	Total number of specimens identified within a zooarchaeological assemblage
Occlusal	Biting surface of a tooth
Ol-pul (il-puli)	Maasai meat-feasting site, located beyond perimeter of the **enkang** or **manyatta**

Ololopoli — Area around Maasai **enkang** reserved for young and pregnant livestock

Organic carbon — Soil carbon derived from organic material

Patch dynamics — Conceptualisation of ecosystems as comprised of interacting, heterogeneous zones, or sub-systems

Ped — Unit of soil structure formed by natural processes, visible as defined block of varying form in thin section

Precambrian — Geological super-eon encompassing the first four billion years of the earth's existence

Plane-Polarised Light (PPL) — light polarised to vibrate along a single plane, used in thin section microscopy

Sand — Particles between 60µm and 2000µm

Savannah — Wooded grassland ecosystem or varying tree density with an open canopy

Sediment — Material derived from rock source or chemical process that is deposited elsewhere

Silt — Particles between 2µm and 60µm

Smallstock — Small domesticated animals, generally sheep and goats

Soil fabric — Constituent elements of a soil and their relationships to each other

Spherulites — Carbonate minerals formed in the gut of grazing animals, visible in thin section under cross-polarised light as pale sphere with diagnostic cruciform

Terras Pretas — Dark-coloured and chemically-enhanced soils created at the sites of Precolombian settlements in Amazonia

Tertiary — Geological sub-era of the Cenozoic, beginning 65 million years ago until start of the Quaternary, 1.6 million years ago

Trophic level — Hierarchy of an ecosystem, shared by organisms with similar function in the food chain

Usufruct — The right to make use of a resource, short of alteration or destruction

Vertisols — Soil with high clay content that expands and contracts with water content, forms deep cracks when dry, (e.g. black cotton soils)

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APPENDICES

Transect SN1 Auger Data

XRF

WP	depth	distance	P	S	K	Ca	Ti	Mn	Fe	Zn	Pb
2	1	10	0	0	28789	6921	12084	939	44449	86	9
3	1	20	0	0	23854	8384	6963	1013	37009	79	14
4	1	30	0	0	24282	17939	7033	788	26043	86	18
5	1	40	0	2283	18457	26934	4698	1067	20818	108	9
6	1	50	0	0	16317	22423	5019	1154	21758	117	0
7	1	60	0	0	18537	16405	5266	977	23069	101	14
8	1	70	0	0	16647	28992	5075	1198	22497	112	14
9	1	90	0	0	17138	9808	4673	882	25696	92	11
10	1	110	0	0	22679	5675	6214	710	22755	58	16
11	1	130	0	0	23615	5514	5602	676	22952	42	18
12	1	150	0	0	25967	4712	5422	596	20347	49	18
12A	1	180	0	0	21551	7737	4923	669	23051	54	17
13	1	200	0	0	21839	8807	5786	748	18901	46	10
14	1	220	0	0	22519	7785	5506	649	17035	45	19
16	1	240	0	0	21335	8804	5088	514	15139	50	22
17	1	260	0	0	20310	7370	5217	617	15241	52	18
18	1	270	0	0	21233	7975	5860	716	19413	60	19
19	1	280	0	0	22819	7461	6605	683	20722	59	14
20	1	290	0	0	20687	7413	8709	887	23015	51	20
21	1	310	0	0	20867	8237	7224	759	23521	59	13
22	1	330	0	0	21922	9796	8510	792	23066	65	20
23	1	340	0	0	19260	10918	8438	839	28188	80	10
24	1	360	0	0	19979	17223	10934	1005	36604	101	11
25	1	380	0	0	18868	27430	10615	895	28579	101	11
26	1	400	0	0	16326	24621	6770	1168	35542	139	0
27	1	410	0	1863	17576	21072	9216	1098	34997	128	10
28	1	420	1578	0	14115	44300	5057	1168	25357	142	0
29	1	440	1547	0	15929	41732	5654	1200	26035	121	14
30	1	460	0	0	21782	29194	7602	969	29037	121	8
31	1	470	0	0	24182	23080	15785	998	60801	120	0
32	1	480	0	0	18737	25741	10391	972	41834	128	10
33	1	500	0	0	23005	21336	18811	1059	72261	102	0
34	1	530	0	0	23896	24534	13222	717	56210	95	0
1	2	0	0	0	31790	6085	7922	1029	42067	73	0
2	2	10	0	0	29865	8209	11467	1079	55620	102	0
3	2	20	0	1364	27925	9489	8835	1308	55351	103	0
4	2	30	1238	0	22445	30194	5908	1105	32750	99	0
5	2	40	1955	1122	14983	66779	2812	1056	17654	139	0
6	2	50	1855	1085	16701	60334	3372	1123	19668	132	0
7	2	60	1223	0	16190	29012	4682	1206	23080	133	0
8	2	70	938	0	21275	31473	6354	990	29044	101	0
9	2	90	0	0	22275	13255	6860	1028	35982	109	6.6

10	2	110	0	0	25927	6432	6666	823	33124	75	8.7
11	2	130	0	0	28331	5793	6021	705	27544	57.4	10.2
12	2	150	0	0	27554	4755	4921	512	28749	56.8	8.2
13	2	200	0	0	22507	10183	4548	715	22275	63.8	10.6
14	2	220	0	0	24127	9773	5075	698	21238	54.5	8
16	2	240	706	0	21943	17265	5226	782	21795	73.9	7.8
17	2	260	0	0	23170	7797	4904	652	19996	56	10.7
18	2	270	0	0	23192	10646	5341	756	24321	70.5	8.3
19	2	280	0	0	23252	9374	6070	738	30301	71.2	7.6
20	2	290	459	0	26236	9366	7577	943	31172	79	7.6
21	2	310	0	0	24970	8567	7359	740	28830	66.4	7.5
22	2	330	428	0	20257	13363	6129	809	29990	97	5.8
23	2	340	462	0	23611	15367	9300	1031	42224	121	4.6
24	2	360	566	0	25755	16166	12157	790	50068	107	0
25	2	380	982	0	23059	46074	11190	880	39792	104	5
26	2	400	1278	0	20537	25727	11338	1140	37406	133	0
27	2	410	815	0	18800	23710	7604	1102	33397	133	0
28	2	420	1367	0	19710	47802	8283	1036	30734	115	0
29	2	440	1643	0	21577	73104	9306	869	37907	125	0
30	2	460	1815	1562	18164	76941	3923	996	21902	145	0
31	2	470	712	0	26239	23972	13497	960	64856	143	0
32	2	480	1778	0	25327	65779	12035	940	46265	134	0
33	2	500	0	0	25758	19610	16762	1056	77947	137	0
34	2	530	810	0	29345	27494	17711	877	85244	132	0
1	3	0	0	0	26411	5899	7488	1157	44799	62	12
2	3	10	0	0	25119	7081	8513	1561	55478	80	13
3	3	20	0	0	28303	6340	8073	1295	60464	77	0
4	3	30	0	0	23075	36906	6223	704	35488	66	9
5	3	40	0	0	16699	64085	3646	967	20828	98	11
6	3	50	0	0	15831	62435	3233	920	20072	96	11
7	3	60	0	0	22683	20112	7898	974	28841	84	13
8	3	70	0	0	23367	18418	7344	831	41165	73	15
9	3	90	0	0	23495	10532	8741	882	39269	77	14
10	3	110	0	0	22698	5733	6087	678	24774	48	13
11	3	130	0	0	22823	7066	5066	560	25157	55	13
12	3	150	0	0	24015	4951	6315	520	28053	56	14
12A	3	180	0	0	24887	11147	5700	721	31924	62	14.3
13	3	200									
14	3	220	0	0	22422	7932	5567	496	19262	42	24
16	3	240	0	0	21788	12021	4420	447	16698	39	19
17	3	260	0	0	20625	8499	4618	517	18908	45	15
18	3	270	0	0	21042	9628	6169	588	26495	61	16
19	3	280	0	0	20658	9454	6948	742	34415	73	14
20	3	290	0	0	24029	7648	6822	640	28774	56	14
21	3	310	0	0	23492	7588	7402	664	27828	59	15
22	3	330	0	0	20695	12887	7412	705	26649	67	17
23	3	340	0	0	20917	12812	8123	733	34437	76	11
24	3	360	0	0	23311	12909	12815	805	47603	96	0
25	3	380	0	0	22889	27309	11618	732	39031	81	0
26	3	400	0	0	22183	19582	12873	873	41332	82	0
27	3	410	0	0	17459	29593	9369	984	35534	114	8
28	3	420	933	0	21634	33084	11376	780	44095	93	11
29	3	440	0	0	21421	41291	14642	737	43490	87	10
30	3	460	0	0	19078	94552	4221	848	20198	124	9
31	3	470	1015	2273	19239	37179	7935	968	38967	139	8
32	3	480	1060	2142	20092	44158	8557	1059	36068	124	0
33	3	500	0	0	21775	18045	17715	978	69503	123	0

Loss on ignition

distance	DEPTH	CRUCIBLE WEIGHT	WEIGHT W. SAMPLE	SAMPLE WEIGHT	TOTAL WEIGHT after 550 C	SAMPLE LOSS 550 C	Sample weight after 550 C	% organic carbon	weight before 1000	TOTAL WEIGHT after 1000 C	weight loss after 1000 C	released CO2	% CO2 (in total sample)	total CaO	total CaCO3	% CaCO3
0	1	13.383	21.136	7.753	20.554	0.582	7.171	7.506771572	20.554	20.504	0.05	0.05	0.644911647	0.0635	0.1137	1.466529086
10	1	14.373	22.435	8.062	21.821	0.614	7.448	7.615976185	21.821	21.766	0.055	0.055	0.68221285	0.06985	0.12507	1.551352022
20	1	11.838	16.805	4.967	16.371	0.434	4.533	8.737668613	16.371	16.307	0.064	0.064	1.288504127	0.08128	0.145536	2.930058385
30	1	14.36	21.223	6.863	20.705	0.518	6.345	7.547719656	20.705	20.654	0.051	0.051	0.743115256	0.06477	0.115974	1.689844092
40	1	12.475	18.346	5.871	17.665	0.681	5.19	11.59938682	17.665	17.595	0.07	0.07	1.192301141	0.0889	0.15918	2.711292795
50	1	5.993	8.367	2.374	8.057	0.31	2.064	13.05812974	8.057	8.013	0.044	0.044	1.853411963	0.05588	0.100056	4.214658804
60	1	9.527	14.735	5.208	14.18	0.555	4.653	10.65668203	14.18	14.128	0.052	0.052	0.998463902	0.06604	0.118248	2.270506912
70	1	9.749	16.554	6.805	15.811	0.743	6.062	10.91844232	15.811	15.732	0.079	0.079	1.160911095	0.10033	0.179646	2.63991183
90	1	8.992	14.109	5.117	13.662	0.447	4.67	8.735587258	13.662	13.595	0.067	0.067	1.309360954	0.08509	0.152358	2.977486809
110	1	11.329	17.841	6.512	17.535	0.306	6.206	4.699017199	17.535	17.477	0.058	0.058	0.890663391	0.07366	0.131892	2.02536855
130	1	5.953	10.032	4.079	9.858	0.174	3.905	4.26575141	9.858	9.825	0.033	0.033	0.809021819	0.04191	0.075042	1.839715617
150	1	14.375	23.76	9.385	23.377	0.383	9.002	4.080980288	23.377	23.34	0.037	0.037	0.394246137	0.04699	0.084138	0.896515717
180	1	14.443	22.731	8.288	22.247	0.484	7.804	5.83976834	22.247	22.206	0.041	0.041	0.49469112	0.05207	0.093234	1.124927606
200	1	4.663	9.633	4.97	9.409	0.224	4.746	4.507042254	9.409	9.357	0.052	0.052	1.046277666	0.06604	0.118248	2.379235412
220	1	13.463	18.289	4.826	18.104	0.185	4.641	3.833402404	18.104	18.063	0.041	0.041	0.849564857	0.05207	0.093234	1.931910485
240	1	9.486	15.801	6.315	15.5	0.301	6.014	4.766429137	15.5	15.453	0.047	0.047	0.744259699	0.05969	0.106878	1.692446556
260	1	14.078	22.516	8.438	22.051	0.465	7.973	5.510784546	22.051	22.016	0.035	0.035	0.414790235	0.04445	0.07959	0.943232994

270	1	11.343	18.677	7.334	18.242	0.435	6.899	5.931278975	18.242	18.206	0.036	0.036	0.490864467	0.04572	0.081864	1.116225798
280	1	10.235	19.359	9.124	18.789	0.57	8.554	6.247259974	18.789	18.748	0.041	0.041	0.449364314	0.05207	0.093234	1.02185445
290	1	9.508	18.687	9.179	18.189	0.498	8.681	5.425427606	18.189	18.148	0.041	0.041	0.446671751	0.05207	0.093234	1.015731561
310	1	12.461	23.128	10.667	22.439	0.689	9.978	6.459173151	20.524	20.469	0.055	0.055	0.515608887	0.06985	0.12507	1.17249461
330	1	14.359	25.478	11.119	24.878	0.6	10.519	5.39616872	22.87	22.814	0.056	0.056	0.503642414	0.07112	0.127344	1.145282849
340	1	11.329	22.127	10.798	21.388	0.739	10.059	6.843859974	19.45	19.383	0.067	0.067	0.620485275	0.08509	0.152358	1.410983515
360	1	13.381	25.414	12.033	24.615	0.799	11.234	6.640073132	22.441	22.358	0.083	0.083	0.6897698	0.10541	0.188742	1.568536525
380	1	10.235	20.985	10.75	20.274	0.711	10.039	6.613953488	18.26	18.193	0.067	0.067	0.623255814	0.08509	0.152358	1.417283721
400	1	9.747	18.258	8.511	17.185	1.073	7.438	12.60721419	15.699	15.629	0.07	0.07	0.822465045	0.0889	0.15918	1.870285513
410	1	9.701	15.625	5.924	14.994	0.631	5.293	10.65158677	13.53	13.476	0.054	0.054	0.911546253	0.06858	0.122796	2.072856178
420	1	10.804	16.634	5.83	16.051	0.583	5.247	10	14.482	14.415	0.067	0.067	1.14922813	0.08509	0.152358	2.613344768
440	1	8.993	15.257	6.264	14.598	0.659	5.605	10.52043423	13.249	13.174	0.075	0.075	1.197318008	0.09525	0.17055	2.722701149
460	1	10.78	18.058	7.278	17.459	0.599	6.679	8.230283045	16.022	15.959	0.063	0.063	0.865622424	0.08001	0.143262	1.968425392
470	1	9.474	17.377	7.903	16.777	0.6	7.303	7.592053651	15.21	15.147	0.063	0.063	0.797165633	0.08001	0.143262	1.81275465
480	1	9.525	17.21	7.685	16.632	0.578	7.107	7.521145088	15.193	15.144	0.049	0.049	0.637605725	0.06223	0.111426	1.44991542
500	1	14.383	24.305	9.922	23.761	0.544	9.378	5.482765571	21.88	21.841	0.039	0.039	0.393065914	0.04953	0.088686	0.893831889
530	1	13.382	24.466	11.084	24.031	0.435	10.649	3.924575965	22.409	22.365	0.044	0.044	0.396968603	0.05588	0.100056	0.902706604
0	2	13.25	18.345	5.095	18.077	0.268	4.827	5.260058881	18.077	18.023	0.054	0.054	1.05986261	0.06858	0.122796	2.410127576
10	2	14.304	23.339	9.035	22.591	0.748	8.287	8.278915329	22.591	22.527	0.064	0.064	0.708356392	0.08128	0.145536	1.610802435
20	2	14.078	20.636	6.558	19.971	0.665	5.893	10.14028667	19.971	19.914	0.057	0.057	0.869167429	0.07239	0.129618	1.976486734
30	2	9.504	14.812	5.308	14.437	0.375	4.933	7.064807837	14.437	14.348	0.089	0.089	1.676714393	0.11303	0.202386	3.812848531
40	2	6.308	8.273	1.965	7.899	0.374	1.591	19.03307888	7.899	7.826	0.073	0.073	3.715012723	0.09271	0.166002	8.447938931
50	2	11.33	16.416	5.086	15.515	0.901	4.185	17.71529689	15.515	15.387	0.128	0.128	2.516712544	0.16256	0.291072	5.723004326
60	2	10.237	16.799	6.562	15.683	1.116	5.446	17.00701006	15.683	15.607	0.076	0.076	1.158183481	0.09652	0.172824	2.633709235
70	2	9.511	16.174	6.663	15.336	0.838	5.825	12.5769173	15.336	15.259	0.077	0.077	1.1556356	0.09779	0.175098	2.627915353
90	2	10.78	16.642	5.862	16.306	0.336	5.526	5.731832139	16.306	16.214	0.092	0.092	1.569430229	0.11684	0.209208	3.56888434
110	2	11.187	20.621	9.434	19.975	0.646	8.788	6.84757261	19.975	19.928	0.047	0.047	0.498198007	0.05969	0.106878	1.132902268
130	2	16.589	23.049	6.46	22.825	0.224	6.236	3.46749226	22.825	22.767	0.058	0.058	0.897832817	0.07366	0.131892	2.041671827
150	2	5.087	10.267	5.18	9.995	0.272	4.908	5.250965251	9.995	9.944	0.051	0.051	0.984555985	0.06477	0.115974	2.238880309
180	2	12.478	21.087	8.609	20.555	0.532	8.077	6.17957951	20.555	20.505	0.05	0.05	0.580787548	0.0635	0.1137	1.320710884
200	2	14.362	22.613	8.251	22.159	0.454	7.797	5.50236335	22.159	22.115	0.044	0.044	0.533268695	0.05588	0.100056	1.212653012
220	2	11.186	16.478	5.292	16.286	0.192	5.1	3.628117914	16.286	16.231	0.055	0.055	1.039304611	0.06985	0.12507	2.363378685

