INTRODUCTION

African soils cannot be separated from African history because they are, in themselves, historical bodies and they have interacted with human history since its beginning. The history of soil other than of its genesis (a concern of pedology) is a history of its perceptions and the consequences of its use. Such a history must necessarily be one of exploration and discovery, of experimentation and classification. The late nineteenth- and twentieth-century European experience is only the latest in a long series of human encounters with the continent. An essential feature of Africa’s soils is their diversity. This is to be expected, when one considers the sheer size of the continent, and its many ecosystems. Africa’s approximately 30,221,392 sq.km. is greater than the land areas of China, Europe and the United States combined, see Figure 6.1. It accounts for 20.4 per cent of the earth’s land (National Geographic Society 1990, p. 130). This vast area contains snow-capped mountains, hot deserts, tropical rainforests, savannas and swamps, as shown in Figure 6.2.

The diversity of African soils was demonstrated in the twentieth century by the many complications encountered when ‘modern’ or ‘improved’ agricultural techniques were implemented throughout the continent. African soils simply did not fit preconceived notions, and did not respond in a manner similar to soils in other places (Lal and Sanchez 1992). Purveyors of modern and improved agriculture were, to use T. Beach’s (1998, p. 400) concept, ‘environmental pioneers’, as had been Africans before them when they migrated and settled in different parts of the continent.

Europeans first encountering the tropical African high forest concluded that the red-coloured soils must be extremely fertile to support such luxuriant growth. In time, red soils became known as the curse of Africa, liable to harden irreversibly and become useless under cultivation. Eventually, all colours of soil were said to erode with ferocity, when not blowing in desiccating winds. Finally, it was said that African soils were worn out by African smallholders’ agricultural ‘mining’ of their fertility, and destroyed by trampling of their livestock. To gain some perspective,
this chapter will attempt to view African soils as understood and used by Africans and Europeans for as much of the past as there is some kind of evidence.

Charting the ideas and activities of various waves of environmental pioneers on the African continent is a complicated process. Africa remains an understudied continent, and African knowledge systems – a profoundly endangered resource – are generally unknown to the larger world community. The historical record (in its broadest sense) is incomplete. Few documents have been analysed from an earth perspective, oral histories of societies and their landscapes have not been collected.
in most locations, and archaeological research has been very limited. However, materials from a wide range of sources do exist from which examples can be drawn for consideration. While the absence of reliable evidence is problematic, the confusion created by apparently authoritative documentation that lacks a firm factual basis must also be clarified. The twentieth century was a time when overlapping knowledge systems and practices existed, but not necessarily to the benefit of the newly arrived environmental pioneers – or the earth. Prejudice and ignorance often prevented information exchanges.
To provide a base for considering a history of African soil, general discussions of the perceptions of Africa and its soils, measurable properties of African soils, and soil knowledge systems will be presented. Attention will then turn to examples of African and European encounters with African soils. Four categories of activities that could have affected soil properties or entire soil bodies will be considered: crop production, livestock management, architecture/urbanisation, and mining. Discussion will centre around specific studies of particular places or systems in an attempt to identify mechanisms of change, rather than a continuous continent-wide analysis in careful chronology. Generalisations from relevant studies will be made hesitantly, keeping in mind Richards’ (1985, pp. 12, 13) cautions about working from a base of ecological particularism and seeking to avoid both ‘glib generalisation’ and ‘ad hoc arguments’ or ‘special pleading’, as well as concerns about the distortions inherent in extrapolation. Topics in need of further consideration or research will be noted, as this chapter is intended as a preliminary survey of the topic.

PERCEPTIONS OF AFRICAN SOILS

For outsiders (and not a few Africans), Africa – as landscape, vegetation or people – has been defined by European perceptions and experiences, particularly in the late nineteenth and twentieth centuries. Without understanding and acknowledging the nature of this definition, it is difficult to discuss Africa as perceived and experienced by others. The first complication is scale. Africa is a huge continent with extremely different climates, landscapes and cultures – not a country with a range of characteristics. Descriptive examples or scientific measurements from specific places or time periods – often extremes – have come to be cited as ‘typical’, and have been so generalised that a large, varied continent has been intellectually collapsed into a smaller, more homogeneous entity. Africa is often referred to as if it were a country defined by a few (largely negative) characteristics.

The creation of British Colonial Africa in the first two decades of the twentieth century nurtured this process at a bureaucratic level; a separate Tropical Africa Service was created within the Colonial Service to staff British Africa, just as the older, separate India Service staffed British India (for discussion of the creation of British Colonial Africa see Showers forthcoming). Officers in the Tropical Africa Service could be – and frequently were – moved from territory to territory. As they met and compared their experiences, and discussed them with other local non-Africans (traders, missionaries), consensus built. It was these generalised perceptions that informed London – insofar as Africa was discussed at all. Until the 1930s, few British Government officials had ever visited the continent (Killingray 2000, p. 42). A similar process of consensus based upon superficial observation informing a colonial bureaucracy took place in France.
With colonial administrations in Africa (British, French, Belgian, German, Portuguese) came expert opinion. An individual with (or without) subject matter specialty would arrive, tour, collect documents, meet with local authorities, and produce a report. In many of these reports opinion, rather than data, dominated. A.T. Grove (2000) reviews this literature of opinion, discussing some of the more notorious – and highly influential – reports responsible for codifying and spreading misinformation about Africa. It is these documents that established the framework for Roe’s (1991, 1995) ‘crisis narratives’. Soil has been central to many of these crises, from laterisation, degradation and desertification through fertility decline and erodibility. Modern expert reports and analysis continue the process. A late-twentieth-century example is the debate about ‘nutrient mining’ in the Sahel. A ten-year ‘comprehensive data bank’ was used to generate numbers that apparently demonstrated a dramatic depletion of soil fertility by traditional land users. The numbers were derived from combinations of soil erosion estimates with semi-quantitative nutrient loss data and ‘best estimates’ (some with coefficients of variation of 50 per cent), that were then ‘upscaled’ and projected across an entire region (Dreschel et al. 2001, pp. 412–23). ‘Science’ had once again validated preconceived belief.

In the late-twentieth century many of the ‘truths’ behind the crisis narratives, as well as the narratives themselves, were challenged (reviews of some of the crisis literature can be found in Scoones 1997; Batterbury et al. 1997; Mazzucato and Niemeijer 2000, pp. 16–21). Nevertheless, crisis narratives and the beliefs they support are so widely accepted that presentation of alternative perspectives is frequently derided as being romantic.¹

For this reason, any attempt at writing a history of African soils must contend not only with the enormous size of the continent and its ancient human history, but also with both the lack of reliable information and an excess of generalisations and misrepresentations. To move beyond a debate about competing

¹ Discussions not based on crisis narratives are often accused of asserting the idea of ‘Merrie Africa’. In defence against such a charge, Helge Kjekshus reminded readers in a footnote to the Introduction to the 1996 impression of his 1976 classic work, Ecology Control and Economic Development in East African History, “The term “Merrie Africa” is first used by Hopkins (1973: 10) as a contrast to “Primitive Africa” of Alfred Marshall (1938) to set the stage for Hopkins’ pioneering work on West African economic history. As the reader will recall, “Merrie Africa” denoted to Hopkins a mythical situation of populations living, without working, in abundance and plenty, but pursuing lives of ease and leisure of which major parts consisted of “interminable dancing and drumming”’. Kjekshus then states that in his book, “The portrait of East Africans that emerges … is that of hard workers, skillful planners, active learners and ultimate survivors. These are clearly not characteristics of the cast that made up A.G. Hopkins’ myth of “Merrie Africa”’ (Kjekshus 1996, p. xxix).
narratives, sources of information must be identified that can suggest the nature of interactions between humans and soils, as well as indicate whether they resulted in transformation, creation or destruction of soil bodies. A not inconsequential problem, as Scoones (1997) points out — and Chambers (1983) before him — is that even reliable studies are simply ‘snapshots’ of a particular place at a specific time. In Africa, ‘some people in some places at some times’ experienced events and conditions that didn’t happen elsewhere, or at that place, but in a different time. Much of Africa has an extremely variable rainfall distribution, making it difficult for anyone to identify what is typical and what is extreme. In many cases, the extremes (drought and flood) are both typical and normal.

But it is the very perception of normal that makes historical documents difficult. As discussed by Showers (1989), normal to most people is that which is familiar, not a statistical concept of mean and deviation. Most documenters of Africa — travellers, residents, or experts — found whatever part of Africa they encountered to be quite different from their place of origin, and judged it to be abnormal. West Africa’s climate and the presence of malaria inhibited European settlements, but not commerce or the establishment of plantations. The ubiquitous red soils were very distinct, even to short-term visitors. In some places, red soils cleared for crops hardened. These soils were described as ‘laterite’, the name coined by British geologist F. Buchanan-Hamilton in 1807 for red earth (it was not referred to as soil) that hardened and was used for bricks in the Kerala District of India (Russell 1973, p. 730; Schantz and Marbut 1923, pp. 118, 180–82). In 1820 P. Berthier analysed soil samples from the Fouta Djallon of West Africa, and found them to be similar to that of Kerala, and in 1911 J.D. Falconer described some Nigerian soils as ‘iron clay’ (Encyclopaedia Britannica 1929 vol. 13, p. 740). Soon all red West African soils were assumed to be laterite.

Semi-arid or arid regions of Africa were frequently perceived as being defective, or in a state of decline or degradation. These conditions were often blamed on local people and their land use system. In the Cape Colony (modern South Africa), R. Grove (1989) first argued, and Endfield and Nash (2002) documented in detail, how fundamentalist interpretations of the Bible led missionaries to believe that the dry landscape was a sign of God’s punishment of the indigenous people; in neighbouring Basutoland (modern Lesotho), the relative lack of trees in the natural grassland was assumed by some to have been due to deforestation by the local residents (Showers 1989; Showers 2005); and in French North Africa, particularly Morocco, the lack of trees was said to be proof of the destructiveness of Arab land-use practices (Davis 2005). In both the semi-arid West African Sahel and southern Africa there is a literature attributing the low fertility status of the soils to traditional land use practices, particularly the burning of grass or dung.

Ideology, bias and perceptions of normal clearly have distorted observers’ accounts of Africa. But these predispositions may well have been magnified by a
confusing biophysical reality. Geomorphologist Martin Williams (2003) illustrates
the difficulties involved with determining whether recent environmental change was
due to earth processes or human activity. Examples from various savanna systems
showed that major geomorphic events, such as tectonic activity, sand dune forma-
tion and historic floods and droughts, could account for recent environmental
change in places where policy was directed at modifying human behaviour that
had been identified as the cause of problems such as deforestation or soil erosion.
Knowledge of the African biophysical world and its processes is fundamental to
understanding human interactions with it.