2	12.462	20.043	7.581	19.65	0.393	7.188	5.184012663	19.65	19.606	0.044	0.044	0.580398364	0.05588	0.100056	1.31982588
2	11.33	20.238	8.908	19.82	0.418	8.49	4.692411316	19.82	19.785	0.035	0.035	0.392905254	0.04445	0.07959	0.893466547
2	10.999	18.626	7.627	18.156	0.47	7.157	6.162318081	18.156	18.113	0.043	0.043	0.563786548	0.05461	0.097782	1.28205061
2	10.974	19.748	8.774	19.141	0.607	8.167	6.918167313	19.141	19.084	0.057	0.057	0.649646683	0.07239	0.129618	1.477296558
2	9.526	16.924	7.398	16.522	0.402	6.996	5.433901054	16.522	16.483	0.039	0.039	0.527169505	0.04953	0.088686	1.198783455
2	14.306	25.115	10.809	24.604	0.511	10.298	4.727541863	22.77	22.713	0.057	0.057	0.527338329	0.07239	0.129618	1.199167361
2	14.077	24.688	10.611	23.993	0.695	9.916	6.549806804	22.258	22.183	0.075	0.075	0.706813684	0.09525	0.17055	1.607294317
2	14.442	24.772	10.33	24.068	0.704	9.626	6.815101646	22.157	22.085	0.072	0.072	0.696999032	0.09144	0.163728	1.584975799
2	14.38	26.313	11.933	25.55	0.763	11.17	6.394033353	23.707	23.629	0.078	0.078	0.653649543	0.09906	0.177372	1.486399061
2	10.905	21.186	10.281	20.556	0.63	9.651	6.127808579	18.444	18.312	0.132	0.132	1.283921797	0.16764	0.300168	2.919638167
2	11.185	20.787	9.602	19.977	0.81	8.792	8.435742554	18.211	18.151	0.06	0.06	0.624869819	0.0762	0.13644	1.420953968
2	9.788	15.849	6.061	15.324	0.525	5.536	8.661936974	13.338	13.292	0.046	0.046	0.758950668	0.05842	0.104604	1.72585382
2	10.985	16.948	5.963	16.452	0.496	5.467	8.317960758	15.012	14.927	0.085	0.085	1.425456985	0.10795	0.19329	3.241489183
2	9.747	16.024	6.277	15.635	0.389	5.888	6.197227975	14.211	14.075	0.136	0.136	2.166640115	0.17272	0.309264	4.926939621
2	8.993	14.069	5.076	13.502	0.567	4.509	11.17021277	12.35	12.188	0.162	0.162	3.191489362	0.20574	0.368388	7.257446809
2	9.503	16.873	7.37	16.341	0.532	6.838	7.218453189	15.125	15.053	0.072	0.072	0.976933514	0.09144	0.163728	2.221546811
2	11.104	16.829	5.725	16.473	0.356	5.369	6.218340611	15.065	14.97	0.095	0.095	1.659388646	0.12065	0.21603	3.773449782
2	11.344	21.123	9.779	20.503	0.62	9.159	6.340116576	19.152	19.084	0.068	0.068	0.695367625	0.08636	0.154632	1.581265978
2	10.9	21.199	10.299	20.726	0.473	9.826	4.592678901	19.121	19.073	0.048	0.048	0.466064666	0.06096	0.109152	1.059831052
3	10.904	15.947	5.043	15.628	0.319	4.724	6.325599841	15.628	15.555	0.073	0.073	1.447551061	0.09271	0.166002	3.291731112
3	14.442	19.989	5.547	19.334	0.655	4.892	11.8081846	19.334	19.274	0.06	0.06	1.081665765	0.0762	0.13644	2.45970795
3	14.309	19.881	5.572	19.273	0.608	4.964	10.91170136	19.273	19.218	0.055	0.055	0.987078248	0.06985	0.12507	2.244615937
3	12.722	17.627	4.905	17.319	0.308	4.597	6.27930683	17.319	17.201	0.118	0.118	2.405708461	0.14986	0.268332	5.47058104
3	5.981	8.31	2.329	8.014	0.296	2.033	12.7093173	8.014	7.923	0.091	0.091	3.907256333	0.11557	0.206934	8.885100902
3	14.383	19.566	5.183	18.818	0.748	4.435	14.43179626	18.818	18.635	0.183	0.183	3.530773683	0.23241	0.416142	8.028979356
3	11.346	17.665	6.319	17.051	0.614	5.705	9.71672733	17.051	16.999	0.052	0.052	0.822915018	0.06604	0.118248	1.871308751
3	11.002	17.879	6.877	17.145	0.734	6.143	10.67325869	17.145	17.064	0.081	0.081	1.177839174	0.10287	0.184194	2.678406282
3	10.976	19.538	8.562	18.619	0.919	7.643	10.73347349	18.619	18.562	0.057	0.057	0.665732306	0.07239	0.129618	1.513875263
3	10.906	21.093	10.187	20.387	0.706	9.481	6.930401492	20.387	20.33	0.057	0.057	0.559536664	0.07239	0.129618	1.272386375
3	5.663	9.381	3.718	9.149	0.232	3.486	6.239913932	9.149	9.111	0.038	0.038	1.022054868	0.04826	0.086412	2.32415277
3	14.383	23.88	9.497	23.443	0.437	9.06	4.60145309	23.443	23.4	0.043	0.043	0.45277456	0.05461	0.097782	1.02960935
3	14.305	23.054	8.749	22.57	0.484	8.265	5.532060807	22.57	22.511	0.059	0.059	0.674362784	0.07493	0.134166	1.533500972

3															
3	10.911	18.943	8.032	18.472	0.471	7.561	5.864043825	18.472	18.391	0.081	0.081	1.008466135	0.10287	0.184194	2.293251992
3	14.308	22.624	8.316	22.312	0.312	8.004	3.751803752	22.312	22.276	0.036	0.036	0.432900433	0.04572	0.081864	0.984415584
3	11.184	20.642	9.458	20.214	0.428	9.03	4.525269613	20.214	20.169	0.045	0.045	0.475787693	0.05715	0.10233	1.081941214
3	10.904	20.033	9.129	19.479	0.554	8.575	6.06857268	19.479	19.423	0.056	0.056	0.613429729	0.07112	0.127344	1.394939205
3	9.747	17.927	8.18	17.342	0.585	7.595	7.151589242	17.342	17.28	0.062	0.062	0.75794621	0.07874	0.140988	1.723569682
3	13.381	23.742	10.361	23.025	0.717	9.644	6.92018145	23.025	22.974	0.051	0.051	0.49223048	0.06477	0.115974	1.119332111
3	14.372	25.752	11.38	25.24	0.512	10.868	4.499121265	22.55	22.495	0.055	0.055	0.483304042	0.06985	0.12507	1.099033392
3	14.302	25.351	11.049	24.741	0.61	10.439	5.520861616	22.756	22.689	0.067	0.067	0.606389719	0.08509	0.152358	1.37893022
3	12.475	23.562	11.087	22.929	0.633	10.454	5.709389375	20.819	20.754	0.065	0.065	0.586272211	0.08255	0.14781	1.333183007
3	10.975	22.332	11.357	21.554	0.778	10.579	6.850400634	19.75	19.673	0.077	0.077	0.67799595	0.09779	0.175098	1.541762789
3	9.508	21.979	12.471	21.392	0.587	11.884	4.706920055	19.696	19.6	0.096	0.096	0.769785903	0.12192	0.218304	1.750493144
3	9.525	21.441	11.916	20.787	0.654	11.262	5.488418933	18.629	18.572	0.057	0.057	0.478348439	0.07239	0.129618	1.08776435
3	9.642	16.144	6.502	15.659	0.485	6.017	7.45924331	14.01	13.956	0.054	0.054	0.830513688	0.06858	0.122796	1.888588127
3	10.752	17.999	7.247	17.573	0.426	6.821	5.878294467	15.896	15.815	0.081	0.081	1.117703877	0.10287	0.184194	2.541658617
3	9.48	18.661	9.181	18.298	0.363	8.818	3.953817667	16.512	16.409	0.103	0.103	1.121882148	0.13081	0.234222	2.551160004
3	11.436	16.628	5.192	16.096	0.532	4.66	10.24653313	14.957	14.723	0.234	0.234	4.506933744	0.29718	0.532116	10.24876733
3	10.83	17.318	6.488	16.796	0.522	5.966	8.045622688	15.255	15.186	0.069	0.069	1.06350185	0.08763	0.156906	2.418403206
3	11.853	16.871	5.018	16.465	0.406	4.612	8.090872858	15.364	15.3	0.064	0.064	1.275408529	0.08128	0.145536	2.900278996
3	11	19.726	8.726	19.174	0.552	8.174	6.32592253	17.507	17.45	0.057	0.057	0.653220261	0.07239	0.129618	1.485422874
3															
4	12.462	20.548	8.086	19.963	0.585	7.501	7.234726688	19.963	19.865	0.098	0.098	1.211971308	0.12446	0.222852	2.756022755
4	6.042	9.804	3.762	9.597	0.207	3.555	5.502392344	9.597	9.552	0.045	0.045	1.196172249	0.05715	0.10233	2.720095694
4	9.55	18.8	9.25	18.358	0.442	8.808	4.778378378	15.811	15.726	0.085	0.085	0.918918919	0.10795	0.19329	2.089621622

Magnetic Susceptibility

		LOW FREQUENCY					HIGH FREQUENCY					
	DEPTH	A	B	C	D	MS	A	B	C	D	MS	pot weight
0	1	0.1	305.5	305.5	0.2	30.035	0	309.8	309.9	0.2	31.475	14.3
10	1	0.2	289.9	289.8	0.4	27.3413462	0.2	285.2	285.3	0.2	27.90865385	14.7
20	1	0.6	261.6	261.7	0.7	27.4736842	0	254.5	254.6	0	26.29473684	13.8
30	1	0.6	298.9	298.9	0.6	29.9387755	-0.7	287.8	287.8	0	29.90306122	14.1
40	1	0.6	283	283	0.8	31.5795455	0	278.5	278.5	-0.5	32.17613636	13.1
50	1	2.6	214.2	214.2	2.9	24.8764706	0.9	204.6	204.6	1.1	20.85294118	12.8
60	1	-67.8	161.1	161.1	-68	24.1236559	-0.1	220.6	220.6	-0.3	24.24193548	13.6
70	1	-67.6	153.7	153.8	-67.5	24.3651685	-0.5	213.9	214	-0.7	24.60674157	13.2
90	1	0.9	211.2	211.2	1.2	23.35	-0.2	200.9	200.9	-0.3	21.85	13.3
110	1	1.3	235	235	1.5	21.045045	-0.3	224.5	224.5	-0.4	19.75675676	15.4
130	1	3	292.6	292.6	3.2	23.3467742	1.2	279.7	279.7	1.3	19.35564516	16.7
150	1	0	180	180.1	0.3	14.2459016	0	171.8	171.8	0.4	14.56557377	16.5
180	1	0.6	186.9	186.9	0.6	15.8421053	0.2	177.6	177.6	0.1	16.06578947	15.7
200	1	3.5	155.7	155.7	3.8	13.1077586	1.5	143.9	143.8	1.9	9.154310345	15.9
220	1	1.6	130.9	130.9	1.9	10.9449153	-0.4	122	122	-0.7	9.88559322	16.1
240	1	4	91	92	4.2	7.94545455	1.8	82.4	82.4	1.8	4.227272727	15.3
260	1	1.5	77.2	77.2	1.5	6.44495413	-0.4	72	72	-0.6	7.151376147	15.2
270	1	-0.2	86.7	86.8	-0.1	7.9	0.2	83.7	83.8	0.4	4.486363636	15.3
280	1	0.1	102.1	102.3	0.3	9.53271028	0.1	97.7	97.6	-0.4	6.040186916	15
290	1	0.2	106.9	106.9	0.5	9.42920354	-0.7	101	100.9	-1	5.908849558	15.6
310	1	0	105.4	105.4	0.2	9.8411215	0.1	100.6	100.6	0.5	6.273831776	15
330	1	0.4	131.9	132	0.5	11.6371681	0.1	126.5	126.5	0	8.090265487	15.6
340	1	0.2	171.6	171.6	0.4	15.7155963	-0.8	162.8	162.8	-0.7	11.90458716	15.2
360	1	0.6	213.8	213.8	0.6	17.6198347	-0.8	204.1	204	-1.3	13.85041322	16.4
380	1	1.2	227.3	227.3	1.3	20.9305556	-1.5	218.6	218.5	-1.6	17.27962963	15.1

400	1	1.5	181.7	181.8	1.6	20.247191	-1.8	171.4	171.5	-1.7	16.36067416	13.2
410	1	0	152.2	152.2	0.4	19.2405063	0	146.4	146.4	0.2	15.41898734	12.2
420	1	1.1	138.9	138.9	1.2	16.3988095	-0.5	132.6	132.5	-0.6	12.7452381	12.7
440	1	1.6	165.2	165.3	1.9	19.6987952	-1.5	155.4	155.4	-1.4	15.79759036	12.6
460	1	2.4	297.6	297.8	2.9	34.3081395	-0.7	282.4	284.4	-0.8	29.94069767	12.9
470	1	0.2	493.9	493.9	0.4	48.3921569	-1.4	481.6	481.6	-1.4	44.25294118	14.5
480	1	0.5	583.6	583.6	0.6	60.1082474	-1.4	571.3	571.3	-1.5	55.94639175	14
500	1	0.8	1009.9	1009.8	1.2	80.0674603	-1.7	995.7	995.7	-1.8	76.06269841	16.9
530	1	1.6	1157.9	1157.9	1.7	89.6317829	-2	1146.3	1146	-2.1	85.91937984	17.2
0	2	1	338.4	338.5	0.2	35.1927083	0.1	333.6	333.7	0.1	34.24479167	13.9
10	2	0.4	278.8	278.8	0.3	25.2824074	0.2	273.4	273.4	0.1	25.80092593	15.1
20	2	0.3	224	224	0.4	22.3214286	0	216.1	216.1	-0.4	22.57142857	14.1
30	2	0.7	308	308	0.7	32.3473684	0	294.2	294.1	0	30.46315789	13.8
40	2	2	119.1	119.1	2.3	18.5634921	1	111.5	111.5	0.7	14.46349206	10.6
50	2	1	151.7	151.7	1.2	21.9776119	-0.5	143.1	143.1	-0.5	21.93283582	11
60	2	-68	73.4	73.4	-68.1	17.4050633	-0.3	136	135.9	-0.3	17.74683544	12.2
70	2	-67.5	135.2	135.1	-67.2	23.0465116	-0.7	195.7	195.7	-0.4	23.31976744	12.9
90	2	1.2	335.9	335.8	1.3	32.1730769	-0.3	320.2	320.1	-0.3	30.3125	14.7
110	2	-66.6	205.5	205.6	-66.4	22.7521368	-0.6	261.8	261.5	-0.5	22.91025641	16
130	2	1.5	250.8	250.8	1.6	21.487069	-0.4	238.3	238.2	-0.4	20.07327586	15.9
150	2	2.4	180.5	180.5	3.5	14.5532787	1.5	106.3	166.4	1.5	7.953278689	16.5
180	2	0.6	180.2	180.3	0.7	16.1296296	0.1	170.9	170.9	0	16.31944444	15.1
200	2	1.1	154.3	154.3	1.3	12.4745763	-0.4	146.1	146.1	-0.4	12.91525424	16.1
240	2	1.9	122.6	122.6	2	10.4008621	-0.7	114.2	114.3	-0.9	9.418103448	15.9
220	2	1.3	107.3	107.3	1.4	9.13181818	-0.4	101.1	101.1	-0.4	9.727272727	15.3
260	2	1.5	82.6	82.7	1.5	6.74553571	-0.6	76.7	76.7	-0.7	7.40625	15.5
270	2	-0.1	90.5	90.5	0	8.79126214	0.2	86.6	86.5	0.1	5.288349515	14.6
280	2	0.3	80.8	80.8	0.2	7.52803738	-0.4	75.7	75.7	-0.4	4.012149533	15

290	2	0.5	114.6	114.7	0.6	10.3727273	-1	108.6	108.6	-1.2	6.872727273	15.3
310	2	0.2	112.3	112.2	0.3	10.3703704	0.5	106.3	106.3	0.3	6.705555556	15.1
330	2	0.5	123.5	123.5	0.1	11.2	0	117.4	117.3	-0.6	7.595454545	15.3
340	2	0.4	139.3	139.3	0.4	12.8611111	-0.7	131	131	-0.9	9.103703704	15.1
360	2	0.6	212	211.9	0.9	17.6	-1.3	200.2	200.2	-1.4	13.69583333	16.3
380	2	1.3	185.9	185.9	1.3	17.4150943	-1.6	176.7	176.7	-1.7	13.7254717	14.9
400	2	1.6	257	257	1.7	25.0343137	-1.7	246.5	246.5	-1.5	21.22352941	14.5
410	2	0.4	172.7	172.8	0.7	21.7974684	0.2	165	164.9	-0.3	17.78607595	12.2
420	2	1.2	184.5	184.5	1.4	22.617284	-0.6	176.9	176.8	-0.7	18.81358025	12.4
440	2	1.9	250.4	250.3	2.1	28.545977	-1.3	241.5	241.5	-1.3	24.80804598	13
460	2	2.9	146	146	3.1	21.0294118	-1.3	136.2	136.2	-1.4	17.12794118	11.1
470	2	0.4	469.5	469.5	0.6	45.5339806	-1.4	456.1	456.1	-1.4	41.31747573	14.6
480	2	0.6	496.8	496.8	0.8	48.1650485	1.5	482.9	482.9	-1.7	43.79320388	14.6
500	2	1.2	834.4	834.4	1.5	67.7276423	-1.8	820.2	820.2	-1.8	63.72926829	16.6
530	2	1.7	1155.1	1155.1	1.8	92.268	-2.1	1133.3	1133	-2.6	87.748	16.8
0	3	2	341.4	341.5	0.6	30.3705357	0.1	334.8	334.9	0	29.39285714	15.5
10	3	0.3	209.4	209.4	0.3	19.4142857	0.1	204.9	205	0	20.01428571	14.8
20	3	0.4	157.1	157.1	0.6	16.3387097	-0.4	152.6	152.6	-0.7	16.96774194	13.6
30	3	0.7	161.2	161.2	0.9	15.5728155	0	152.6	152.5	-0.2	14.32038835	14.6
40	3	2.3	197.2	197.3	2.6	23.7560976	0.7	186.2	186.3	0.9	19.51585366	12.5
50	3	-65.4	83.7	83.8	-65	19.36	-0.1	144	144.1	-0.1	19.72	11.8
60	3	-68.1	241.7	241.9	-67.6	29.2740385	-0.3	300.6	300.7	-0.5	29.44711538	14.7
70	3	-67.2	217.4	217.3	-67	23.6059322	-0.5	270.5	270.5	-0.6	23.47033898	16.1
90	3	-67	289.8	289.8	-66.6	33.7884615	-0.6	341.8	341.8	-0.6	33.42307692	14.7
110	3	-66.4	200.4	200.5	-66.2	21.9159664	-0.5	255.4	255.5	-0.5	22.00840336	16.2
130	3	3.2	236.2	236.2	3.2	19.7457627	1.3	220.8	220.8	1.5	15.49322034	16.1
150	3	0.3	198.2	198.2	0.6	16.4017094	0.4	187.4	187.5	0.2	16.4957265	16
180	3	0.7	131.2	131.2	1.1	11.2387387	0	122.1	122.1	-0.4	11.51801802	15.4

200	3											
220	3	3.8	106.3	106.3	4	8.6779661	1.9	94.3	94.3	1.8	4.734745763	16.1
240	3	1.4	70.1	70.1	1.5	5.03629032	-0.4	64.9	64.9	-0.4	5.766129032	16.7
260	3	0	81.9	81.9	-0.2	7.00854701	0.1	78	78.1	0.2	3.558119658	16
270	3	0	63.8	63.8	0.1	5.90277778	0.4	60.5	60.5	0.2	2.474074074	15.1
280	3	0.2	58.1	58.1	0.2	5.56730769	-0.4	54.5	54.4	-0.7	2.188461538	14.7
290	3	0.6	123.1	123	0.8	10.1958333	-1.2	113.6	113.6	-1.1	6.4625	16.3
310	3	0.3	105.6	105.8	0.4	9.08189655	0.3	99.7	99.6	0.1	5.473275862	15.9
330	3	0.1	111.4	111.4	0.2	9.67391304	-0.6	104.9	104.8	-0.8	6.07826087	15.8
340	3	0.4	140.9	140.9	0.6	12.5357143	-0.9	132.7	132.7	-0.8	8.824107143	15.5
360	3	0.9	187.4	187.3	1.2	16.0603448	-1.4	176.8	176.9	-1.5	12.27068966	15.9
380	3	1.3	216.1	216.1	1.5	16.9055118	-1.7	204.6	204.7	-1.89	13.15551181	17
400	3	1.7	317.9	317.9	1.8	25.4959677	-1.5	306.5	306.5	-1.6	21.74274194	16.7
410	3	0.7	196.7	196.7	1.1	21.0537634	-0.3	188.7	188.7	-0.5	17.23333333	13.6
420	3	1.4	310.4	310.4	1.6	28.3394495	-1	300.4	300.4	-1.1	24.5559633	15.2
440	3	2.1	385.8	386	2.4	35.8551402	-0.8	372.7	372.7	-1	31.81588785	15
460	3	3.1	211.1	211.1	3.3	28.0945946	-1.4	195.9	195.9	-1.2	23.54864865	11.7
470	3	0.6	302.6	302.5	0.5	34.3181818	-1.4	293.3	293.2	-1.4	30.38295455	13.1
480	3	0.8	363.9	363.9	0.8	42.2209302	-1.7	349.4	349.4	-1.7	37.7255814	12.9
500	3	1.5	775.04	775.3	1.6	64.4683333	-1.8	760.6	760.6	-2	60.44166667	16.3
530	4											
240	4	0.8	247.3	247.3	1	20.3813559	-0.5	235.7	235.6	-0.5	20.51271186	16.1
270	4	2.9	398.7	398.9	3	28.6847826	1.1	384.2	384.2	1.2	24.65724638	18.1
	4	3.3	479.6	479.6	3.5	44.0925926	-1.2	464.6	464.5	-1.3	40.02962963	15.1
		0.8	0.7	0.7	1.2	-3	-1.1	-0.8	-0.8	-1.6	2.4	4.4
		1.8	1.4	1.5	1.9	#DIV/0!	-1.6	-1	-1	-1.6	#DIV/0!	4.3