In an attempt to dispel northern hemisphere biases and presumptions, and
to begin to establish notions of African normalities, it is important to have an idea
of the soil properties to be expected under the range of soil forming conditions on
the African continent. Africa must be compared to itself, and not misconstrued as
a deviation from other continents.²

AFRICAN SOIL IN THE ABSENCE OF HUMANITY

The African continent is ancient and the soils have been unaffected by glaciation
(Mt Kenya’s and Mt Kilimanjaro’s glaciers’ local effects being exceptions). Outside
of volcanic regions, African soils did not have additions in the Quarternary. For
this reason, along with Australia, the Amazon shield and southern India, Africa
contains some of the oldest geomorphic surfaces on earth (Eswaran et al. 1992, p.
3). Soils formed on these surfaces are so ancient that they are no longer related to
the underlying rock. Adjacent to these extremely old surfaces are newer ones, largely
the result of uplift and peneplanation. Volcanic eruptions and stream deposition
have also influenced local soil properties. Geomorphology has, therefore, been an
important control on soil forming processes (Eswaran et al. 1992, p. 3). Although
all of the rocks found in the temperate zones except glacial till are found in the
tropics, some soil forming processes related to time are unique to that region,

² When considering environmental factors in an historical context, historians are confronted
by two problems: the belief of some post-modernists that science is just a social construc-
tion, and a charge of environmental determinism. Those concerned with these ideas might
consider Nancy Jacobs’ discussion of the distinction between nature, a social construction,
and ‘an actually existing nonhuman biophysical world with its own integrity’ (Jacobs 2003,
p. 19). Jan Vansina (1990) argues that historians’ ‘underestimation of this diversity [within
a rainforest] leads to a flawed understanding of the interactions between people and their
habitats’ (Vansina 1990, p. 41). Consideration of the biophysical world (of which soils are a
fundamental part) is, therefore, not environmental determinism but, rather, an opportunity
to look at the ways in which people engage with their surroundings, to see previously ignored
expressions of creativity, and to more fully appreciate local environmental knowledge.
resulting in soil types unknown in the northern hemisphere (Eswaran et al. 1992, p. 3). Since the African continent lies in the tropics and subtropics, except in high mountain areas, the activities of flora and fauna are uninterrupted by cold, so that soil forming processes can occur year round. Soils in Africa more resemble those of Brazil, peninsular India and Australia than those of Europe or North America (Grove, A.T. 1970, p. 26).

The only statement that can be made with certainty about African soils is that they are enormously diverse. For every general statement made about African soil conditions, an example to the contrary can be found. With this in mind, let us consider some broad characterisations. According to the documentation accompanying the Africa sheet of the FAO/Unesco Soil Map of the World (1977), many African soils are highly weathered and have lower plant nutrient contents than northern hemisphere soils. Levels of phosphorus are low enough in much of the continent to limit plant growth. Elevated levels of aluminium and manganese, which can inhibit root growth of many plants, are also common in highly weathered soils. In some places the iron content approaches that of low-grade ore. Sub-Saharan West African soils have their fertility rejuvenated each year when dust, laden with basic cations (calcium, magnesium, potassium and sodium), blows in with the Harmattan winds. Arid and semi-arid regions of the north, east and south of the continent have sandy, stony and/or rocky soils that can be quite shallow (FAO/Unesco 1977, p. viii). Surface crusting and sealing, as well as salt deposition, are common in these soils. Areas of moving sand dunes exist in both the Sahara and Namib deserts. Layers of dense or hard soil, called ‘pans’, can be found below the surface of soils in all rainfall regimes.

Many of Africa’s highly weathered clay soils have a red colour, signifying high iron content (Eswaran 1988, p. 6). The fate of this iron depends upon soil conditions. It may simply accumulate as a stain on the surface of soil particles, or it can be concentrated. Where the water table fluctuates – either locally or on the scale of a floodplain – the soil solution can become enriched with iron, which is subsequently deposited as mottles, concretions, nodules or continuous sheets 2–5 metres – or even 10 metres – thick (Eswaran 1988, p. 7; Buckle 1978, p. 68). Referred to variously as laterite or plinthite, this material is characteristically soft and permeable when moist, but hardens upon drying. (Note: the word laterite has been used so broadly that its precise meaning is unclear. For this reason, some pedologists and soil scientists have refused to use the term. However, forms of the word are components of some international soil classification systems [see Faniran and Areola 1978, p. 161; Eswaran et al. 1992, p. 7]). The extent of hardness achieved, and its irreversibility, varies (Russell 1973, p. 731). When hard, it can be referred to as ferricrete, lateritic duricrust, or petroplinthite (Buckle 1978, p. 68; Eswaran 1988, p. 7). Soils with lateritic or plinthic layers have developed under both forest and savanna in West Africa, and are extensive in regions with annual rainfalls of
200–500 mm/year, or 10–16° N, such as Niger, Burkina Faso, northern Nigeria and Guinea’s Fouta Djallon (Cassel and Lal 1992, p. 77; Buckle 1978, p. 68; Russell 1973, p. 729). Obeng (1978, cited in Cassel and Lal 1992, p. 77) reported that approximately 113 million hectares of forested soils and another 113 million hectares of savanna soils in West Africa had concretionary or iron hardpans. Although soil structure, texture and fertility establish potentials for plant growth, rainfall defines much of Africa’s growing season(s).

African soils can be characterised in terms of their relations with water (FAO/Unesco 1977). Soils of the high rainfall region can have weak physical structures, making them susceptible to erosion. Soils lying between the semi-arid zones and the high rainfall regions (savanna and dry forest) can be sandy, and thus do not retain water, while others have physical and chemical properties which cause them to be poorly drained or prevent the downward movement of water (hardpans, ironpans, duripans). Those soils with high clay contents can hold water or block its movement, and some can be sticky when wet, and hard when dry. In the Niger and Congo River basins and in the Sudd region of the Sudan – as well as in many river valleys of the humid and temperate parts of Africa – there are large areas of poorly drained soils. The Mediterranean climate zones of northern and southern Africa have soils whose structures make them susceptible to erosion by water. Traditional soil use and management practices have been shaped by the combinations of soil physical and chemical properties and water relations at specific locations. For this reason, land use practices, like general statements, must be transferred from their landscape of origin with care.

SOIL KNOWLEDGE SYSTEMS

Soil comes to peoples’ attention because of its properties – or lack of them. Soil knowledge systems begin when systematic observations are ordered. Soil properties are identified, named, and associated with particular soil bodies, allowing comparisons to be made. Distinctions among soils, and decisions about soil boundaries, are determined by the classifiers’ perceptions, assumptions and needs. The resulting classification system provides a means of simplifying the complex and continuous soil reality into understandable, discrete classes (Krasilnikov and Tabor 2003, p. 203). Today, two major categories of soil knowledge systems are recognised: local and western scientific. Each type contains many classification systems, which reflect different perceptions of the world and have different purposes (Krasilnikov and Tabor 2003, p. 204). Local soil taxonomic systems are constructed to address particular concerns at a specific place. The relationships identified and names given may not have meaning in an adjacent region, but can identify particular soil-landscape relations extremely accurately, especially where there is great soil variability (Krasilnikov and Tabor 2003, pp. 209, 211; Niemeijer and Mazzucato 2003, p.
404). In contrast, western scientific soil classification systems seek to ‘interweave’ ‘general principles and detailed observations’ (Buol et al. 1973, p. 617) so that multiple purposes can be addressed over large regions, or even globally (Krasilnikov and Tabor 2003, p. 203).

In the late twentieth century, scholars in the emerging field of ethnopedology began to ask Africans about their understandings of soils (see WinklerPrins 1999 and the Ethnopedology Special Issue, Geoderma vol.11, 2003). Local soil knowledge was found to be widespread among rural people; to be somewhat specialised – people knew about soils they encountered; and to have strong historical dimensions. This dynamic knowledge base is the product of experience, observation and some systematic experimentation over time, and thus provides a long-term perspective to particular soil-plant systems. The length of these long-term perspectives can be centuries or millennia (WinklerPrins and Sandor 2003, p. 165).

Interpreting ethnopedological information is not simple, for each system of local soil knowledge reflects a unique way of perceiving the world (Krasilnikov and Tabor 2003, p. 204). To understand local soil knowledge, it must be considered within its own context, which means that outsiders must be open to different ways of knowing, or, in anthropological terms, avoid ethnocentrism (WinklerPrins and Sandor 2003, p. 165; Sillitoe 1998, pp. 190,192). An extreme example of this for most North Americans and Europeans would be the use of sound by the Bété people of Ivory Coast when classifying their soil. While these forest dwellers only distinguish three classes of colour (dark, light and bright/red), they listen to determine differences in soil texture (grittiness) (Birmingham 2003, pp. 486–7). Few residents of the northern hemisphere could imagine listening to soil as method of classification – but would accept as scientific the shaking of particles in water and watching their different rates of settling. In addition, there is a tendency to treat knowledge as static or finite. Local knowledge systems have been shown to be dynamic, changing over time as a result of changes in its ‘natural and social context’ (Niemeijer and Mazzucato 2003, p. 409; WinklerPrins 1999, p. 155). As a result, categories, or members of categories, can change as circumstances change. This is particularly true for value – a soil that is considered to be good for one crop may not be good for another, and so on.

There is a direct link between local soil knowledge systems and those of western science. V.V. Dokuchaev’s study of the chernozem soils of European Russia resulted in the first scientific classification of soils and a soil map (Dokuchaev Central Soil Museum, 2000–2002 undated; Buol et al. 2003, p. 9). Many of the terms he used to describe soil – and soil names – came from original folk names (Krasilnikov and Tabor 2003, p. 201). In his subsequent work Dokuchaev clearly distinguished soil from geological deposits, and identified it as an ‘independent natural and historical body’ whose origins were related to climate, vegetation, and time. This association between a soil and its factors of formation was the birth of
genetic soil science. The idea of factors of soil formation was later expanded upon in the United States of America and expressed in the simplified ‘flower diagram’ shown in Figure 6.3.

Dokuchaev’s ideas reached those who could only read English when *The Great Soil Groups of the World and Their Development*, written by his student, D.K. Glinka, was translated from German to English by C.F. Marbut and published in 1927 (Lipman 1933; Soil Survey Staff 1951, p. 3; Faniran and Areola 1978, p. 6). A variety of national soil classification systems were subsequently devised based upon physical and chemical properties of soils as revealed by soil profile analysis. Characteristics such as colour, texture (amounts of sand, silt and clay), pH (a measure of acidity), base status (amounts of calcium, magnesium, sodium and potassium), water relations, and position in the landscape were used as determining characteristics.
Soil classification and mapping has been an interest in Europe and North America since the turn of the twentieth century. According to the FAO/Unesco Soil Map of the World, two significant early soil maps of the African continent were those of C.F. Marbut in 1923 and Z.Y. Shokalskaya in 1944. Both were general maps of hypothesised soil distribution based on climatic, lithological or phytogeographical factors. Working in East Africa, chemist G. Milne used local soil names and knowledge in his early studies of soil catenas (sequences of soils down a slope) (Payton et al. 2003, p. 357). Until the 1950s, very few African soil maps existed that were based on actual surveys (FAO/Unesco, 1977, p. 1). The idea of a map of the African continent’s soils based on regional soil surveys emerged at the Commission de coopération technique en Afrique au Sud du Sahara (CCTA)’s Inter-African Pedological Service (Service pédologique inter-africain – SPI)’s first Administrative Council meeting in Yangambi (then Belgian Congo) in 1953. At its second meeting in 1955, the SPI Administrative Council recommended that a 1:5,000,000 map for soil conservation and use be drafted in close collaboration with the four regional committees – southern, eastern, central and western Africa. This decision stimulated preparation of new maps throughout the continent. Subsequent meetings produced compromises among Belgian, French, British, Portuguese and South African classification systems to reach agreement on a uniform map legend. When produced in 1963, it was the first map ever drawn as the result of international agreement, and ‘made it possible to establish the relationship between pedogenesis [soil formation] and the development of major soil units’ (FAO/Unesco 1977, p. 1). This map legend became the reference point for subsequent work. The idea of a World Soil Map arose at the seventh Congress of the International Soil Science Society in Madison, Wisconsin. The CCTA African soil map provided the base from which the first draft of the Soil Map of Africa was produced in 1968 (FAO/Unesco 1977, p. 2). In the same year the Organization of African Unity (OAU) published its International Atlas of West Africa. Since the scales and much of the data were the same, the OAU map was incorporated into the second draft of the FAO/Unesco map. This 1971 draft became the final version of the Africa map of the FAO/Unesco Soil Map of the World (FAO/Unesco 1977, p. 2).