Particle Size Analysis

		size class percentages										
WP	depth	fine clay	med clay	coarse clay	very fine silt	fine silt	med silt	coarse silt	very fine sand	fine sand	med sand	coarse sand
1	1	0.70441	1.80530	3.73854	5.71476	7.56718	8.30813	9.09843	10.82646	10.47860	7.52528	34.23292
2	1	0.83283	2.05576	4.40679	6.73204	8.29961	8.07380	8.30516	9.81232	8.57593	6.12574	36.78004
3	1	0.00000	0.09754	3.17284	7.30880	14.11102	15.43985	13.61427	9.84281	3.65212	0.24044	32.52033
4	1	0.85030	2.67204	5.79810	8.17834	9.40380	9.03638	10.22384	12.45868	10.36389	4.96718	26.04747
5	1	0.57257	2.27745	5.58252	8.37061	10.89154	11.20153	11.25959	11.55557	8.08576	3.46119	26.74168
6	1	0.00000	0.18181	2.11451	3.85207	6.14710	8.47978	12.99350	17.29711	13.34218	7.16294	28.42899
7	1	0.56375	1.92340	4.16379	5.90960	7.23628	6.99234	7.05457	8.16834	7.66586	5.39444	44.92763
8	1	0.57521	2.45755	5.73718	7.77703	9.73944	10.38356	10.81246	10.91623	7.74778	3.09909	30.75448
9	1	0.00000	0.06070	3.18918	7.48461	14.07358	13.84300	11.97328	12.07959	6.11358	0.30013	30.88235
10	1	0.00000	0.18829	3.71919	7.97923	15.67036	17.23114	14.05481	9.45928	3.32260	0.14928	28.22581
11	1	0.00000	0.22204	2.45349	4.47288	7.29758	7.87341	9.36672	14.77910	17.53962	12.23926	23.75591
12	1	1.16275	2.71906	4.83017	6.14738	6.83186	6.67326	7.73833	9.79851	11.18750	9.86891	33.04227
12.5	1	0.84917	2.06565	4.02802	5.47208	6.43368	6.49181	7.67601	10.15251	10.70097	9.76148	36.36862
13	1	0.00000	0.34164	3.37871	5.68530	7.72708	6.65050	7.30481	11.26264	14.06008	15.09792	28.49131
14	1	0.00000	0.18131	3.82239	8.43774	17.34860	16.86752	13.53744	9.72291	2.82435	0.27361	26.98413
16	1	0.00000	0.15354	1.62004	2.90090	4.23007	4.40399	6.67399	12.02393	14.53127	16.79299	36.66929
17	1	0.57544	1.68063	3.38293	4.79770	5.98158	6.35811	7.11328	8.80784	11.84078	13.65254	35.80916
18	1	0.86548	2.43801	4.76647	6.61992	7.96307	8.06876	9.55608	12.44791	12.62333	11.44459	23.20638
19	1	0.62819	1.74069	3.46602	5.03524	6.51224	7.06207	8.60638	11.53067	11.94698	9.95853	33.51300
20	1	0.97751	2.39636	4.56413	6.38916	7.88113	8.16864	9.36664	11.35354	11.35357	8.24783	29.30149
21	1	0.75032	2.04836	4.20170	6.24234	7.99914	7.95489	8.21127	10.08030	10.95609	9.86920	31.68641
22	1	0.88499	2.54906	5.15751	7.46044	9.42257	9.55550	10.50845	12.40012	10.99755	7.72203	23.34178
23	1	0.60903	2.13503	5.04758	7.79145	9.58660	8.53554	8.28048	9.84041	10.09317	7.35983	30.72088
24	1	1.17412	3.73987	7.65282	9.48928	10.29087	8.94803	7.82210	7.25657	5.40409	3.16183	35.06043
25	1	0.65556	2.55544	5.97908	8.61459	10.88600	10.52463	9.52441	10.84335	9.74131	4.50607	26.16957
26	1	0.41141	1.50384	3.67401	5.73561	7.33994	7.32827	7.60799	7.95611	5.86437	3.45411	49.12434

27	1	0.48124	1.73496	4.14142	6.31626	7.79684	7.23537	6.84469	7.44750	6.49834	6.93237	44.57101
28	1	0.75926	2.95144	6.93283	10.07561	13.01427	13.30766	11.86519	8.86302	4.73516	2.47797	25.01758
29	1	0.66468	2.66275	6.18757	8.73910	11.08365	11.18794	10.07969	8.67378	6.95659	4.93227	28.83197
30	1	0.72572	2.31583	4.91732	7.09737	9.26349	9.99047	10.35914	10.67324	8.20667	4.50973	31.94103
31	1	0.79908	2.40840	4.95769	6.89700	8.77507	9.15747	9.06006	9.59704	8.82554	6.02700	33.49565
32	1	0.54257	1.70642	3.66565	5.43553	7.00533	7.27150	8.42801	11.91033	12.24149	9.64292	32.15025
33	1	1.28681	2.56758	4.46108	5.84864	6.91224	7.02121	8.00507	10.49210	10.64228	10.19193	32.57106
34	1	0.95822	2.15262	4.18573	5.71497	6.90040	7.70427	11.06835	17.70102	16.83184	8.61090	18.17168
1	2	0.00000	0.07865	2.34913	5.65694	11.72658	14.77172	15.71146	10.84054	2.97602	0.11661	35.77236
2	2	0.89842	2.26796	5.02343	7.70670	9.89498	10.30085	10.26021	9.65519	6.22965	2.95927	33.92857
3	2	0.95325	2.24088	4.79704	7.14086	8.63449	8.72496	9.38074	10.74454	9.07393	5.37904	31.95876
4	2	0.00000	0.21892	6.10575	12.36162	17.85942	14.03813	12.44652	8.51289	2.30290	0.00000	26.15385
5	2	0.00000	0.07087	2.16125	4.32527	8.57786	14.10691	18.82318	14.97626	8.66933	4.88417	21.42857
6	2	0.73492	1.99073	4.14240	6.52088	10.18578	12.85892	13.46968	12.91507	10.25192	4.83521	21.73913
7	2	0.55543	2.36328	5.88536	8.56909	10.22055	9.09203	8.24952	7.64323	4.55889	1.93336	40.50633
8	2	0.62975	1.73426	3.56280	5.30686	7.90494	10.54730	13.05732	13.79942	9.84896	4.59798	28.08989
9	2	0.00000	0.10749	2.85593	6.39407	11.92972	12.49966	11.88700	11.21478	3.97993	0.04051	39.09091
10	2	0.95531	2.58206	5.24829	6.91296	7.32161	6.43447	6.85290	9.19668	11.16912	8.03700	33.91304
11	2	0.00000	0.29586	3.36302	6.21502	9.69531	9.09883	11.48853	19.51237	9.01978	0.11129	31.20000
12	2	0.00000	0.22704	2.40224	3.86265	5.20484	4.75766	4.99167	7.18859	10.60629	21.95845	30.50847
12.5	2	0.77721	1.97591	3.95530	5.53136	6.38982	5.69015	5.86553	7.72038	8.72740	8.12626	42.00000
13	2	1.07356	2.93621	5.94899	8.06026	9.00780	7.74397	7.89155	10.58597	11.37920	8.32078	25.00000
14	2	0.00000	0.19307	3.39655	7.09919	12.57012	13.17343	16.69065	12.26390	2.43286	0.18024	32.00000
15	2	1.11948	2.81534	5.30771	6.82626	7.33330	6.49624	7.51361	10.81635	12.11287	9.45157	28.07018
17	2	0.84264	2.24652	4.48727	6.32087	7.51150	7.20290	7.45544	8.48659	9.69948	9.95637	32.69231
18	2	1.15068	2.77684	5.21821	7.00476	7.96771	7.72116	8.75639	11.35659	12.07732	8.97031	25.00000
19	2	1.05035	2.96107	5.58734	6.81624	7.47107	7.50063	8.60594	10.22885	8.72080	4.65436	35.84906
20	2	1.07228	3.28205	7.17786	9.84288	10.48235	8.82518	8.85700	9.45646	7.91090	3.95068	28.84615

21	2	0.77458	1.98389	3.96579	5.71103	6.83185	6.44235	6.83169	8.58218	10.24757	9.71579	35.84906
22	2	0.83732	3.13854	7.08775	9.54590	10.25196	8.31990	7.63711	8.69269	8.51506	6.37789	28.30189
23	2	0.84154	2.53525	5.32711	7.45842	8.81252	8.09127	7.58482	7.79261	7.11611	4.72450	38.88889
24	2	1.31539	3.47089	6.90057	8.98362	10.28875	9.80132	8.90001	8.07286	5.47017	2.94938	33.33333
25	2	0.80838	2.49308	5.60098	8.66602	11.95908	12.34912	10.75295	9.82234	8.21690	3.94864	25.00000
26	2	0.95769	2.73131	5.51230	7.39957	8.25044	7.24815	7.38725	9.46584	10.30231	7.71368	31.37255
27	2	0.48244	1.88950	4.56112	6.73764	7.95043	6.89153	6.51108	7.95440	8.30268	6.12323	41.17647
28	2	0.87253	2.32653	4.78617	7.35362	10.62577	12.55833	12.80113	11.49314	8.35691	4.57505	23.63636
29	2	0.91335	2.44883	5.22985	7.90885	10.68377	11.45442	11.13183	10.96631	9.44633	5.67965	22.91667
30	2	0.61865	1.46481	3.01396	4.92825	8.51464	11.95568	13.51511	13.77835	12.13992	8.15350	19.56522
31	2	1.02030	2.77499	5.37367	7.28451	9.07090	9.12929	8.81812	9.58712	8.89830	6.17315	30.43478
32	2	0.68498	1.79398	3.50558	5.20262	7.45318	9.14136	10.90689	13.77179	14.75440	12.23138	16.00000
33	2	1.30741	2.98087	5.87697	7.92284	9.32451	8.97468	8.47162	9.79172	10.01423	5.58320	29.16667
34	2	1.15378	2.49083	4.84465	6.58761	7.98397	8.65856	10.15621	13.81864	13.18064	7.20765	22.72727
1	3	0.00000	0.13672	2.33233	4.76202	8.87177	11.62763	13.67067	13.39462	5.71325	0.17473	39.31624
2	3	0.86423	2.03547	4.28854	6.08725	7.27240	7.39473	7.35311	7.97591	7.02177	4.22785	44.44444
3	3	0.98236	1.96061	4.01781	5.87422	7.04308	7.16730	7.59451	7.89281	6.58375	5.02571	44.21053
4	3	0.00000	0.13518	2.09256	4.38990	8.25088	12.79463	17.29635	17.60131	6.33200	0.21288	30.89431
5	3	0.00000	0.07418	1.96150	4.22962	8.14532	12.10675	16.65898	19.23631	12.80267	6.45032	17.64706
6	3	0.78226	1.73289	3.36627	5.06993	7.73106	10.22692	12.05890	12.58206	11.96876	8.81156	23.68421
7	3	0.63547	1.71715	3.50891	5.22368	7.45834	9.26780	11.18888	13.08614	12.64890	8.76989	24.76190
8	3	1.00541	2.59062	4.50465	6.07971	8.58769	10.88748	11.93249	11.19361	8.05922	4.31171	29.66102
9	3	0.86176	2.17952	4.57629	6.45214	7.41301	6.65112	6.59689	8.41691	8.66286	5.41538	41.66667
10	3	0.98570	2.34030	4.48762	5.64586	5.80755	5.09667	5.28320	6.39186	8.43924	9.48876	42.85714
11	3	0.00000	0.36014	3.97604	7.26282	10.42832	9.53205	9.49251	10.62379	10.96797	8.05804	28.84615
12	3	1.64360	3.81575	6.66918	7.96005	8.35881	8.09502	9.46241	12.16037	13.18418	8.92447	18.46154
12.5	3	1.12828	2.74428	5.02343	6.67677	7.99103	8.24249	9.32066	11.19692	10.73829	7.15630	28.30189
13	3											

14	3	0.00000	0.50951	4.24582	7.06160	9.48477	8.42203	8.90245	10.76846	8.89931	8.76546	32.14286
15	3	1.26590	2.85332	4.86625	5.96248	6.50964	6.35001	7.84299	10.07279	10.28822	9.91572	30.61224
17	3	1.02883	2.44465	4.26630	5.45148	6.21492	6.30024	7.92162	10.66002	12.03957	10.18812	30.76923
18	3	1.32810	3.26138	5.75353	6.99153	7.45623	6.90716	7.52675	8.96883	8.84612	7.89125	32.14286
19	3	1.45048	4.61334	8.41121	9.21029	8.87790	8.10171	8.77171	9.68333	7.09605	3.86529	28.84615
20	3	1.27040	3.20918	6.17362	8.20250	9.14993	8.04280	7.85120	8.00598	7.91489	7.88615	30.18868
21	3	1.08672	3.02009	6.59373	9.79591	11.18799	8.87181	7.73715	8.12519	7.45908	5.91521	29.41176
22	3	1.00643	3.14085	6.45391	8.43717	8.98437	7.62921	7.72148	8.83280	8.19872	6.12028	32.14286
23	3	1.07240	3.14992	6.51045	8.95046	10.15923	8.90636	8.37248	8.07308	6.03722	3.60934	34.61538
24	3	1.39007	3.34640	6.26061	7.91988	9.40176	9.70811	9.01799	8.06799	6.45557	3.86104	34.00000
25	3	0.84376	2.44952	5.46381	8.20591	9.65238	8.71944	7.88066	8.60799	9.51981	9.65786	25.49020
26	3	1.20333	2.97513	5.63935	7.56169	9.08454	8.84910	9.00549	10.88559	10.54316	6.21647	26.92308
27	3	0.75724	2.85135	6.87553	10.10379	11.31590	8.98718	7.12268	6.92909	5.77900	3.84067	34.61538
28	3	1.13343	2.70244	5.05712	7.28400	9.94906	11.66863	12.39504	12.27664	9.64984	5.28771	21.15385
29	3	0.89242	2.14239	4.23417	6.23198	8.52381	9.82702	10.94397	12.99150	12.94801	10.07314	18.00000
30	3	0.62578	1.38507	2.71310	4.40169	7.70754	11.08749	12.95904	13.66947	12.53001	9.45591	20.83333
31	3	0.65839	2.15977	4.80872	7.19301	9.70480	10.88213	11.57153	11.27784	7.96898	4.43926	28.57143
32	3	0.86859	2.29774	4.62191	7.01975	10.22418	12.61527	13.55157	11.69507	8.05449	5.23143	18.18182
33	3	1.14095	2.73566	5.43804	7.33371	8.54925	8.22265	8.04148	9.32608	8.61224	5.36929	34.09091

Particle Size Analysis cont.

SAMPLE		PARTICLE SIZE								
distance	depth	<2mm weight	>2mm weight	total weight	% <2mm	% <2mm	total	<500um	% <500um	SOIL pH
0	1	37.1	2.6	39.7	93.45	6.55	10	6.8	68.00	6.42
10	1	37.1	3.4	40.5	91.60	8.40	10.7	7	65.42	6.62
20	1	27.7	2.2	29.9	92.64	7.36	12.3	8.3	67.48	6.63
30	1	42.4	2.1	44.5	95.28	4.72	9.8	7.3	74.49	7.11
40	1	33.9	6.4	40.3	84.12	15.88	8.8	6.5	73.86	7.5
50	1	37.7	2.9	40.6	92.86	7.14	5.4	4	74.07	7.18
60	1	37.4	2.8	40.2	93.03	6.97	9.2	5.2	56.52	7.21
70	1	40.3	1.6	41.9	96.18	3.82	9.2	6.4	69.57	7.55
90	1	28.2	1.4	29.6	95.27	4.73	13.6	9.4	69.12	6.99
110	1	29.4	0.3	29.7	98.99	1.01	12.4	8.9	71.77	6.93
130	1	41.2	0.6	41.8	98.56	1.44	6.1	4.9	80.33	7.03
150	1	40.5	1.8	42.3	95.74	4.26	5	3.5	70.00	6.85
180	1	40.1	0.9	41	97.80	2.20	6.2	4.2	67.74	7.07
200	1	39	1	40	97.50	2.50	5.6	4.2	75.00	6.81
220	1	29.4	0.4	29.8	98.66	1.34	12.6	9.2	73.02	6.71
240	1	39.8	0.9	40.7	97.79	2.21	5.9	4.2	71.19	6.48
260	1	40.5	2.1	42.6	95.07	4.93	4.9	3.4	69.39	6.79
270	1	45.6	0.9	46.5	98.06	1.94	5.1	4.2	82.35	7
280	1	41.8	1.3	43.1	96.98	3.02	5.4	3.8	70.37	6.58
290	1	40	1.2	41.2	97.09	2.91	5.1	3.7	72.55	6.54
310	1	38.1	2.8	40.9	93.15	6.85	5.2	3.7	71.15	6.79
330	1	39.7	2.8	42.5	93.41	6.59	5.1	4	78.43	6.62
340	1	38.7	3.8	42.5	91.06	8.94	5.1	3.6	70.59	6.66
360	1	40.4	4.7	45.1	89.58	10.42	5.2	3.4	65.38	6.81
380	1	40	3.5	43.5	91.95	8.05	5.1	3.8	74.51	7.04
400	1	37.9	3.8	41.7	90.89	9.11	5.2	2.7	51.92	7.05

410	1	41	1.5	42.5	96.47	3.53	5	3	60.00	7.83
420	1	38.8	3.5	42.3	91.73	8.27	5.3	4	75.47	7.66
440	1	38.9	2.2	41.1	94.65	5.35	5	3.6	72.00	7.9
460	1	41	3	44	93.18	6.82	4.6	3.2	69.57	8.47
470	1	36.8	3.2	40	92.00	8.00	4.7	3.2	68.09	8.03
480	1	39	2.3	41.3	94.43	5.57	4.6	3.4	73.91	7.47
500	1	39	3.3	42.3	92.20	7.80	4.9	3.6	73.47	7.13
530	1	36.7	3.9	40.6	90.39	9.61	4.7	3.9	82.98	6.9
0	2	25.1	4.6	29.7	84.51	15.49	12.3	7.9	64.23	6.23
10	2	30	14.8	44.8	66.96	33.04	11.2	7.4	66.07	6.9
20	2	21.1	18.6	39.7	53.15	46.85	9.7	6.6	68.04	6.83
30	2	26.3	3.4	29.7	88.55	11.45	13	9.6	73.85	6.89
40	2	49	1	50	98.00	2.00	7	5.5	78.57	8
50	2	29	11.7	40.7	71.25	28.75	6.9	5.4	78.26	8.38
60	2	39.6	2.2	41.8	94.74	5.26	7.9	4.7	59.49	7.52
70	2	42.6	1.7	44.3	96.16	3.84	8.9	6.4	71.91	8.28
90	2	27.1	2.2	29.3	92.49	7.51	11	6.7	60.91	6.8
110	2	39.7	2.4	42.1	94.30	5.70	11.5	7.6	66.09	7.3
130	2	28.8	0.8	29.6	97.30	2.70	12.5	8.6	68.80	6.6
150	2	37.5	1.8	39.3	95.42	4.58	5.9	4.1	69.49	7.32
180	2	39.5	2.1	41.6	94.95	5.05	5	2.9	58.00	7.15
200	2	37.7	3	40.7	92.63	7.37	6.4	4.8	75.00	6.85
220	2	27.9	1.6	29.5	94.58	5.42	12.5	8.5	68.00	6.82
240	2	44.3	1.1	45.4	97.58	2.42	5.7	4.1	71.93	7.26
260	2	46.3	3.2	49.5	93.54	6.46	5.2	3.5	67.31	6.77
270	2	43.2	1.7	44.9	96.21	3.79	5.2	3.9	75.00	7.27
280	2	41.6	3.1	44.7	93.06	6.94	5.3	3.4	64.15	6.96
290	2	39.7	2.2	41.9	94.75	5.25	5.2	3.7	71.15	7.01

310	2	39.5	4	43.5	90.80	9.20	5.3	3.4	64.15	6.85
330	2	38.4	1.6	40	96.00	4.00	5.3	3.8	71.70	6.7
340	2	40	2	42	95.24	4.76	5.4	3.3	61.11	6.95
360	2	38.7	5.9	44.6	86.77	13.23	5.1	3.4	66.67	6.64
380	2	38.9	4.4	43.3	89.84	10.16	5.2	3.9	75.00	7.54
400	2	39.2	2.2	41.4	94.69	5.31	5.1	3.5	68.63	6.93
410	2	34.8	4.7	39.5	88.10	11.90	5.1	3	58.82	7.61
420	2	38.7	1	39.7	97.48	2.52	5.5	4.2	76.36	8.42
440	2	36.9	4.3	41.2	89.56	10.44	4.8	3.7	77.08	8.78
460	2	40	1	41	97.56	2.44	4.6	3.7	80.43	8.33
470	2	39.2	1.4	40.6	96.55	3.45	4.6	3.2	69.57	8.44
480	2	39.9	1.6	41.5	96.14	3.86	5	4.2	84.00	8.71
500	2	35.6	3.5	39.1	91.05	8.95	4.8	3.4	70.83	7.51
530	2	30.3	12.9	43.2	70.14	29.86	4.4	3.4	77.27	7.02
0	3	14.4	15.4	29.8	48.32	51.68	11.7	7.1	60.68	6.32
10	3	19.6	19.2	38.8	50.52	49.48	10.8	6	55.56	7.02
20	3	17.1	23.6	40.7	42.01	57.99	9.5	5.3	55.79	7
30	3	17.4	12.1	29.5	58.98	41.02	12.3	8.5	69.11	7.65
40	3	47.4	2.6	50	94.80	5.20	5.1	4.2	82.35	8.76
50	3	44.5	2.4	46.9	94.88	5.12	7.6	5.8	76.32	8.8
60	3	42.2	1.6	43.8	96.35	3.65	10.5	7.9	75.24	8.1
70	3	36	1.9	37.9	94.99	5.01	11.8	8.3	70.34	8.77
90	3	34.6	2.6	37.2	93.01	6.99	10.8	6.3	58.33	7.27
110	3	36.6	1.6	38.2	95.81	4.19	11.9	6.8	57.14	7.08
130	3	38.2	2.7	40.9	93.40	6.60	5.2	3.7	71.15	7.2
150	3	28	3.1	31.1	90.03	9.97	6.5	5.3	81.54	7.05
180	3	37.6	3.5	41.1	91.48	8.52	5.3	3.8	71.70	7.91
220	3	39.6	1.5	41.1	96.35	3.65	5.6	3.8	67.86	7.54

240	3	44	2.6	46.6	94.42	5.58	4.9	3.4	69.39	7.77
260	3	41.9	2.2	44.1	95.01	4.99	5.2	3.6	69.23	7.19
270	3	42.4	2.9	45.3	93.60	6.40	5.6	3.8	67.86	7.63
280	3	42.9	2	44.9	95.55	4.45	5.2	3.7	71.15	7.7
290	3	38.4	2.2	40.6	94.58	5.42	5.3	3.7	69.81	7.64
310	3	38.6	3.5	42.1	91.69	8.31	5.1	3.6	70.59	6.66
330	3	37.4	1.4	38.8	96.39	3.61	5.6	3.8	67.86	6.88
340	3	40	2.9	42.9	93.24	6.76	5.2	3.4	65.38	7.13
360	3	27.6	1.9	29.5	93.56	6.44	5	3.3	66.00	7.01
380	3	33	14.1	47.1	70.06	29.94	5.1	3.8	74.51	8
400	3	42	6.9	48.9	85.89	14.11	5.2	3.8	73.08	7.23
410	3	38.9	2.8	41.7	93.29	6.71	5.2	3.4	65.38	7.76
420	3	38.4	2.6	41	93.66	6.34	5.2	4.1	78.85	8.65
440	3	36.7	2.2	38.9	94.34	5.66	5	4.1	82.00	8.71
460	3	37.5	2.3	39.8	94.22	5.78	4.8	3.8	79.17	8.79
470	3	41.5	3.1	44.6	93.05	6.95	4.9	3.5	71.43	8.75
480	3	40.3	1.1	41.4	97.34	2.66	4.4	3.6	81.82	8.31
500	3	36.4	5	41.4	87.92	12.08	4.4	2.9	65.91	7.58

Transect WE1 Auger Data

	SAMPLE		PARTICLE SIZE				SOIL pH
WP	distance	depth	<2mm weigh	>2mm weigh	total weight	% <2mm	
40	0	1	36.9	1.7	38.6	95.60	6.7
41	25	1	39	1.6	40.6	96.06	6.64
42	50	1	36.7	0.9	37.6	97.61	6.64
43	75	1	36.1	0.3	36.4	99.18	6.91
44	100	1	38.5	1	39.5	97.47	6.84
45	125	1	36	0.7	36.7	98.09	6.65
46	150	1	34.9	1	35.9	97.21	7.07
47	175	1	41	1.8	42.8	95.79	6.83
48	200	1	35.1	1	36.1	97.23	6.67
49	225	1	35.4	0.7	36.1	98.06	6.57
50	250	1	34.5	1.5	36	95.83	6.63
51	275	1	36	1.7	37.7	95.49	7.15
52	300	1	33.9	1.2	35.1	96.58	6.89
53	325	1	41.7	3.4	45.1	92.46	7.22
54	350	1	36.8	4.2	41	89.76	8.27
55	375	1	37.9	1.2	39.1	96.93	7.46
56	400	1	37.7	1	38.7	97.42	8.05
57	425	1	38	1.7	39.7	95.72	7.08
58	450	1	36.6	0.8	37.4	97.86	6.7
59	475	1	37	22.2	59.2	62.50	7.58
40	0	2	37.1	1.6	38.7	95.87	6.39
41	25	2	37.5	1.7	39.2	95.66	6.47
42	50	2	36.2	1.4	37.6	96.28	6.82
43	75	2	37.8	1.1	38.9	97.17	7.09
44	100	2	34.6	1.3	35.9	96.38	7.01
45	125	2	40.9	1.4	42.3	96.69	7.07
46	150	2	35.9	1.8	37.7	95.23	6.94
47	175	2	38.5	1.6	40.1	96.01	6.96
48	200	2	35.7	1.6	37.3	95.71	6.91
49	225	2	35.6	1.5	37.1	95.96	6.75
50	250	2	34	2	36	94.44	6.98
51	275	2	34.4	1.4	35.8	96.09	7.41
52	300	2	35.1	1.6	36.7	95.64	7.21
53	325	2	33.2	12.4	45.6	72.81	7.53
54	350	2	38.1	1.6	39.7	95.97	8.71
55	375	2					8.36
56	400	2					8.24
57	425	2					7.28
58	450	2					7.02
59	475	2	25.4	26.1	51.5	49.32	7.53
40	0	3	33.2	13.5	46.7	71.09	6.22
41	25	3	26.1	1205	1231.1	2.12	6.3
42	50	3	36	2.6	38.6	93.26	6.87
43	75	3	35	1.4	36.4	96.15	7.29
44	100	3	33.4	2.3	35.7	93.56	7.16
45	125	3	35.2	1.5	36.7	95.91	7.21
46	150	3	32	3	35	91.43	7.09

47	175	3	36	1.1	37.1	97.04	7.64
48	200	3	39.9	3.2	43.1	92.58	7.18
49	225						
50	250	3	39.5	3.3	42.8	92.29	7.19
51	275	3	41.1	3.1	44.2	92.99	7.37
52	300	3	41	4.6	45.6	89.91	7.47
53	325	3	39.5	63.2	102.7	38.46	8.06
54	350	3	31.1	7.5	38.6	80.57	8.83
55	375	3					8.91
56	400	3					8.59
57	425	3					7.48
58	450	3					7.28
59	475	3	30.9	38.3	69.2	44.65	7.44

Magnetic Susceptibility

			LOW FREQUENCY				
WP	**distance**	**DEPTH**	**A**	**B**	**C**	**D**	**MS**
40	0	1	0.6	152.7	152.8	0.9	10.2042254
41	25	1	0	103.2	103.2	0.2	7.81451613
42	50	1	0.2	109.4	109.4	0.3	7.02758621
43	75	1	0.2	92.4	92.4	0.1	7.25210084
44	100	1	0.3	78.9	78.9	0.3	7.36
45	125	1	2	86.8	86.8	1.9	6.45491803
46	150	1	0.6	175	175	0.7	14.2754237
47	175	1	1.9	112.8	112.9	1.8	8.03846154
48	200	1	0.1	186.4	186.4	0.2	14.5201613
49	225	1	0.2	117.8	117.8	0.3	8.68359375
50	250	1	0.2	122.1	122.1	0.4	8.79770992
51	275	1	0.5	92.3	92.3	0.6	6.6124031
52	300	1	0.6	634.2	634.2	0.7	48.2346154
53	325	1	2	181.3	181.3	2	13.6181102
54	350	1	2	63	62.9	2	6.27222222
55	375	1	0	130.2	130.5	1.7	12.8505155
56	400	1	2.6	131.7	131.6	3	13.8166667
57	425	1	3.3	155.2	155.2	3.4	13.0580357
58	450	1	3.3	366.8	366.9	3.4	26.4259259
59	475	1	2.1	388	388	2.4	31.1188525
40	0	2	1	151.7	151.7	1.3	11.2617188
41	25	2	1.8	131.3	131.3	2	8.80935252
42	50	2	2	105	105	2	7.94262295
43	75	2	0.1	105.1	105.1	0.2	8.10245902
44	100	2	0.3	86.5	86.5	0.5	7.62264151
45	125	2	1.9	96.4	96.4	2	6.82170543

46	150	2	0.7	149.8	149.8	0.7	11.6219512
47	175	2	0	107.1	107.1	0.2	7.73076923
48	200	2	1.9	90.6	90.8	1.8	6.13059701
49	225	2	0.3	109	109	0.2	8.48760331
50	250	2	0.4	111.4	111.4	0.5	8.23622047
51	275	2	0.6	101.2	101.2	0.6	8.17241379
52	300	2	0.7	316.5	316.5	0.7	27.9504505
53	325	2	2	157.6	157.5	2	13.2654867
54	350	2	2	47.2	47.2	1.9	4.52777778
55	375	2	1.7	85.2	85.2	2.5	10.1538462
56	400	2	3	125.1	125.1	3.1	13.5287356
57	425	2	3.2	180.5	180.6	3.3	14.1528926
58	450	2	3.4	363.2	363.3	3.3	27.1846154
59	475	2	2.4	241.8	242	2.6	19.45
40	0	3	1.3	465.9	466.2	2	32.9100719
41	25	3	0.2	118.4	118.4	0.2	9.68965517
42	50	3	0.3	87.2	87.2	0.2	6.93162393
43	75	3	0.2	84.9	84.9	0.3	6.61344538
44	100	3	0.5	87.7	87.7	0.6	6.52822581
45	125	3	2	80	80	1.9	5.50384615
46	150	3	1.8	122.7	122.7	1.9	9.09126984
47	175	3	0.2	86.2	86.2	0.1	5.96992481
48	200	3	1.8	78.9	78.9	1.8	5.81967213
49	225						
50	250	3	1.8	115.8	115.9	2	8.00373134
51	275	3	0	112.9	113.1	1.8	8.68852459
52	300	3	1.8	196.6	196.6	2	14.8307087
53	325	3	0.7	124.9	124.9	0.7	10.4911504
54	350	3	1.9	67.5	67.5	1.9	6.55376344
55	375	3	2.5	134	134.1	2.6	9.85433071
56	400	3	3.1	160.9	160.9	3.3	17.8372093
57	425	3	3.2	178.6	178.6	3.3	13.528
58	450	3	3.3	400	399.9	3.4	29.7748092
59	475	3	2.6	163.8	163.8	2.6	12.9333333

Loss on ignition

wp	distance	DEPTH	CRUCIBLE WEIGHT	WEIGHT W. SAMPLE	SAMPLE WEIGHT	TOTAL WEIGHT after 550 C	SAMPLE LOSS 550 C	Sample weight after 550 C	% organic carbon	weight before 1000	TOTAL WEIGHT after 1000 C	weight loss after 1000 C	released CO2	% CO2 (in total sample)	total CaO	% CaO	total CaCO3	% CaCO3
40	0	1	7.143	11.756	4.613	11.616	0.14	4.473	3.035	11.62	11.596	0.02	0.02	0.4336	0.0254	0.5506	0.0455	0.9859
41	25	1	7.143	12.674	5.531	12.495	0.179	5.352	3.236	12.5	12.467	0.028	0.028	0.5062	0.0356	0.6429	0.0637	1.1512
42	50	1	8.508	14.181	5.673	13.972	0.209	5.464	3.684	13.97	13.942	0.03	0.03	0.5288	0.0381	0.6716	0.0682	1.2025
43	75	1	7.212	13.497	6.285	13.241	0.256	6.029	4.073	13.24	13.206	0.035	0.035	0.5569	0.0445	0.7072	0.0796	1.2663
44	100	1	7.796	13.699	5.903	13.478	0.221	5.682	3.744	13.48	13.448	0.03	0.03	0.5082	0.0381	0.6454	0.0682	1.1557
45	125	1	8.239	12.965	4.726	12.708	0.257	4.469	5.438	12.71	12.675	0.033	0.033	0.6983	0.0419	0.8868	0.075	1.5879
46	150	1	8.067	13.648	5.581	13.289	0.359	5.222	6.433	13.29	13.237	0.052	0.052	0.9317	0.066	1.1833	0.1182	2.1188
47	175	1	8.18	13.314	5.134	12.983	0.331	4.803	6.447	12.98	12.937	0.046	0.046	0.896	0.0584	1.1379	0.1046	2.0375
48	200	1	8.58	16.173	7.593	15.986	0.187	7.406	2.463	15.99	15.96	0.026	0.026	0.3424	0.033	0.4349	0.0591	0.7787
49	225	1	7.309	12.869	5.56	12.565	0.304	5.256	5.468	12.57	12.534	0.031	0.031	0.5576	0.0394	0.7081	0.0705	1.2679
50	250	1	7.896	12.546	4.65	12.282	0.264	4.386	5.677	12.28	12.249	0.033	0.033	0.7097	0.0419	0.9013	0.075	1.6138
51	275	1	5.792	10.28	4.488	9.897	0.383	4.105	8.534	9.897	9.865	0.032	0.032	0.713	0.0406	0.9055	0.0728	1.6214
52	300	1	5.733	10.929	5.196	10.665	0.264	4.932	5.081	10.67	10.631	0.034	0.034	0.6543	0.0432	0.831	0.0773	1.488
53	325	1	7.309	12.992	5.683	12.686	0.306	5.377	5.384	12.69	12.643	0.043	0.043	0.7566	0.0546	0.9609	0.0978	1.7206
54	350	1	7.896	11.29	3.394	10.803	0.487	2.907	14.35	10.8	10.684	0.119	0.119	3.5062	0.1511	4.4529	0.2706	7.9731
55	375	1	7.143	10.437	3.294	10.076	0.361	2.933	10.96	10.08	10.032	0.044	0.044	1.3358	0.0559	1.6964	0.1001	3.0375
56	400	1	5.831	8.752	2.921	8.305	0.447	2.474	15.3	8.305	8.261	0.044	0.044	1.5063	0.0559	1.913	0.1001	3.4254
57	425	1	7.767	12.173	4.406	11.826	0.347	4.059	7.876	11.83	11.788	0.038	0.038	0.8625	0.0483	1.0953	0.0864	1.9612
58	450	1	8.18	13.617	5.437	13.338	0.279	5.158	5.132	13.34	13.3	0.038	0.038	0.6989	0.0483	0.8876	0.0864	1.5893
59	475	1	5.733	9.661	3.928	9.375	0.286	3.642	7.281	9.375	9.337	0.038	0.038	0.9674	0.0483	1.2286	0.0864	2.1999
40	0	2	8.019	12.293	4.274	12.138	0.155	4.119	3.627	12.14	12.116	0.022	0.022	0.5147	0.0279	0.6537	0.05	1.1705
41	25	2	5.831	10.12	4.289	9.974	0.146	4.143	3.404	9.974	9.955	0.019	0.019	0.443	0.0241	0.5626	0.0432	1.0074
42	50	2	7.212	12.252	5.04	12.051	0.201	4.839	3.988	12.05	12.02	0.031	0.031	0.6151	0.0394	0.7812	0.0705	1.3987

43	75	2	8.239	13.098	4.859	12.922	0.176	4.683	3.622	12.92	12.89	0.032	0.032	0.6586	0.0406	0.8364	0.0728	1.4976
44	100	2	8.391	14.49	6.099	14.252	0.238	5.861	3.902	14.25	14.207	0.045	0.045	0.7378	0.0571	0.937	0.1023	1.6778
45	125	2	7.767	12.261	4.494	12.023	0.238	4.256	5.296	12.02	11.987	0.036	0.036	0.8011	0.0457	1.0174	0.0819	1.8216
46	150	2	8.429	14.157	5.728	13.816	0.341	5.387	5.953	13.82	13.766	0.05	0.05	0.8729	0.0635	1.1086	0.1137	1.985
47	175	2	8.084	13.415	5.331	13.089	0.326	5.005	6.115	13.09	13.03	0.059	0.059	1.1067	0.0749	1.4056	0.1342	2.5167
48	200	2	8.067	12.575	4.508	12.329	0.246	4.262	5.457	12.33	12.291	0.038	0.038	0.8429	0.0483	1.0705	0.0864	1.9169
49	225	2	8.438	14.886	6.448	14.545	0.341	6.107	5.288	14.55	14.498	0.047	0.047	0.7289	0.0597	0.9257	0.1069	1.6575
50	250	2	8.643	13.855	5.212	13.595	0.26	4.952	4.988	13.6	13.556	0.039	0.039	0.7483	0.0495	0.9503	0.0887	1.7016
51	275	2	5.822	10.534	4.712	10.263	0.271	4.441	5.751	10.26	10.223	0.04	0.04	0.8489	0.0508	1.0781	0.091	1.9304
52	300	2	5.836	10.382	4.546	10.148	0.234	4.312	5.147	10.15	10.112	0.036	0.036	0.7919	0.0457	1.0057	0.0819	1.8008
53	325	2	8.438	13.818	5.38	13.449	0.369	5.011	6.859	13.45	13.39	0.059	0.059	1.0967	0.0749	1.3928	0.1342	2.4938
54	350	2	8.643	11.848	3.205	11.334	0.514	2.691	16.04	11.33	11.112	0.222	0.222	6.9267	0.2819	8.7969	0.5048	15.751
55	375	2	8.019	11.043	3.024	10.649	0.394	2.63	13.03	10.65	10.575	0.074	0.074	2.4471	0.094	3.1078	0.1683	5.5647
56	400	2	7.212	10.413	3.201	9.997	0.416	2.785	13	9.997	9.929	0.068	0.068	2.1243	0.0864	2.6979	0.1546	4.8307
57	425	2	7.796	11.669	3.873	11.386	0.283	3.59	7.307	11.39	11.346	0.04	0.04	1.0328	0.0508	1.3116	0.091	2.3486
58	450	2	8.067	13.907	5.84	13.617	0.29	5.55	4.966	13.62	13.573	0.044	0.044	0.7534	0.0559	0.9568	0.1001	1.7133
59	475	2	5.836	9.514	3.678	9.138	0.376	3.302	10.22	9.138	9.084	0.054	0.054	1.4682	0.0686	1.8646	0.1228	3.3387
40	0	3	8.508	12.835	4.327	12.684	0.151	4.176	3.49	12.68	12.661	0.023	0.023	0.5315	0.0292	0.6751	0.0523	1.2087
41	25	3	8.019	14.034	6.015	13.826	0.208	5.807	3.458	13.83	13.792	0.034	0.034	0.5653	0.0432	0.7179	0.0773	1.2854
42	50	3	5.831	11.048	5.217	10.867	0.181	5.036	3.469	10.87	10.834	0.033	0.033	0.6325	0.0419	0.8033	0.075	1.4384
43	75	3	7.767	13.863	6.096	13.681	0.182	5.914	2.986	13.68	13.644	0.037	0.037	0.607	0.047	0.7708	0.0841	1.3802
44	100	3	8.18	13.973	5.793	13.774	0.199	5.594	3.435	13.77	13.738	0.036	0.036	0.6214	0.0457	0.7892	0.0819	1.4132
45	125	3	7.796	12.373	4.577	12.124	0.249	4.328	5.44	12.12	12.085	0.039	0.039	0.8521	0.0495	1.0821	0.0887	1.9376
46	150	3	8.391	12.749	4.358	12.482	0.267	4.091	6.127	12.48	12.439	0.043	0.043	0.9867	0.0546	1.2531	0.0978	2.2437
47	175	3	8.194	13.193	4.999	12.843	0.35	4.649	7.001	12.84	12.777	0.066	0.066	1.3203	0.0838	1.6767	0.1501	3.0023
48	200	3	8.429	13.541	5.112	13.224	0.317	4.795	6.201	13.22	13.178	0.046	0.046	0.8998	0.0584	1.1428	0.1046	2.0462
49	225	3																
50	250	3	8.084	13.45	5.366	13.146	0.304	5.062	5.665	13.15	13.098	0.048	0.048	0.8945	0.061	1.136	0.1092	2.0341
51	275	3	8.194	12.622	4.428	12.335	0.287	4.141	6.481	12.34	12.29	0.045	0.045	1.0163	0.0572	1.2907	0.1023	2.311
52	300	3	8.58	14.758	6.178	14.424	0.334	5.844	5.406	14.42	14.369	0.055	0.055	0.8903	0.0698	1.1306	0.1251	2.0244
53	325	3	6.489	10.966	4.477	10.695	0.271	4.206	6.053	10.7	10.649	0.046	0.046	1.0275	0.0584	1.3049	0.1046	2.3365
54	350	3	5.792	9.184	3.392	8.761	0.423	2.969	12.47	8.761	8.587	0.174	0.174	5.1297	0.221	6.5147	0.3957	11.665