The years of consultative preparation described above demonstrate the extent to which the FAO/Unesco soil map embodied the international consensus of western scientific approaches to both soil identification and knowledge of African soils. Finally published in 1977, this ‘paper map’ is accepted as ‘the appropriate source of soil information for studies at a continental, regional or global nature’ (Nachtergaele, undated). It has been the basis for all subsequent African continental soil maps, including those involving ‘simplifications and transformations’, such as the USDA maps using their Soil Taxonomy classification system, and the Russian simplified 1:15 million scale map of world landscapes, as well as electronic maps, including the recent digital maps (For historical description of the evolution of
electronic soil maps of the world see Nachtergaele, undated, pp. 2–3). Changes in
the maps have been largely due to data transformations, in which mathematical
relationships between two or more soil characteristics are used to estimate or predict
missing information (For discussions of pedotransfer functions and taxotransfer
functions see Nachtergaele, undated, p. 4). Nachtergaele admits that ‘some of the
information contained in the [World Soils] map is of uneven quality, often outdated
and completely wrong’ (Nachtergaele, undated, p. 5). National and regional soil
mapping exercises have been funded by a variety of institutions using a range of
classification systems (USDA Soil Taxonomy, Orstrom, FAO and local systems),
as listed in Nachtergaele’s appendix, ‘Country Soil Maps of Africa’.

However, Eswaran et al. (1992) argued that the FAO/Unesco map’s lack of
data perpetuates misinformation about tropical soils. As shown in Figure 6.4, when
it was prepared, approximately 7 per cent of the African continent had been covered
by large or medium scale survey maps with some ground-truthing for accuracy; 38
per cent had coverage by reconnaissance maps that showed soils in relation to other
features such as climate, geomorphology or vegetation, and 55 per cent of the continent
was ‘virtually unknown’ (FAO/Unesco 1977, p. 7). Information from a few specific,
detailed surveys was extrapolated to areas for which no information existed. These
‘best estimates’, once displayed in map form – on paper or with digital technology,
have the appearance of authority (See Figure 6.5 for example). Boardman (1998)
decrees ‘scientific myth making’, in which specific and reliable data travel tortuous
routes and undergo transformations, making them incredible.

While Boardman’s discussion centres on the extrapolation of carefully col-
lected measurements of soil erosion from a specific place to a regional, national or
continental scale, the same could be said for maps based upon similar processes.
For these reasons, people interested in specific places find local soil knowledge
more useful than internationally constructed soil maps reflecting international
consensus on the ways in which soils should be distinguished and classified (Nie-
meijer and Mazzucato 2003, pp. 404, 411). Similarly, those interested in making
general statements about soil over large areas recoil from the regional variation and
inconsistencies inherent in local soil knowledge.

A significant amount of effort has been put into comparing local soil classifica-
tion systems with those of western science. Since the systems being compared have
completely different origins and, often, purposes, the match is invariably imperfect.
It is extremely important to avoid the common assumption that western scientific
systems of knowledge are superior to other knowledge systems. Many studies by
western scientists have validated distinctions identified by, and conclusions drawn
from, local soil knowledge systems (WinklerPrins 1999, p. 153). Krasilnikov and
Tabor (2003, p. 203) point out that soil classification systems provide a common
means for talking about soils by simplifying a complex continuum into discrete
classes. For this reason, they argue, all soil classification systems are artificial, based
upon the information available and the beliefs and needs of the classifier. Each type of information has its purposes; care must be taken to ensure appropriate application. Although these systems should be understood and used as complimentary perspectives from which to learn about the soil and its processes, the apparent authority of western science with its generalised maps and specialised terminology threaten the very existence of complex and detailed local soil knowledge systems (Krasilnikov and Tabor 2003, p. 202).
Figure 6.5. African soil types according to the FAO World Soil Resources map, 2003
AFRICAN SOIL IN THE PRESENCE OF AFRICANS

The African continental surface is ancient, as is human experience on it. Archaeological evidence shows the high grasslands of eastern and central Africa to have been the ‘cradle of humanity’ (Oliver 1991, p. 3), the region in which the human species emerged. Oliver (1991) describes the pioneering aspects of humanity’s move out from the abundance, or ‘Eden’, of the East African highlands 1.5 million years ago to regions of the continent that were both hotter and drier, or wetter and more densely vegetated, than the highland savannas. They did so with simple tools, and encountered ecosystems with much less abundant game, and very different vegetation.

This pioneering did not take place in a static environment. Climate (and thus vegetation) change at the end of the Pleistocene and throughout the Holocene greatly affected the human experience. As precipitation regimes shifted, so did the extent of moist and dry forest, and of savanna (Casey 2005, p. 232). Learning from observation and experience, with subsequent adaptation of life styles, was essential for survival. With the advent of grinding stones and pottery (as far back as the sixteenth millennium BC) came the harvest of wild grasses, which, mixed with other kinds of foraging, hunting and fishing, sustained people for 6,000 years (Neumann 2005; Klieman 2003, p. 57). These earliest environmental pioneers were few in number (Casey 2005, p. 232) and they were not farmers. Presumably their impact upon soils was slight.