55	375	3	8.508	13.226	4.718	12.966	0.26	4.458	5.511	12.97	12.909	0.057	0.057	1.2081	0.0724	1.5343	0.1296	2.7473
56	400	3	8.239	11.216	2.977	10.859	0.357	2.62	11.99	10.86	10.698	0.161	0.161	5.4081	0.2045	6.8683	0.3661	12.298
57	425	3	8.391	13.425	5.034	13.087	0.338	4.696	6.714	13.09	13.038	0.049	0.049	0.9734	0.0622	1.2362	0.1114	2.2135
58	450	3	8.429	13.745	5.316	13.402	0.343	4.973	6.452	13.4	13.348	0.054	0.054	1.0158	0.0686	1.2901	0.1228	2.3099
59	475	3	6.489	10.159	3.67	9.79	0.369	3.301	10.05	9.79	9.735	0.055	0.055	1.4986	0.0698	1.9033	0.1251	3.4079

Transect eWP1 Auger Data

Particle Size Analysis

waypoint	depth		<2mm weight	>2mm weight	total weight	% <2mm	total	<500um	% <500um	pH
60	2	0	28.6	1.4	30	95.33	6.4	3.6	56.25	7.52
61	2	2	39.5	2	41.5	95.18	6.1	4.6	75.41	7.54
62	2	4	39.5	1.8	41.3	95.64	6.4	4.8	75.00	7.89
63	2	6	40	1.6	41.6	96.15	5.5	4.2	76.36	8.11
64	2	8	32.4	12.5	44.9	72.16	6.1	4.3	70.49	8.12
65	2	10	40.4	2.6	43	93.95	5.1	3.4	66.67	8.13
66	2	12	38.1	4.2	42.3	90.07	6	3.7	61.67	8.06
67	2	14	39.5	3.2	42.7	92.51	5	3.3	66.00	8.19
68	2	16	39.4	3	42.4	92.92	5.7	4.4	77.19	8.21
69	2	18	39.6	3.5	43.1	91.88	5.5	4.1	74.55	8.27
70	2	20	38.3	2	40.3	95.04	5.1	3.7	72.55	8.28
71	2	22	40.2	1.9	42.1	95.49	5.7	3.8	66.67	8.02
72	2	24	38.3	4.1	42.4	90.33	5.7	3.6	63.16	8.01
73	2	26	38.5	3.1	41.6	92.55	5.3	3.3	62.26	8.07
74	2	28	40.8	2.2	43	94.88	5.3	3.7	69.81	8.26
75	2	30	38.5	2.6	41.1	93.67	5.2	3.1	59.62	7.93
76	2	32	36.6	4	40.6	90.15	5.2	2.8	53.85	7.77

Magnetic Susceptibility

		LOW FREQUENCY					HIGH FREQUENCY					
WAYPOINT	DEPTH	A	B	C	D	MS	A	B	C	D	MS	pot wt.
60	2	0	260.5	260.5	0.1	30.5059524	0	251	251	0.5	30.3511905	12.7
61	2	0.1	217.3	217.4	0.3	32.9076923	0.5	207	207.4	0.7	32.3153846	10.8
62	2	0.3	200.7	200.6	0.4	28.9558824	0.7	193	192.9	0.7	28.7647059	11.1
63	2	0.4	185.6	185.7	0.6	25.95	0.7	178	178.3	0.7	25.8714286	11.3
64	2	0.6	136.1	136.1	0.6	18.8571429	0.7	132	132.3	0.6	19.3071429	11.3
65	2	0.6	166.8	166.9	0.6	21.9662162	0.6	162	162	0.4	22.3243243	11.7
66	2	0.6	179.4	179.4	0.7	23.0197368	0.4	174	174	0.3	23.3486842	11.9
67	2	0.7	189.8	189.9	0.9	22.8395062	0.3	184	184.1	0.2	23.191358	12.4
68	2	0.9	382.1	382.1	1	55.5514706	0.2	361	361.2	-0.1	53.6102941	11.1
69	2	1	116.8	116.9	1.1	17.8809524	-0.1	112	112	-0.4	18.3253968	10.6
70	2	1.1	150	150	1.2	22.7578125	-0.4	143	142.7	-0.5	22.875	10.7
71	2	1.2	163.6	163.5	1.3	21.7328767	-0.6	156	156.2	-0.7	21.9931507	11.6
72	2	1.3	211.8	211.9	1.4	23.9767442	-0.7	203	202.5	-0.8	24.1395349	12.9
73	2	1.4	166.1	166.2	1.5	21.46	-0.8	157	156.9	-0.8	21.5333333	11.8
74	2	1.5	166.8	166.8	1.6	19.652439	-0.8	161	161	0.1	20.1829268	12.5
75	2	1.6	181.9	181.8	1.6	22.3164557	0	173	173.1	-0.6	22.4493671	12.2
76	2	1.6	215.7	215.8	1.8	26.5949367	-0.6	204	204.2	-0.9	26.443038	12.2

Loss on ignition

WP	DEPTH		WEIGHT W. SAMPLE	SAMPLE WEIGHT	TOTAL WEIGHT after 550 C	SAMPLE LOSS 550 C	Sample weight after 550 C	% organic carbon	weight before 1000	TOTAL WEIGHT after 1000 C	weight loss after 1000 C	released CO2	% CO2 (in total sample)	total CaCO3	% CaCO3
60	2	0	20.423	7.962	19.527	0.896	7.066	11.25345391	19.527	19.442	0.085	0.085	1.067570962	0.19329	2.427656368
61	2	2	20.508	6.202	19.757	0.751	5.451	12.1089971	19.757	19.668	0.089	0.089	1.435020961	0.202386	3.263237665
62	2	4	20.845	6.473	20.176	0.669	5.804	10.33523868	20.176	19.984	0.192	0.192	2.966167156	0.436608	6.745064112
63	2	6	20.679	6.32	19.987	0.692	5.628	10.94936709	19.987	19.824	0.163	0.163	2.579113924	0.370662	5.864905063
64	2	8	20.54	6.463	19.656	0.884	5.579	13.67785858	19.656	19.492	0.164	0.164	2.537521275	0.372936	5.770323379
65	2	10	21.123	6.821	20.23	0.893	5.928	13.09192201	20.23	20.11	0.12	0.12	1.759272834	0.27288	4.000586424
66	2	12	18.4789	7.1499	17.615	0.8639	6.286	12.08268647	17.615	17.502	0.113	0.113	1.580441684	0.256962	3.593924391
67	2	14	22.05	7.608	21.185	0.865	6.743	11.36961094	21.185	21.035	0.15	0.15	1.971608833	0.3411	4.483438486
68	2	16	19.009	6.534	18.285	0.724	5.81	11.08050199	18.285	18.158	0.127	0.127	1.943679216	0.288798	4.419926538
69	2	18	19.172	5.791	18.434	0.738	5.053	12.74391297	18.434	18.309	0.125	0.125	2.158521844	0.28425	4.908478674
70	2	20	20.245	5.865	19.511	0.734	5.131	12.51491901	19.511	19.363	0.148	0.148	2.52344416	0.336552	5.73831202
71	2	22	17.892	6.917	17.102	0.79	6.127	11.42113633	15.24	15.173	0.067	0.067	0.968628018	0.152358	2.202660113
72	2	24	18.335	8.1	17.348	0.987	7.113	12.18518519	15.206	15.123	0.083	0.083	1.024691358	0.188742	2.330148148
73	2	26	18.039	7.134	17.133	0.906	6.228	12.69974769	15.137	15.054	0.083	0.083	1.163442669	0.188742	2.645668629
74	2	28	17.049	7.541	16.086	0.963	6.578	12.77018963	14.201	14.075	0.126	0.126	1.670865933	0.286524	3.799549131
75	2	30	17.345	7.598	16.489	0.856	6.742	11.26612266	14.248	14.176	0.072	0.072	0.947617794	0.163728	2.154882864
76	2	32	18.581	7.396	17.737	0.844	6.552	11.41157382	15.801	15.733	0.068	0.068	0.9194159	0.154632	2.090751758

Vegetation Survey
Transect SN1

	vegetation	quality	dung	note
1	cynodon dachtylon, ipomoea garckeana	bare	elephant, baboon	nearby Acacia drepanolobium
2	cynodon dachtylon, craterostigma sp., ipomoea	sparse	cattle, elephant	
3	cynodon dachtylon	lush	warthog	
4	cynodon dachtylon	sparse	cattle, elephant	next to dense patch of p. stramineum, achyranthes aspera, solanum incanum
5	cynodon dachtylon	fair	zebra, grant's, giraffe	
6	cynodon dachtylon, panicum sp.	fair	cattle, giraffe	
7	cynodon dachtylon	fair	cattle. Baboon, buffalo	
8	cynodon dachtylon	bare	cattle, scrub hare	soft ground, patches of p.stram c.5m either side
9	pennisetum stramineum, hibiscus flavifolias, achyranthes aspera	lush		
10	cynodon dachtylon, pennisetum stramineum, ipomoea, themeda tr	lush	grant's, impala	
11	cynodon dachtylon, harpachne schimperi, pentonesia sp.	fair	grant's, eland	
12	cynodon dachtylon, panicum sp.	sparse	cattle, giraffe	nearby Acacia drepanolobium
12.5	pennisetum stramineum, solanum incanum, ipomoea, abutilon rehı	sparse		sparse clumps make up patch
13	cynodon dachtylon, olosiphon sp, panicum sp., ipomoea	sparse	zebra, grant's	
14	cynodon dachtylon, panicum sp., harpachne schimperi, pentonesia	fair	buffalo	
16	cynodon dachtylon, panicum sp., harpachne schimperi, pentonesia	sparse		
17	cynodon dachtylon, panicum sp., harpachne schimperi, comelina	fair	elephant, zebra, grant's	
18	pennisetum stramineum	lush	eland, zebra	
19	cynodon dachtylon	sparse	zebra	
20	cynodon dachtylon. Olosiphon sp.	fair	cattle, buffalo	close to p stramineum patch/clumps
21	cynodon dachtylon, harpachne schimperi, pentonesia, olosiphon	lush	zebra	
22	cynodon dachtylon, panicum sp.	fair	cattle	
23	pennisetum stramineum, solanum incanum (rare)	lush	zebra	
24	cynodon dachtylon	bare	zebra, scrub hare	pot and obsidian
25	cynodon dachtylon	sparse		between p. stram patches
26	cynodon dachtylon	lush	cattle	
27	pennisetum stramineum, solanum incanum	lush		

	vegetation	quality	dung	note
28	cynodon dachtylon	sparse	cattle	
29	cynodon dachtylon	lush	zebra	
30	cynodon dachtylon	lush	zebra, elephant	
31	pennisetum stramineum	lush	zebra, elephant	
32	cynodon dachtylon, solanum incanum	fair	baboon	
33	cynodon dachtylon, harpachne schimperi, ipomoea, panicum sp.	fair		among boulders and A. drep
34	cynodon plechtostachyus, pennisetum stramineum, olosiphon, achy	lush	grant's, zebra	among boulders and A. drep

Transect WE1

waypoint	vegetation	quality	dung	note
40	c. dachtylon	lush	zebra, impala, buffalo, baboon	some forbs
41	c. dachtylon	fair	scrub hare, zebra, buffalo, grant's	
42	c. dachtylon, harpachne schimperi	lush	impala, eland, buffalo, zebra	
43	harpachne schimperi (dominant), c. dachtylon	fair	zebra, giraffe	
44	c. dachtylon, comelina	bare	zebra	sample in light track but lush elsewhere with some p stram
45	p. stramineum,	lush	buffalo, zebra, impala	near termite mound
46	p. stramineum, c. dachtylon (equal), forbs	lush	eland, zebra, scrub hare	less dense than 45
47	c. dachtylon	bare	scrub hare	very sparse
48	c. dachtylon	bare	elephant, grant's,egyptian goose	mostly bare, road junction
49	c. dachtylon, pentonesia, comelina	lush	zebra, cattle	
50	c. dachtylon, p. stramineum, solanum incanum	lush	zebra	close to patch
51	c. dachtylon, achyranthes aspera, p. stramineum, hibiscus flavifolias, pentonesia	lush	zebra	
52	c. dachtylon	sparse	elephant, warthog	
53	c. dachtylon	sparse		
54	c. dachtylon, pennisetum stramineum, panicum sp.	fair	zebra	next to patch edge
55	c. dachtylon	fair	impala, zebra	near patch of p stram, achyranthes etc
56	p. stramineum, hibisucs, solanum	lush	zebra	
57	c. dachtylon, p. stramineum, solanum	fair	elephant, zebra	
58	p. stramineum, a. drepanolobium	lush	giraffe	near termite mound
59	c. plechtostachyus, a. drepanolobium, ipomoea	sparse	cattle, giraffe	5-10 acacias within 10 m radius

Micromorphology

THIN SECTION DESCRIPTION

SLIDE – MS/A/i/1
UNIT – A, east-facing section, c.1.4-1.5m from northern end of unit
CONTEXTS- 001 (topsoil), (0-75mm)

Homogeneity – homogeneous though of slightly decreasing density towards the bottom

Microstructure - massive/complex micropedal (pellets/granules)

Microfabrics/Peds:

1) pellets, c.0.05mm, rounded/sub-rounded, spherical, complex packing voids (70:30 pellets:voids, though near 50:50 in some areas near bottom), moderately developed (more so towards bottom), 50% total area TA
2) patches of massive/weakly developed with diffuse boundaries, colour same as pellets (10yr 5/8?), 10% TA

Voids:

1) complex packing voids between granules, 30% top, 40-50% bottom,
2) infrequent channel voids, increasing size with depth 0.15 – 1.5mm, some showing signs of collapse/infilling, generally rough regular shaped walls though less so towards bottom (larger voids) and some very smooth walled
3) rare vughs, though may be channel voids in cross-section, some with organic staining of surrounding matrix

Basic mineral components

Coarse fraction

C:F ratio 70:30 (with slight variation)

Single mineral grains:

Quartz: 95% Total coarse mineral (TCM), random distribution, unsorted sub-angular to rounded, blocky/tabular, mainly coarse silt to coarse sand though some granules (very rare), mainly mono-crystalline, some poly-

Feldspar: 4% TCM, mainly microcline, very rare plagioclase, similar shapes and sizes to quartz

Mica: very rare <1% elongate/platy, fine to med sand, some clustering (ie. Some areas have no mica)

Aggregates

1) ferruginous, clay rich, generally medium spherical, rounded to sub-angular, c. 0.2-1mm, well-accomodated, sharp-clear boundaries, contains quartz of similar size and shape to main fabric, sometimes appears to coat larger quartz grains though usually as pellet with c50:50 matrix:inclusions, some darker patches within (higher Fe content?/organic?), orange to grey-

ish yellow (2.5 YR 5/12 to 7.5 YR 7/12) in OIL, dark reddish brown (5 YR 2/6) in PPL, reasonably common – c. one nodule visible per frame at 2.5x, perhaps some clustering of 1 or 2 nodules

2) organic rich spherical nodule, rounded, c.1mm, well-accomodated, sharp boundaries, contains fine sand quartz grains 30%, charcoal 10%, matrix is dark brown at centre though paler around edge (similar to aggregate (1) colour in OIL) but no change of surrounding matrix colour, not common, maybe 2 or 3 in slide
3) charcoal rich (organic rich) sub-rounded slightly elongate nodule, clear boundaries, 0.05-0.1mm charcoal grains (30%) medium spherical sub-rounded, 0.05mm quartz, med spherical sub-rounded, orthic, dark brown (PPL) organic rich matrix, also dark brown in XPL and OIL, not common, 2 noted in slide
4) sub-rounded, near spherical nodule, c.2.5mm diameter of similar matrix to main fabric of slide but no packing voids, well accommodated, clear boundaries, contains example of aggregate 1, few angular quartz grains (fine sand) (5%), very few sub-rounded charcoal grains (fine sand) <5%, crystallitic b-fabric – aggregate not defined in XPL and OIL but maybe discernible in XPL through higher density calcium crystals (yellow speckling)

Groundmass
Greyish brown in PPL, greyish yellow in OIL, high order speckling in XPL

Organic
Occasional roots at varying stages of decomposition, pseudomorphic root channels, little evidence of staining of main soil fabric

Anthropogenic
2% TA unsorted charcoal, very fine flecking to fine sand grains, some iron staining of peripheries around grains (incomplete carbonisation or phosphate enrichment?), grains range from rounded/sub-rounded equant (most common, 70% charcoal fraction) to sub-angular elongate, slightly less frequent than in MS/A/i/2 below

Pedofeatures

Textural
- very rare instances of micropan clay coatings of mid to low limpidity on larger quartz grains, also some low limpidity typic coatings, very rare throughout slide
- loosely packed infillings of voids, but not all, some vughs/x-section channels maybe filled but hard to distinguish between main fabric and infillings due to granular/excremental structure
- spherical limpid nodules of illuviated clay, c.1% TA, generally isolated

Crystalline
- Very rare micritic calcite hypocoating of vughs, (rapid precipitation of calcium carbonate due to root metabolism (Wieder & Yaalon, 1982) (biogenic calcite)
- Some calcification of root fibres, throughout section but very rare

Amorphous/Cryto-crystalline
-

Fabric
- aggregate 4 may fall under this category

Excremental
- granular excremental fabric throughout, though varying density
- rare discontinuous infilling of voids with excremental pellets, well defined spherical, reddish orange to greyish brown in PPL (resemble iron-rich nodules reported in matrix coating textural feature), more common at top of slide, some denser accumulations
- faecal spherulites, present throughout but very rare, more frequent towards bottom of slide , generally single instances but occasional denser accumulations (>15)

THIN SECTION DESCRIPTION

SLIDE: MS/A/i/2
UNIT: A, east-facing section, 1.4-1.5m from northern end of unit
CONTEXTS: 001, 002, (75-150mm)

Homogeneity: homogeneous with several fabric sub-types

Microstructure: massive complex, micropedal (pellet/micro-granular)

Microfabrics/Peds:
1a) pellets , c.0.05mm, rounded/sub-rounded, spherical, complex packing voids (c.60:40 pellets:voids), clear boundaries, c.20% total area (TA) (more towards bottom of sample)
1b) as 1a but more tightly packed (c.80:20 p:v), 30% TA
2a) weakly developed sub-angular blocks, c.0.2-0.25mm, sharp-diffuse boundaries, c.40% TA (more towards top of sample), well accommodated, some amorphous patches, some spherical rounded inclusion-like areas (0.5-1mm)

Voids:
- channels show generally regular walls, moderately smooth, unoriented, some with partially intact root matter, little evidence of collapse
- vughs rounded to sub-rounded, moderately equant (though some may be channels in x-section), 0.2-1mm
- packing voids in microfabrics as above

Basic Mineral Components

Coarse Fraction
C:F ratio 30:70 (though varies), limit at 10 μ m
Single mineral grains:
- Quartz, 95% total coarse mineral (TCM), unsorted sub-angular/rounded,

blocky/tabular, coarse silt to small pebble (very rare), some mono- some poly-crystalline
- Feldspar – mainly microcline, some plagioclase(?), sub-angular/rounded, tabular, 4% TCM, unsorted, coarse silt to coarse sand
- Mica, <1% TCM, angular, platy, very fine to fine sand

Aggregates
- 1a) spherical, yellowish grey (PPL) aggregate, c.0.4mm, higher order IC clusters yellowish w. XPL, well accommodated within micropedal matrix, contains quartz (0.04mm grains, 25%) poorly sorted, sub-angular, some iron rich patches (0.02-4mm), slight darker thin coating (iron staining?), <0.02mm (#msai2_10 XPL 1.5mm, msai2_11 PPL 3mm), single instance
- 2a) blocky, dark greyish brown peds/aggregate, <5% TA, some more spherical, diffuse to clear boundaries, granite clasts (1.5mm, sapprolite?) fine sand quartz, clay coating?, sub-rounded equant grains, c:f 50:50, groundmass dark brown PPL, isotropic, rounded charcoal grains 0.2-0.4 (10%), magnetite (reddish in OIL) (#msai2_14 PPL 6mm, _15 OIL, _16 XPL)

Groundmass
Generally greyish brown in PPL yellowish grey in OIL (more orange in lower right corner and certain stained patches), high order speckling in XPL (higher density than ms/a/i/1)

Organic
Occasional roots at varying stages of decomposition,
Pseudomorphic root channels

Anthropogenic
2% TA unsorted charcoal, very fine flecking to fine sand grains, some iron staining of peripheries around grains (incomplete carbonisation or phosphate enrichment?), grains range from rounded/sub-rounded equant (most common, 70% charcoal) to sub-angular elongate

Pedofeatures

Textural
- few micritic calcitic accretions (#msai2_1, 3mm, XPL), some large >3mm (very few of these), some smaller typic nodules calcium carbonate c.0.1mm
- common iron-rich dusty clay coatings of coarse grains, micropan most frequent but common-few with very thin typic coatings, groundmass generally depleted in clay
- organic rich quasi-coating of large quartz granule, c0.08mm void on two sides of granule, no sign of clay enrichment in OIL
- matrix coating (#msai2_3 PPL 6mm, _18 XPL 0.3mm, _19 OIL 0.3mm), dense iron rich infilling of channel, dark brown PPL isotropic clayey silt, c:f <10:90, few fine quartz grains single fine sand charcoal grain (c.0.15mm), denser fine silt charcoal flecking than rest of slide, lower order speckling, few fine silt iron nodules (though resemble excremental pedofeature 2), feature possibly related to slaking of organic rich layer above eg. Enclosure sediment, may be from trampling, causes downward movement of

fine sediments, secondary channel seems to follow original,

Crystalline
some with formation of calcium oxalates (druses?) as root pseudomorphs (#msai2_17 XPL 3mm)

Amorphous/Cryto-crystalline
-partially decalcified calcite nodule, porous with peripheral iron-staining from organic acids (#msai2_8 XPL 3mm, _9 PPL)
- very few calcite nodules throughout, 0.1-0.4mm, rounded/sub-rounded equant, generally clear boundaries in XPL, different stages of decalcification, perhaps more frequent towards bottom, greyish in PPL, one contains excremental pellets
-possible phosphatic apatite nodules, c.0.2mm, light yellowish grey in PPL, first order white speckling (dense) in XPL, well accommodated, sub-rounded, (Karkanas & Goldberg)
-micritic calcite coating of quartz grain (coarse), overlying micropan clay coating, greyish, possibly degraded rhomboidal crypto-crystals (a la Canti), ash? Near large area of calcitic accretions
-large amorphous patch of micritic calcite with possible rhomboidal ash crystals, formed either side of channel void, no evidence of excess organic material (except recent root with no sign of degradation/calcification), less dense fine fraction, some excremental pellets
-possible phosphate nodule (reddish orange in PPL) wavy internal laminations

Excremental
1) granular excremental fabric throughout, though varying density (soil microfabrics 1a and 1b)
2) rare discontinuous infilling of voids with excremental pellets, well defined spherical, reddish orange to greyish brown in PPL (resemble iron-rich nodules reported in matrix coating textural feature), more common at top of slide, some denser accumulations

3) faecal spherulites, frequent throughout (usually can be seen in any given frame at max magnification) some dense accumulations (>30 spherulites), some degraded, much more frequent than above slide (ms/a/i/1)

4) very few darker vermiforms 1-2mm, usual fabric but more dense some amorphous, others defined

THIN SECTION DESCRIPTION
Slide: MS/A/ii/1
Unit: A, east facing section, 1.4-1.5m from northern end of unit
Context(s): 007, (150-225mm)

Homogeneity: generally homogeneous with some differences in fabric density,
Microstructure: complex massive granular/excremental, generally poorly defined boundaries between microfabrics (except some textural features)

Microfabrics/Peds:

1a) pellets , c.0.05mm, rounded, spherical, complex packing voids (c.60:40 pellets:voids), clear boundaries, c.20% total area (TA) (more towards bottom of sample)

1b) as 1a but more tightly packed (c.80:20 p:v), 30% TA

2) massive but seems to be degraded and compacted pellets with some welding, generally darker brown – perhaps due to higher organic content or pigment staining, 10% TA

Voids

- some small (<0.5mm) channels/planes, particularly nearer base of section, generally regular walls, little organic matter/roots but a few visible in central part of section,
- more frequent vughs than above sections
- complex packing voids between pellets

Basic Mineral Components:

Coarse Fraction:

C:F ratio: 40:60 – 30:70 (some patches), mainly single minerals but rare pieces of weathered granite?

Single mineral grains:

Quartz: 95% TCF unsorted, open spaced, sub-angular to sub-rounded, fine silt to fine gravel (fine sand most common – 95% total quartz), few poly-crystalline

Feldspar: 2% TCF unsorted sub-angular, generally med sand with rare coarse grains

Mica: 3% TCF (slightly more common than above sections), fine sand elongate sub-angular

Aggregates

1) clay rich nodule, high organic content in centre (much darker brown/black in PPL and OIL, isotropic, no birefringence), contains 30% sub-angular quartz grains (coarse silt to medium sand, unsorted), gradiation of organic/phosphate staining towards edge of nodule from centre, well accommodated, clear boundaries, c.2mm diameter, rounded, med sphericity
2) strongly impregnated orthic iron-rich nodule, c.0.2mm, rare but throughout, med sphericity, clear to diffuse boundaries
3) iron/phosphate rich sub-angular, low sphericity nodule, containing 0.02-0.05mm charcoal grains (20%), , clear boundaries, well accommodated, partially coated (micropan) with greyish (PPL) calcareous ash?? Micritic in XPL, possibly degraded rhomboidal structure, single instance in centre of TS

Fine fraction:

Greyish brown (shades lighter and darker) in PPL, light yellowish orange in OIL (higher clay content than above TS) high order speckling in XPL,

Organic:

rare dark brown staining of fine fabric (photo aii1.2)

- single instance (noted) of dense phytolith accumulation, generally rect-

angular, appear to coat channel void and vaguely aligned to void wall (photo aii1.5)
occasional fragmentary root matter (modern)

Anthropogenic:

- 2-5 % cf charcoal, generally sand sized, sub-rounded equant to elongate platy, single large grain (c.2.5x1mm) in bottom right corner
- bone, 2 significant pieces (I immediately next to large charcoal, photo aii1.3),

Pedofeatures:

Textural-

-frequent typic clay coatings of mineral grains (mainly quartz), mainly of larger grains (>0.4mm), generally high limpidity of typic coatings but micropans much less so with often higher organic content (ie. More red in OIL), no sign of laminations though some gradation of colouring under OIL with more red internally (i.e. nearer mineral grain)
- very few clay-rich nodules, spherical rounded, limpid, similar colour (yellowish orange) to typic coatings described above (low organic content?)
-few organic/phosphate rich coatings of coarse grains, sometimes overlying clay
- loose continuous infilling of channel feature near top of section, 1.5-2.5mm across (wider at base), mainly straight-sided, infilled with clay-coated (organic-rich) sub-rounded quartz grains of fine to med sand, 10-15%, occasional mica and feldspar, very few well-rounded, spherical channel cross sections,

Crystalline

Amorphous/Crypto-crystalline

-Frequent micritic calcite nodules, very fine amorphous calcitic material throughout fine fraction with occasional rhomboidal crystals and larger (fine sand/coarse silt) nodules, generally in pockets
-occasional calcitic hypocoating of voids
calcitic coating (rhomboidal?) of iron rich aggregate nodule (4), typic with some micropanning
-very rare phosphate nodules rounded, near spherical, yellowish grey in PPL, darker grey in XPL, similar to potential apatite nodules noted in previous TS

Fabric

Excremental

- general excremental fabric, fine sand size rounded spherical granules/pellets, generally weakly coalesced, very packing densities, reddish orange to greyish brown in PPL

- infilling of channel features (see above in textural pedofeature section)

- faecal spherulites, very few light accumulations (2-10 spherulites) but much fewer than in higher thin section

THIN SECTION DESCRIPTION
Slide: MS/A/ii/2
Unit: A, east facing section, 1.4-1.5m from northern end of unit
Context(s):

Homogeneity: generally homogeneous with some random variations in fabric density, though less pronounced than in higher TS (MS/A/ii/1)

Microstructure: complex, massive granular/excremental

Microfabrics/peds:

- Pellets, c.0.05mm, rounded, spherical (slightly elongate?), mainly clear boundaries, complex packing voids – density varies from 60:40 to 90:10 pellets:voids, 50% TA (pellets and voids)
- massive, probably degraded pellets, slightly more prevalent towards bottom of TS, light reddish brown, 25% TA

Voids

- complex packing voids, as above
- some channels, well-partially accommodated, c.0.1-1mm, generally regular smooth walls but no visible coating (except micritic calcite, see below), rounded/sub-rounded in cross sections
- vughs, elongate (<1.5mm long) angular, irregular, unoriented

Basic Mineral Components:

Coarse fraction:

C:F ratio: 50:50, mainly single minerals but some composite grains (quartz and feldspar/mica – granite?)

Single mineral grains:

Quartz – 80% TCF, fine sand to small pebbles, unsorted, generally sub-angular, spherical to semi-elongate, larger grain generally polycrystalline
Feldspar – 15% TCF, fine sand to small pebbles, unsorted, sub-rounded to sub-angular, more frequently spherical than quartz grains, though few larger elongate crystals, 90% microcline with some plagioclase
Mica - <5% TCF, fine to med sand, lath shaped crystals

Aggregates

1) clay/iron rich spherical nodule, very dark red in PPL/XPL, reddish orange in OIL, c.1.5-2mm diameter, sub-rounded spherical, contains spherical to elongate angular unsorted, very fine to fine quartz grains (90% TCF), single very fine feldspar grain and magnetite (charcoal?) (3% TCF), thin slightly micropanned clay coating of nodule, very distinct boundaries
2) spherical, rounded, clay rich nodule, c.1mm diameter, maybe a dark brown amorphous nodule (sub-angular, sharp to merging boundaries) with micropanned clay coating producing spherical dimensions, inclusions generally within darker area – densely packed unsorted, very fine to med

sand sub-angular quartz grains 40-50% TSA (90% TCF) with some magnetite/charcoal and very rare feldspar,

Fine fraction
Orangish brown in PPL, light greyish orange in OIL (similar clay content to above TS) , high order speckling in XPL

Organic:

- occasional fragmentary modern root matter
-

Anthropogenic:

- some charcoal flecking but less frequent than higher in the section (<1% TSA), perhaps slightly more frequent (more fine grains) in top part of this TS

Pedofeatures:

Textural

- frequent micropan clay coatings of coarse fraction, particularly larger grains, also some typic though might be expected within (and sometimes differentiate from , the generally higher clay content of the fine fraction, more frequent than in ms/a/ii/1 above
- rare and light infilling of root channels with excremental pellets – surface now below level of peak bioturbation?

Amorphous/Cryto-crystalline

- Frequent micritic calcite nodules, very fine amorphous calcitic material throughout fine fraction with occasional rhomboidal crystals (greyish in PPL?) and larger (fine sand/coarse silt) nodules, generally in pockets
- Some micritic calcite formation of relict root channels and in decomposition of extant roots

Crystalline

Fabric

Excremental

- general excremental fabric, fine sand size rounded spherical granules/pellets, generally weakly coalesced, very packing densities, reddish orange to greyish brown in PPL

- infilling of channel features (see above in textural pedofeature section)

- very rare isolated faecal spherulites – one or two noted throughout TS, perhaps others in later stages of decomposition

THIN SECTION DESCRIPTION
Slide: MS/B/1

Unit: B, east facing section, northern half, 20-30cm from north end
Context(s): 010, (0-70mm)

Homogeneity

Top third of TS lighter in colour (light brown) with horizontal striations/ microfacies, slightly darker in centre of this area and possibly above though cut off by TS edge (maybe another striation), fairly distinct boundary with darker brown layer below and darkest for c.1mm at boundary, lower 2/3 homogeneous

Microstructure weakly developed massive granular in top part (hereafter fabric A, bottom) complex massive (fabric B)

Microfabrics/Peds

- A) weakly developed pellets, c.0.05mm, rounded spherical, diffuse-clear boundaries, horizontal striations with more massive material in top third of TS, apedal, light grey to light greyish orange, density varies between 10:90 and 70:30 pellets:voids
- B) complex massive, lower two-thirds of TS, light greyish brown (some darker brown (organic rich?) patches near A/B boundary, some weakly-moderately developed sub-angular blocky peds in certain areas (c.10% of microfabric area)

Voids

- complex packing voids in fabric A (see above), density according to striation
- channels, definite root channels, some with intact root matter, some sign of collapse (though little infilling), <0.05mm-0.3mm, undulating-rough generally regular walls, 5-10% TA (fabric B), very rare in fabric A (though live root matter suggests might be rapidly infilled/bioturbated)
- vughs/vesicles, angular-sub-rounded, near-equant, rare 1% TA,msmooth walls

Basic mineral components

Coarse fraction

C:F ratio 30:70/20:80 depending on striation in fabric A, 20:80 in fabric B, predominantly single mineral grains throughout though very rare composite granite (quartz, feldspar, mica)

Single mineral grains

- quartz, 90% TCF, fabric A) sub-rounded-sub-angular, very fine sand-granules (fine-med sand most common, 80%) moderately sorted by striation based on size – smaller grains set in granular matrix, larger grains show most complex packing voids, closed-single spacing, fabric B) angular-sub-angular, coarse silt to very coarse sand (occasional granule, fine sand most common (80%), unsorted, single-open spacing
- feldspar, 9% TCF, as above, generally more rounded in fabric A than B, some elongate grains in fab B, otherwise simila shapes and sizes to quartz
- mica, 1% TCF, occasional small (fine sand) grains of biotite and other mica (possibly),

Aggregates

- clay/iron rich spherical nodule, very dark red in PPL/XPL, reddish orange in OIL, c.1.5-2mm diameter, sub-rounded spherical, contains spherical to elongate angular unsorted, coarse sand quartz grains (3 grains total (90% TCF) some fine sand quartz grains (10% TCF), very rare (<5% TA small, <0.05mm, rounded equant vesicles), several smaller examples within fab B
- clay rich (orange) spherical aggregate, possibly agglomeration of excremental pellets, single instance fab A
-

Fine fraction
Light greyish brown in PPL, little or no speckling in XPL, very light orange brown in OIL (low clay content), lathy mineral crystals (mica?) (not

Organic

Occasional fragmentary root material, common in fab A but present (rare) in fab B

Anthropogenic

Charcoal flecking (though some magnetite and haematite), sub-angular – sub-rounded, generally fine-med sand, more frequent in fab A (c.5% TSA, fab B=c.1-3%)

Pedofeatures

Textural
- rare typic and micropan clay coating of quartz grains (usually larger grains) and some appear as aggregates (ie. Distinct from groundmass/surrounding microfabric) (fabrics A & B)
- infilling of root channels in fabric A with excremental pellets (costant bioturbation)
- striations in fabric A, horizontal of varying thicknesses (c. 0.5-2mm), higher density bands are thinner, thicker bands continuous across TS

Amorphous/Cryto-crystalline
- very rare micritic calcification of root relicts in fabric B
- very rare and very thin <0.01mm typic calcite formation on vugh/channel (cross section) void walls

Excremental
- as above, excremental fabric A and some infilling of void space with excremental pellets (but no so clearly visible as in unit A thin sections)
- - no evidence of dung spherulites

THIN SECTION DESCRIPTION
Slide: MS/B/2
Unit: B, east facing section, northern half, 20-30cm from north end
Context(s): 010,011 (70-140mm)

Homogeneity

Fairly homogeneous, slightly more fragmented (more void space) in lower two thirds, higher CF, same fabric throughout (more excremental at base?)