Whether these non-agriculturalists acquired soil knowledge by noting correlations between plant distribution or topography and soil types is not known, but African soil awareness is certainly old. The production of ceramics in West Africa in the early seventh millennium BC and in coastal Central Africa from the late sixth century BC, and their inclusion in Central African regional trade networks in the fourth millennium BC (Klieman 2003, pp. 52–4; Casey 2005, p. 234) suggests at least a developing knowledge of properties associated with different soil textures. The ancient name for Egypt was Kemet, which means fertile black alluvial

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3 African archaeology has been both under-funded and hindered by ideas generated by archaeological work in Western Asia and Europe, as well as by theories about stages of development. Vast areas of the continent have had little or no archaeological attention, and important questions within archaeology have not been addressed. Like African soil, the findings of African archaeology do not conform to experiences elsewhere, and have, therefore, been either ignored or accepted with great difficulty. For general discussion of these problems see Stahl 2005a, and for discussion related to specific topics, from hominins to urbanisation, see various authors within Stahl 2005b.

4 Like all archaeological reconstructions, the detail of Oliver’s model of humanity’s spread is disputed. See Stahl 2005b.
soil. *Deshret* was the name for red desert land. Three thousand years ago Egypt’s soils had established commercial values: *nemhura* soils cost three times more than *sheta-teni* soils (Krupenikov 1981 cited in Krasilnikov and Tabor 2003, p. 199). In other parts of Africa (for which written records are sparse or absent and historical linguistics methods have not yet been applied), ancient soil names have not been documented and dates can be less clearly assigned to soil classification, value or management systems. However, Central African oral tradition makes it clear that the Bantu settlers arriving in the rainforest regarded knowledge as a key resource (Gyer and Belinga 1995; Klieman 2003). They eagerly acquired the environmental knowledge required for survival, as well as that for pottery production, from the Batwa, the autochthons living in the rainforest (today referred to as ‘Pygmies’). Soil knowledge was certainly a component of this information transfer.

Archaeologists have shown that first herding (cattle, sheep and goats) and, much later, the cultivation of food plants, spread slowly across the continent, intermingling with existing lifeways based on foraging, hunting and fishing. It is these newer forms of sustenance that had the potential to influence soil properties, and thus offer the opportunity to consider human beings as soil forming factors on the African continent. Unlike patterns of land use evolution in western Asia/the Near East and Europe (Stahl 2005a), the earliest food producers in Africa were mobile pastoralists who left limited archaeological traces (Shahack-Gross et al. 2003), not agriculturalists. As a stable and widespread way of life, pastoralism existed in the Sahara and Sahelian grasslands by around 4500 BC (Gifford-Gonzalez, 2005, p. 188; Neumann 2005, p. 257). By 2000 BC they produced ceramics, which were traded to hunter-gatherers (Shahack-Gross et al. 2003, p. 440).

While archaeological evidence clearly shows the development of African pastoralism, documentation for the rise of agriculture is less clear. Neumann (2005) usefully distinguishes between cultivation, ‘any human activity that increases the yield of harvested or exploited plants’, and domestication, the ‘genetic, morphological, and physiological changes of the plants resulting from cultivation and conscious or unconscious human selection’ (Neumann 2005, p. 250). Cultivation can be practised with wild plants as well as with domesticated plants, an important concept when trying to understand African land use systems, and one that chal-

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5 For discussion of the methods and applications of historical linguistics, see Klieman 2003.

6 For excellent review articles with comprehensive bibliographies see Stahl 2005b. It is important to remember Kjekshus’ (1996) restatement of a main theme in Johnson and Anderson (1988) that it is unhistorical to assert rigid classifications of African societies by ethnicity or economic roles such as pastoralist, agriculturalist or hunter-gatherer, since these societies were both socially dynamic and ecologically adaptive as they met survival challenges (Kjekshus 1996, p. xxii).
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Challenges common assumptions about the definition of agriculture. Like pastoralism, agriculture did not spread continuously throughout the continent; it occurred in different regions at different times. Cultivation was commonly added to – but did not replace – other means of food acquisition such as foraging, hunting and herding. This is why Neumann (2005) cautions that finding evidence of domesticated plants at an archaeological site does not indicate a reliance on agricultural production or warrant labelling the occupiers as farmers.

Although agricultural crops existed in Egypt from around the sixth millennium BC, a clear pattern of crop production is not found in archaeobotanical assemblages in the south-western and south-central Sahara until slightly before c. 1800 BC, and much later, from around the middle of the first millennium BC onwards, in the rest of the continent (Neumann 2005, pp. 263–4). There is no evidence to support notions of agricultural diffusion from Egypt to the rest of the continent, and no centres of plant domestication have been identified. Instead, there is evidence of a great diversity of agricultural production systems involving the cultivation of both wild and domesticated plants throughout the continent. For example, it was Near Eastern crops that were produced in about the sixth millennium BC Egypt, oasis agriculture based on ‘emmer, barley, bread wheat, date palm and Mediterranean fruit trees’ was practised in the northern Sahara from approximately the first millennium BC, and plants were domesticated in Ethiopia from around 500 BC. (Neumann 2005, p. 253). Although pearl millet (Pennisetum glaucum) was domesticated by about 1800 BC in the western Sahara and spread quickly through the dry regions of West Africa, rather than leading to an agricultural lifeway, its cultivation was simply added to existing practices of herding, hunting and foraging (Neumann 2005, p. 261). In humid African forests, yam cultivation and the management and cultivation of trees were practised (Vansina 1990). Many archaeological sites in the Central African rainforest provide evidence of a fully developed agricultural life without any direct evidence of domesticated plants or animals. These sites dating from the middle to late first millennium BC indicate a system of agroforestry based upon palm nuts, cola nuts, and/or the fruit of Aielé (Canarium schweinfurthii) (Klieman 2003, p. 58). Evidence of the cultivation of oil palm (Elaeis guineensis) in Central Ghana and the Niger Delta around 1000 BC, and of cultivated banana (Musa sp) in the Cameroonian rainforest from around 800/400 BC, supports notions of incipient aboriculture (Casey 2005; Neumann 2005). Very little work has been done to establish the development of agriculture in southern Africa (Neumann 2005).