Microstructure

- complex massive, excremental in parts, particularly lower down (diffuse boundaries), possibly degraded excremental pellets throughout, apedal

voids

- complex packings voids, varying densities, c. 30% TA on average (some areas particularly at top of TS are much denser, pockets of higher CPV frequency lower down)
- channels, 0.1-1mm, generally regular undulating walls, some infilling, much less frequent than in above TS MS/B/1, unoriented (possibly slightly vertical)
- vughs, irregular, 3% TA, rough walls, random

Basic mineral components

Coarse fraction

C:F ratio 30:70 (top) to 50:50 (bottom), mainly single mineral grains

Single grains

Quartz – 80% TCF, fine sand to small pebbles, unsorted, generally sub-angular, spherical to semi-elongate, larger grain generally polycrystalline

Feldspar – 15% TCF, fine sand to small pebbles, unsorted, sub-rounded to sub-angular, 90% microcline with some plagioclase

Mica - <5% TCF, fine to med sand, near-spherical and lath shaped crystals

Aggregates

- clay rich rounded nodule, contains 50% sub-angular fine sand polycrystalline quartz and feldspar (granite?) notably higher clay content than surrounding fine fraction, also single piece magnetitite, c.1mm across, clear boundaries
- - deep red iron-rich clay nodule, sub-rounded, very clear boundaries, contains sub-rounded coarse silt quartz single grains,

Fine fraction

Light greyish brown in PPL, slightly more orange towards bottom of TS, brown in XPL with little or no speckling, generally light orange brown (similar clay content to ms/b/1) with some more vivid areas

Organic

Very rare root matter, little staining of fine fraction, various stages of decomposition

Anthropogenic

Some very rare angular charcoal flecking (various sizes – silt to fine sand), present throughout TS but <1% TCF

Pedofeatures

Textural

- clay coatings of sand-sized grains, generally micropan though some typic, more common at bottom of TS (also coatings present on smaller grains), possibly more iron rich lower down (deeper orange)
- some infilling of root channels (with excremental material) but less frequent

than ms/b/1

Amorphous/Cryto-crystaline
- some very thin calcite coating of void walls, rare

Excremental
- *some excremental infilling of voids as mentioned above, less clear as an excremental fabric than above*
- no evidence of dung spherulites
-

THIN SECTION DESCRIPTION
Slide: MS/B/3
Unit: B, east facing section, northern half, 20-30cm from north end
Context(s): 012, (140-190mm)

Homogeneity: homogeneous fine fraction, possibly with larger pebble-size inclusions at top of TS

Microstructure

Complex massive, apedal

voids

- complex packing voids? Vughs and unoriented channels though rougher/irregular walls than above – collapsed? Voids c.30% TA throughout

Basic minerals components

Coarse fraction

C:F ratio 40:60 (though 60:40 if large inclusions are counted), coarse frac mix of single mineral grains and large pebbles of parent rock (gneiss), larger grains generally sub-rounded, angular small grains, possible bimodal sorting, large grains and coarse silt-sand grains
Quartz: 80% TCF, fine sand to polycrystalline pebbles
Feldspar: 15:
Mica: 5%

Aggregates
- very rare clay/iron-rich deep reddish brown (XPL) spherical nodules containing fine sand sub-angular quartz (15% TA), clear boundaries (agg 1), c. 0.2mm
-

Fine fraction
- dark greyish brown XPL, greyish brown PPL, lightly speckled XPL

Organic
Very rare root matter, some iron staining though perhaps not organic origin

Anthropogenic

- possible rare charcoal frags though probably magnetite/haematite (reddish boundaries)

Pedofeatures

Textural

- *frequent clay coatings (micropan and typic) of coarse grains throughout, some infilling of cracks in coarse material possible illuviation*

Amorphous/*cryptocrystalline*

- possibly some calcite nodules (spherical, clear boundaries), very rare – 1 ro 2 instances,

excremental

partially granular structure may be attributed to excrements, possible from termite bioturbation, though no clear indication of excremental origin, and certainly not fresh

THIN SECTION DESCRIPTION

Slide: MS/D/1
Unit: D, east facing section, 50-60cm from south end
Context(s): 040, (0-70mm)

Homogeneity

Homogeneous

Microstructure

Complex massive granular, excremental in parts – though remainder could be formed of degraded excremental pellets

Voids

- complex packing voids (c10%, particularly in excremental/pellet areas
- channels/vughs, 20% TA, some clear regular undulating walls, others signs of infilling

Basic mineral components

-C:F ratio 50:50, mainly single min grains, quartz, feldspar, mica (85:10:5), generally sub-anugular though greater sphericity and roundedness in larger grains, mostly coarse silt/fine sand though some coarse sand grains, mica lathy crystals

Aggregates

Fine fraction

Very dark brown in PPL and XPL, little speckling, light orange in OIL, more so in bottom half of section, slightly more orange than upper TSs from unit A (eg ms/a/i/1) also much darker in PPL (organic content much higher)

Organic

Significant organic staining of fine fraction, very dark brown, unoriented and

lacking fibrous texture
Some cross sections of roots, up to 3-4mm diameter, throughout TS but more frequent in top half c.5% TA
Some accumulations of phytoliths in voids see photo d1.1

Anthropogenic
Some possible charcoal flecking but my be magnetite/haematite, mainly small grains but some smudging

Pedofeatures
Textural
- clay coatings of larger grains, maybe iron rich, throughout

Amorphous/Crypto-crystalline
- some light calcification of root matter
- possibly occasional apatite phosphatic nodules, spherical, clear boundaries

Excremental
-common microfauna excrement in top 10mm of TS, coarse silt sized, clear boundaries, main fabric appears to be massive but may be largely excremental, degraded,

THIN SECTION DESCRIPTION
Slide: MS/D/2
Unit: D, east facing section, 50-60cm from south end
Context(s): 040, 041 (70-140mm)

Homogeneity
Homogenous, but for single feature (textual pedofeature 1)

Microfabric
Complex massive granular, excremental in parts – though remainder could be formed of degraded excremental pellets, more frequently excremental than msd2, lighter brown in PPL than MSd1

Voids
- complex packing voids (c10%, particularly in excremental/pellet areas
- channels/vughs, 20% TA, some clear regular undulating walls, others signs of infilling

Basic mineral components
-C:F ratio 50:50, mainly single min grains, quartz, feldspar, mica (85:10:5), generally sub-anugular though greater sphericity and roundedness in larger grains, mostly coarse silt/fine sand though some coarse sand grains, mica lathy crystals

- *Aggregates*
- - deep red iron-rich clay nodule, sub-rounded, very clear boundaries, contains sub-rounded coarse silt quartz single grains, two instances, though other similar material occasionally though less coherent nodules (irregular shape, more

diffuse boundaries, no inclusions etc)

Fine fraction
Very dark brown in PPL and XPL, little speckling, light orange in OIL, more so in bottom half of section, slightly more orange than upper TSs from unit A (eg ms/a/i/1) also much darker in PPL (organic content much higher)

Organic
Less staining of fine fabric, lighter brown in PPL
Fewer instances of fresh or degraded root matter, though still occasional root pseudomorphic void spaces

Anthropogenic
Very rare coarse silt charcoal grains and some possible fine flecking, difficult to differentiate from haematite/magnetite

Pedofeatures
Textural
- very rare micropan coatings of coarser grains, though not so common as above
    - probably infilling of large near-vertical channel/planar void, c.0.5mm wide, 7-8mm long, c:f ratio 10:90 (much fewer inclusions), probably enriched in clay/iron, slightly redder in PPL, some med sand sub-angular quartz and feld-spar, as in major fabric, med silt quartz also

Amorphous/Crypto-crystalline
- some light calcification of root matter
- possibly occasional apatite phosphatic nodules, spherical, clear boundaries

Excremental
- probably total excremental fabric
- more common infilling of voids with microfauna exc. pellets

THIN SECTION DESCRIPTION
Slide: MS/D/3
Unit: D, east facing section, 50-60cm from south end
Context(s): 042, (140-210mm)

Homogeneity
No major fabric changes, larger mineral grains towards base

Microstructure
complex massive granular/excremental

voids
- complex packing voids (c10%, particularly in excremental/pellet areas
- channels/vughs, 20% TA, some clear regular undulating walls, others signs of infilling

- possibly greater void area towards base of TS

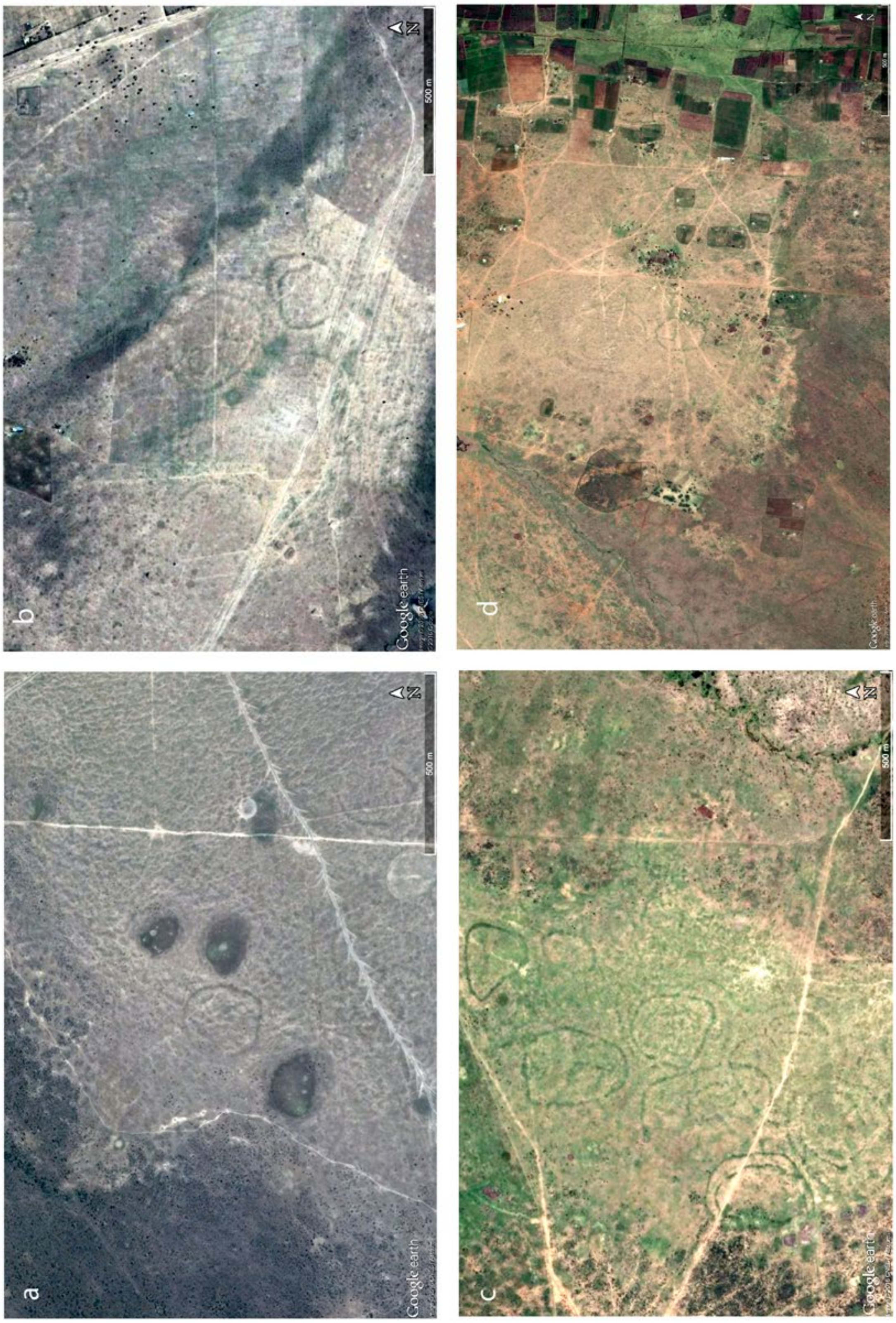
Basic mineral components

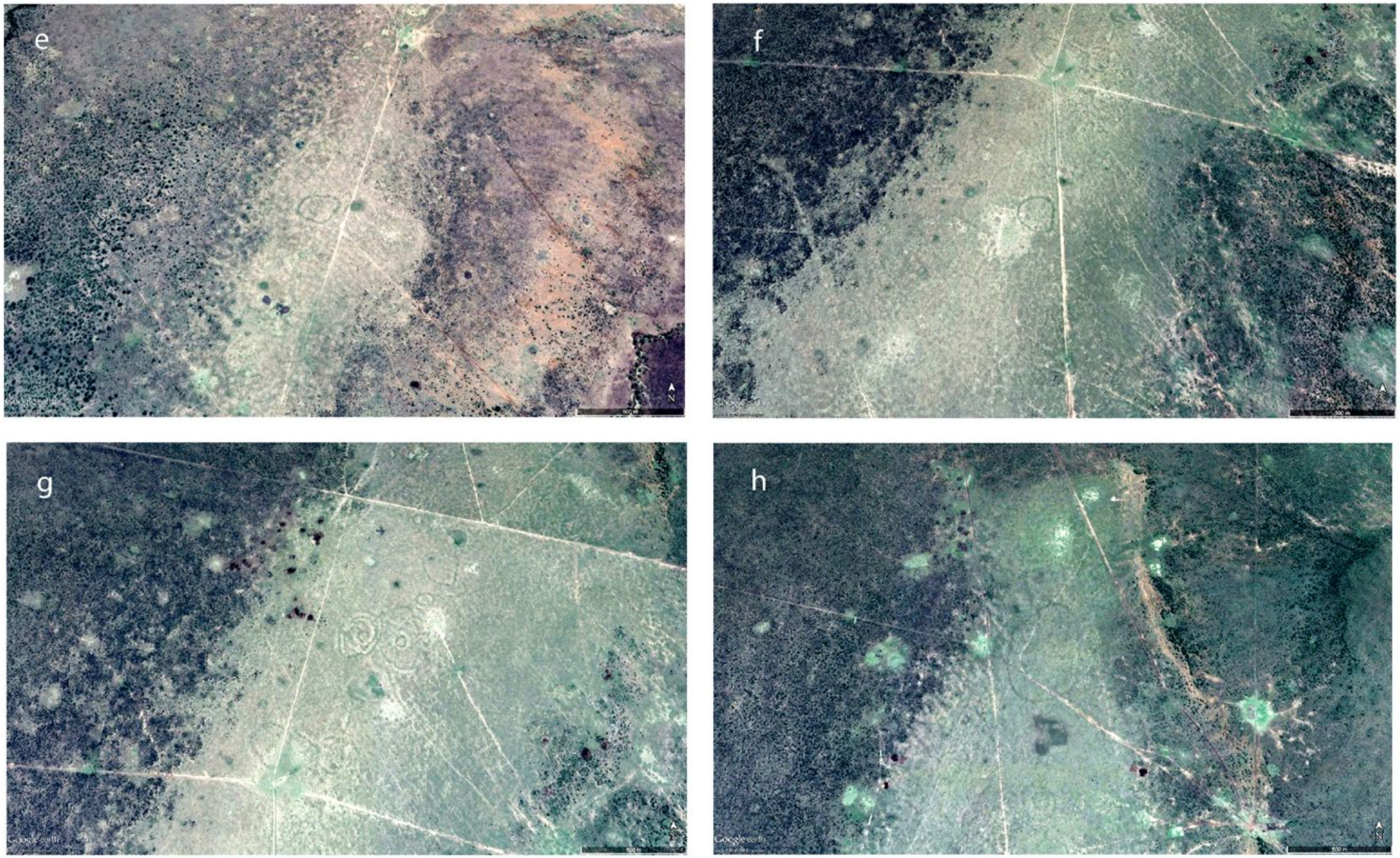
-C:F ratio 50:50, mainly single min grains, quartz, feldspar, mica (85:10:5), generally sub-anugular though greater sphericity and roundedness in larger grains, mostly coarse silt/fine sand though some coarse sand grains, mica lathy crystals

Isotopes

Sample	Dist from ERJ	C	O	Sr
LH1A	2.8	-0.0356592	1.47204606	
LH1B	6.3	-0.0759336	2.66842052	0.706683
LH1C	10.2	0.32461388	2.02160207	
LH1D	14	0.46740047	1.25159145	0.706668
LH1E	17.9	0.26522915	1.99057963	
LH1F	21.6	0.05742737	2.02840945	0.706578
LH1G	25.7	-0.0694282	2.06201582	
LH1H	30.2	-0.0671854	0.84777968	
LH1I	33.1	-0.044616	1.51145849	0.706501
LH2A	15.7	-0.3884737	-1.3469646	
LH2B	19.4	-0.3729122	-1.4421559	
LH2C	22.6	-0.3878344	-1.2745417	
LH2D	27.9	-0.2544825	-1.2832053	
LH2E	31.1	-0.1597806	-1.6926938	
LH2F	34.9	-0.2670729	-1.4635688	
LH2G	38.4	-0.4126108	-1.8891566	
LH2H	42.4	-0.3893242	-1.62011	
MA1A	3.7	-5.2054246	-0.3837183	0.706801
MA1B	5.8	-4.5564085	-0.5640175	
MA1C	8.3	-3.6742128	-1.650309	0.706725
MA1D	12.2	-2.4018722	-0.8709283	
MA1E	15.6	-1.9130677	-0.6731505	
MA1F	19.1	-1.4729388	-0.5710183	
MA1G	22.2	-1.5496589	-0.9791069	0.707143
MA1H	25.3	-1.5691293	-0.1148664	
MA1I	28.2	-1.6349367	-0.1413048	0.707321
MA1J	31.3	-1.7464253	-0.1620768	
BA1A-A	3.1	2.77031158	-0.8552915	0.706688
BA1A-B	5.9	2.51824027	-0.7261997	
BA1A-C	8	2.30965151	-0.7637833	0.706626
BA1A-D	10.6	2.42521501	-1.3358992	
BA1A-E	12.5	2.24854188	-1.2226062	0.706585
BA1A-F	14.3	1.93745879	-1.2048178	
BA1A-G	17.4	2.12574164	-1.0069168	
BA1A-H	20.3	2.20557736	-1.0679004	0.706405
BA1B-A	4.3	1.29189994	0.58909109	
BA1B-B	7.1	1.16571124	-0.2948902	
BA1B-C	9.7	1.31704612	-0.721385	
BA1B-D	12	1.36950503	-0.6173101	
BA1B-E	14.3	1.71982858	-0.229305	
BA0A-A	4.2	0.78920292	-0.0060243	
BA0A-B	6.5	0.71245959	1.11048066	
BA0A-C	8.5	0.81956422	0.38128157	
BA0A-D	11.2	0.71761765	1.56546466	
C12A	4.6	0.63619015	-1.2891564	
C12B	6.3	0.59991123	-1.1534056	
C12C	8.3	0.35499254	-0.6590998	
C12D	10.4	0.13010299	-0.8726371	
C12E	12.2	0.24254724	-1.0671056	
C12F	14.3	0.28598025	-0.8428462	

Regional survey sites (Google Earth)

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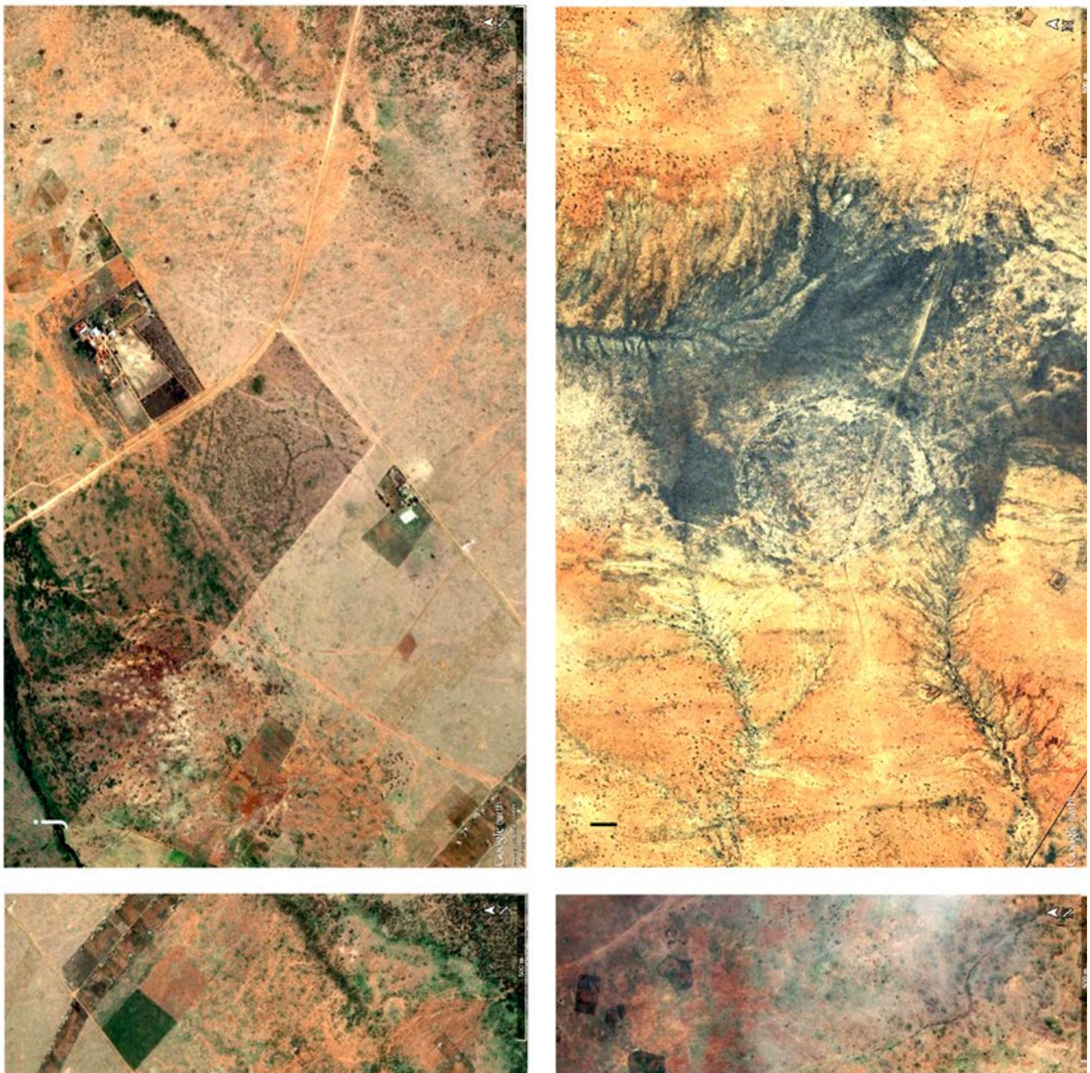
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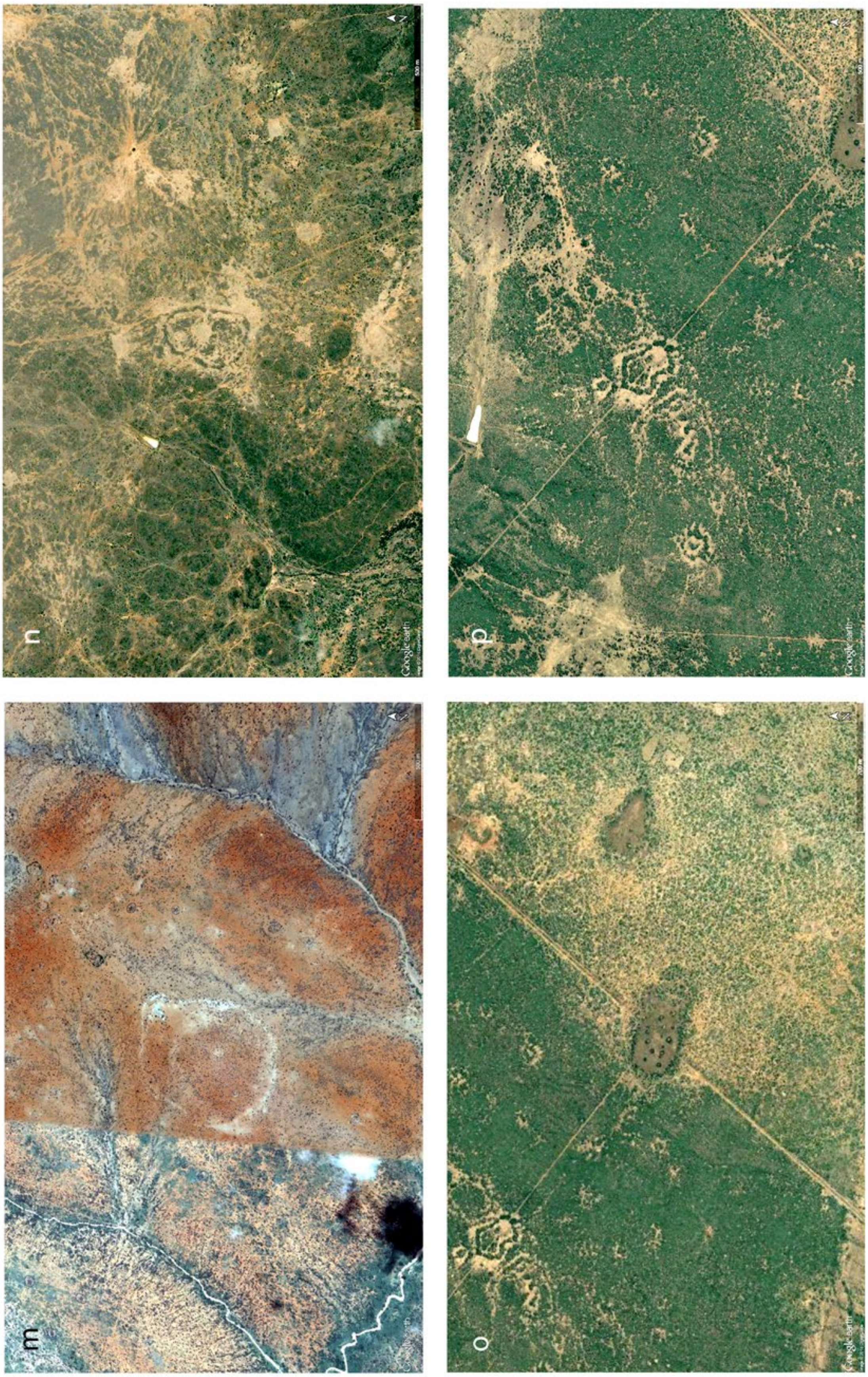

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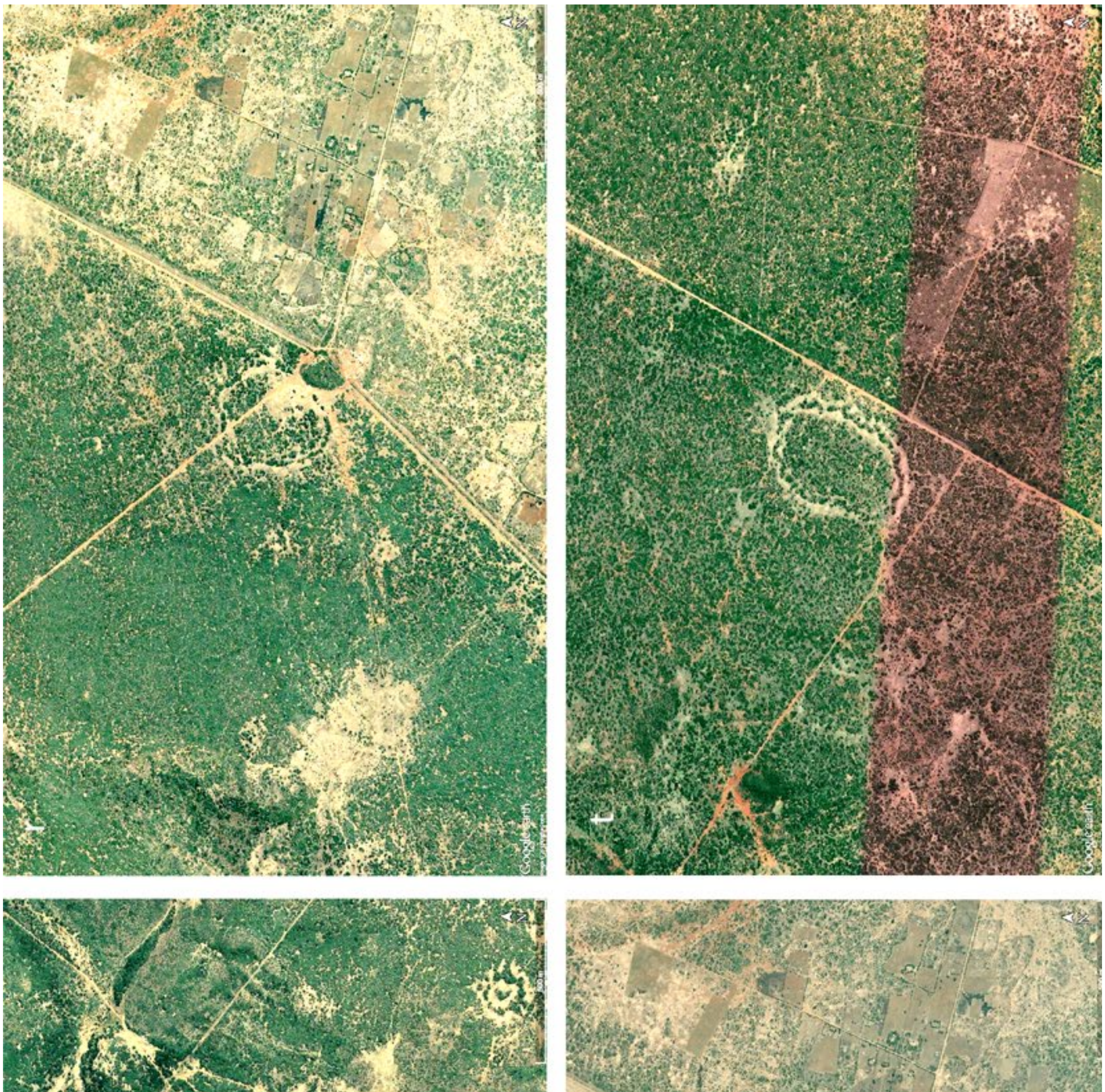
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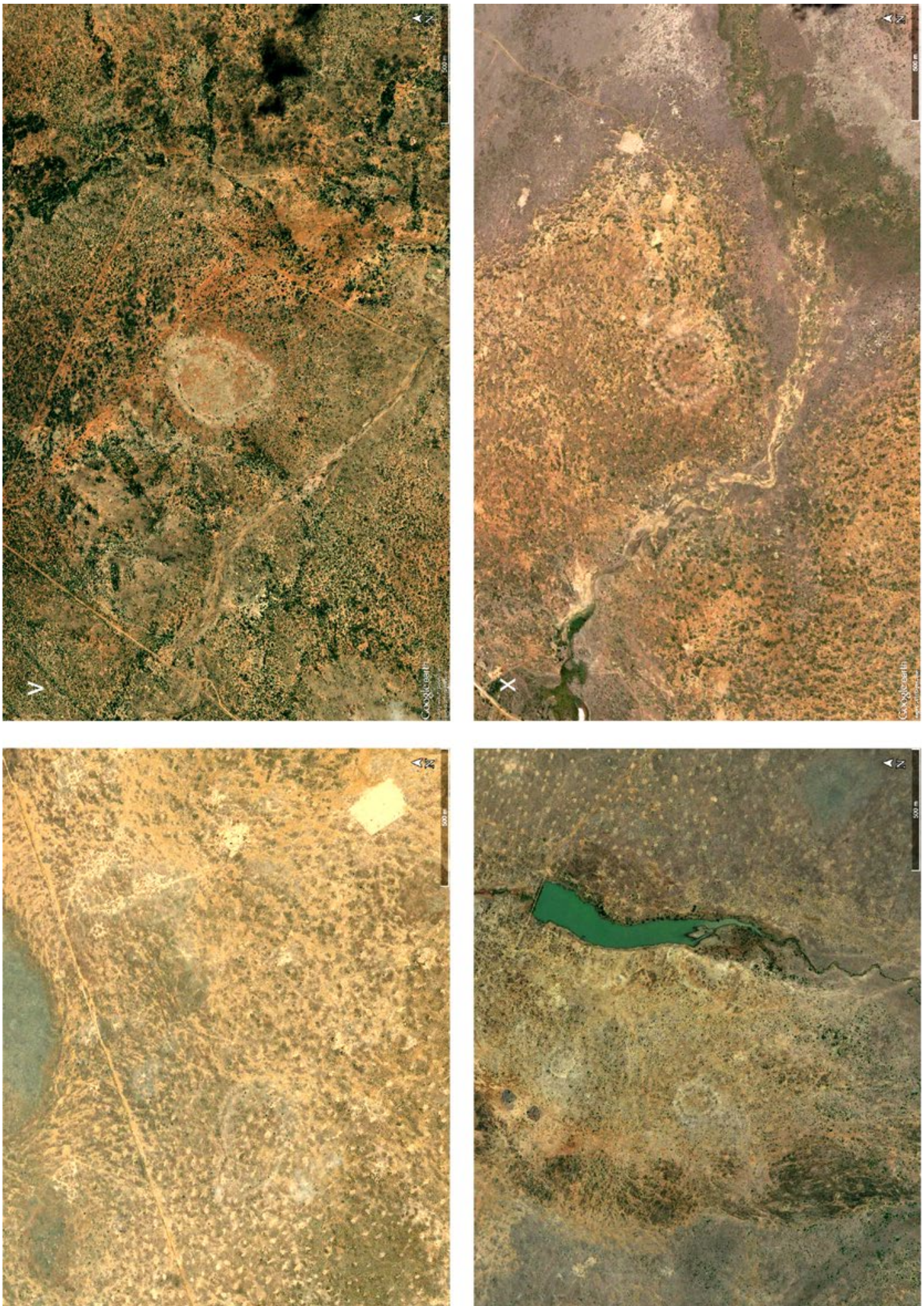

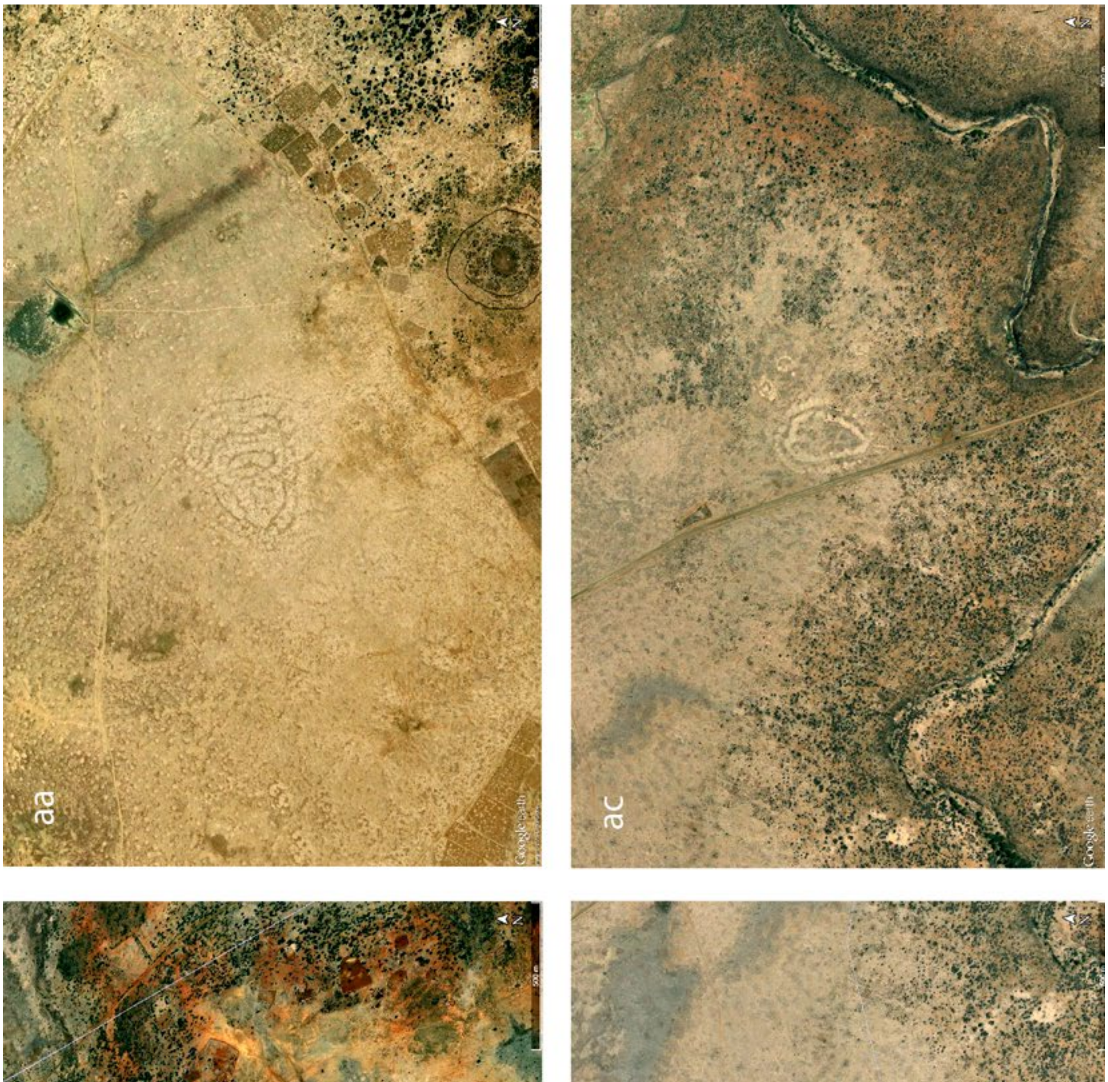
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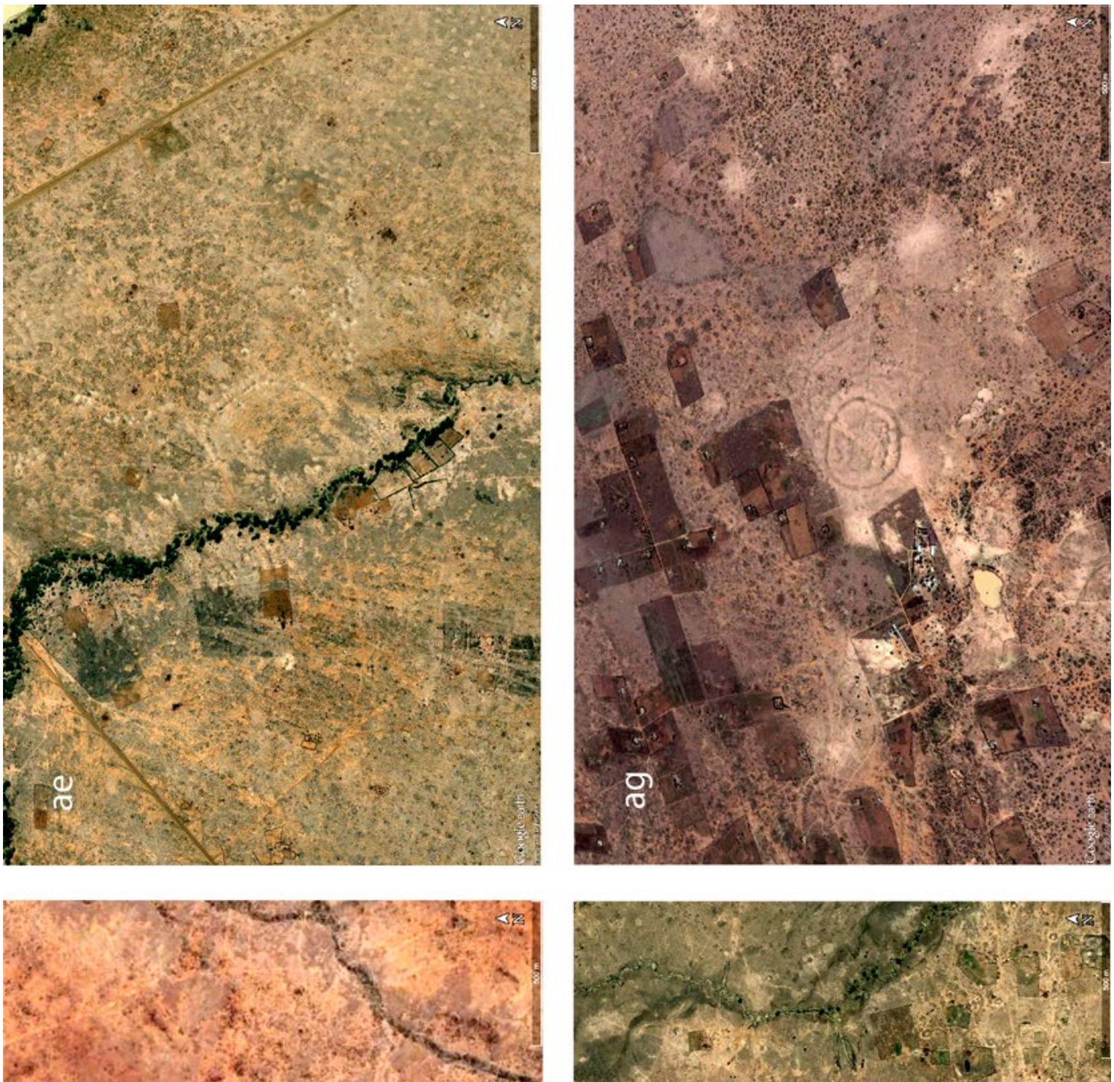
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