Although a wide variety of plants were used for food, there was little possibility for soil disturbance. Crop production – whether clearing trees or planting seeds, tubers or cuttings – was initially based upon stone tools such as axes and digging sticks (Klieman 2003, p. 41). Associated with the widespread use of iron tools – axes and hoes – are more diversified agricultural systems, and larger field
sizes, but not necessarily increased soil disturbance (Neumann 2005, p. 266). Hoed fields have rough surfaces that inhibit erosion, and hoed clods left in place serve as a mulch, protecting the soil surface (Showers 2005, pp. 12, 14).

Causality between the spread of iron tools and agricultural diversification is not clear. Where trees needed to be cut or other vegetation cleared or removed, the acquisition of iron tools made agricultural production easier. However, in Central Africa, it is argued, it was the introduction of a high-yielding, less labour-intensive crop – the banana – that created the possibility for the development of metallurgy. This more productive agricultural system could support non-agricultural specialisation (Klieman 2003, p. 99). Vansina (1990, p. 6) argues that it was the banana, not iron tools, that enabled Bantu immigrants settled along rainforest river systems to move deeper into the forest and ‘colonise all of its habitats everywhere’.

Oliver (1991, p. 49) states that modern African cultures reflect the fact that all of the life styles – hunting, fishing, herding and agricultural production – coexisted, and persist. What is difficult to show is the effect these diverse and complex land use systems have had on soil properties and soil bodies during the millennia in which they have been practised. It can be argued that life styles centred on fishing and hunting had little influence on soils. Although the East African trade in ivory dates to at least 2000 years ago, and hunting was an integral part of most African societies, hunting techniques other than the digging of pits in which to trap animals did not disturb the soil (MacKenzie, J.M. 1988, pp. 63, 77, 148).

In contrast, livestock management and crop production have potentially significant consequences for African soils. The basic concepts of dispersed grazing with transhumance (seasonal movement of stock to a different region) and crop-fallow rotational cropping systems have been applied with variation over much of the continent for millennia. Even where there have been traditions of urbanisation in Africa, studies have shown that these settlements were always linked to larger landscapes; sub-Saharan iron-using urbanised people engaged in mixed farming date to around the first millennium AD (LaViolette and Fleisher 2005, pp. 332, 327; Oliver 1991, p. 93; Lewis and Berry 1988, p. 29).

Archaeologists have begun to study the prehistory of land use systems. Part of the challenge of this work is to overcome such soil problems as acidity that cause

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7 While discussion of the ‘Bantu migration’ is beyond the scope of this chapter, it should be kept in mind that, as Childs and Herbert (2005, p. 281) point out, ‘Bantu-speaking peoples were borrowers rather than innovators; they acquired knowledge of ironworking, seed agriculture, and animal husbandry from their non-Bantu-speaking neighbors’. For critical discussion of the Bantu migration, see Vansina 1990, Klieman 2003 and Eggert 2005.

8 Neumann (2005, pp. 250–1) provides a useful history of the archaeology of African plant food production, noting the subject’s very recent origins.
a rapid decomposition of organic materials and, thus, of evidence for subsistence practices (Klieman 2003, p. 24). Mobile populations (pastoralists as well as foragers and part-time cultivators) who carry their dwellings with them and conserve their tools left little for archaeologists to find (Gifford-Gonzalez 2005, p. 189). Shahack-Gross et al. (2003) point out that pastoral sites are often distinguished from those of foragers by the presence of dung deposits associated with night-time corralling of livestock. However, dung is only preserved if buried, decomposing at open-air sites. Sutton's (1989) inquiry into constructing histories of agricultural fields points out that existing techniques of ‘archaeological recognition’ could only identify ancient agricultural fields if they were ‘mounded, ridged, bounded with banks or ditches or terraced in a pronounced way … Rarely can an excavator of a living site show just where … fields were, let alone define their shapes and sizes’ (Sutton 1989, p. 102). He concluded that the primary tools for reconstructing the ‘typical’ fields and farms that supported Africans since agriculture began were extrapolations back from documentation of existing and recent land use practices, aided by specialised soil and vegetation studies not then undertaken. Accepting Sutton's caution about the non-existence of a ‘typical’ field, it is, perhaps, useful to consider elements of the two most common African land use systems – extensive grazing systems and crop/fallow rotational agriculture – to see what possibilities for soil change might exist. As was indicated earlier, sharp separation of land use systems is not a reflection of reality. For the sake of analysis, each component will be considered separately, and then interactions will be noted. Finally, examples of traditional soil conservation practices will be discussed to suggest that for generations, centuries, or longer, awareness of soil erosion processes existed at least in particular places, and techniques were devised to control them either for field construction or stabilisation.

a. Livestock Management

Africa has experienced ancient traditions of dispersed or extensive grazing, since pastoralists move according to the needs of their stock for pasture and water. Cattle were tended on the continent before sheep and goats, and in Egypt before the Sahara, but by about the fifth millennium BC a successful cattle-based pastoral economy existed in the central Sahara. This ended during the arid years from approximately 3550–2550 BC as pastoralism shifted to the south and east. Cattle, sheep and goat pastoralism (the Saharan triad) first appeared in East Africa’s Lake Turkana basin around 2050–2550 BC. Less archaeological evidence exists for southern Africa, but it seems that only sheep arrived in south-west South Africa in about the first millennium AD (Gifford-Gonzalez 2005, pp. 203, 204, 206). The existence of pastoralism in the absence of agriculture has been explained in terms of a system that could respond successfully to climate change (Gifford-Gonzalez 2005), and as a response to Africa’s rich environmental resources, particularly in the savanna,
that made labour-intensive agriculture unnecessary (Neumann 2005). Pastoralism was, however, limited to savanna regions by the presence of livestock disease, and it is these soils that might show the impact of millennia of pastoralism.

A striking characteristic of African savanna ecosystems is the seasonal occurrence of fire (Goldammer and de Rende 2004). Europeans were alarmed by it, while Africans used it (Laris 2004; Wardell et al. 2004). Set naturally by lightning strikes in storms at the end of the dry season, fire has been considered to be a beneficial disturbance, causing changes in vegetation structure and composition, as well as promoting nutrient cycling and distribution (Goldammer and de Rende 2004, p. 1). Recent studies of marine sediments taken off the coast of Sierra Leone show that during the past 400,000 years the greatest intensity of vegetation fires occurred in the West African region during periods when global climate was changing from interglacial to glacial mode (Bird and Cali 1998 cited in Wardell et al. 2004). Wardell et al. (2004) state this study also asserts that human activity has ‘shaped the fire regime’ for the last 10,000 years, making difficult historical distinctions between naturally occurring and human-set fires. At the turn of the twenty-first century the large number of fires set by African land users was causing economic damage, but little attention has been paid to the effects of fire on soils.

Burning has been widely used as a range management practice in savanna regions because it improves the nutritional value of vegetation. Van der Vijver et al. (1999) investigated the extent to which burning increased the concentration of nutrients in above-ground plant growth and contributed to the loss of nutrients from the system through volatilisation and ash convection. The study was carried out on the nutrient-rich savanna soils of Tarangire National Park, Great Rift Valley, northern Tanzania. Only a brief effect was found in vegetation immediately after burning, and burning did not affect root biomass. Measured plant changes were due more to changes in plant growth (increased leaf: stem ratios) than to added nutrient supplies, since the soils had inherently good plant nutrient status. This led to the conclusion that nutrient losses were not significant in comparison to the soil supplies, and that the repeated effects of burning were ‘not as extreme’ on these soils as compared to ‘nutrient poor savannas’, which were not included in the study (Van der Vijver et al. 1999, p. 183). The extent to which wind-blown ash is ‘lost’ to the system depends upon how far it is blown, and how far ‘the system’ is considered to extend. The primary nutrient lost through volatilisation would be nitrogen. The amount of loss depends upon the nitrogen content of the material that was burned. At the end of the dry season, when most burning occurs, grasses have very low nitrogen contents. (The consequences of burning as a tool of crop production is discussed below under forest and savanna agricultural systems.)

Grazing stock can affect soil physical properties (Showers 2005, pp. 13, 14). The weight of animals can compress or compact soil, and hooves can dig down below the soil surface, destroying soil structure. The greatest damage occurs when soil is
wet (Tanner and Mamaril 1959; Gradwell 1968; Twerdoff et al. 1999). Hooves dig deeper into wet soils, compressing and remoulding or puddling them (Gradwell 1968). Damage under these conditions could reduce pasture growth, and could be irreversible. The severity of compaction depends upon the intensity of grazing, soil type, and vegetation (Warren et al. 1986; Krenzer et al. 1989; Twerdoff et al. 1999). Alternating periods of grazing with nongrazing allows some, if not complete, recovery (Gradwell 1968; McCarty and Maurak 1976; Haynes and Francis 1993). Studies have shown that compaction occurs only in surface soils (Krenzer et al. 1989), and dense vegetation can mitigate this consequence of grazing. Although soils in grazed pastures may be permanently denser or more compacted than those of nongrazed areas, this does not necessarily affect plant growth (Tanner and Mamaril 1959; Gradwell 1968). However, water enters a compacted soil with greater difficulty, and compacted soils can hold less water. Compacted soils can, therefore, be drier than non-compacted soils, so that plants growing on them are more likely to experience water stress (Gradwell 1968).

Livestock play a role in nutrient cycling as they eat and then deposit manure and urine. This is discussed in detail below, under savanna systems of agricultural production. Powell et al. (1996, p. 145), working in the semi-arid Sahel of West Africa, argued that cattle grazing on rangeland represents a closed cycling system, but as livestock producers increasingly settle, corralling of range-grazed livestock on crop land could create imbalances.

Because in many African pastoral systems livestock were herded to different locations in the landscape for food and water at different times of the year, what were recognised in the late twentieth century as conservation range management principles were being followed (Pendleton 1982; Coupland 1979). There is a possibility of some intensely grazed areas having permanently compacted soils, which affected soil-water relations. However, it is reasonable to assume that most African pastureland was unstressed by traditional pastoralists. This is not to say that there are no examples of soils disturbed by livestock management. River crossings and paths certainly had compacted soils, and where large herds of livestock were concentrated (such as the settlements of the Zimbabwean plateau in the eleventh–fifteenth centuries AD, particularly Great Zimbabwe), all the ills associated with over grazing and trampling undoubtedly occurred.

b. Agricultural Production

Nye and Greenland’s (1960) classic study *The Soil under Shifting Cultivation* assesses the effects of crop-fallow rotation systems in both the evergreen and semi-deciduous high forests and the tall tussocky grass and tall and short bunch grass savannas of West Africa. Samples were taken and literature reviewed of soil and vegetation systems in the mature fallow state, immediately after clearing and burning, and in the succeeding three years of crop production. At the time this study was made,
no generally recognised system existed for detailed soil classification, so discussion was of broadly grouped soils associated with distinct vegetation types. Although focusing on West Africa, this study establishes a base from which to consider the effects of rotational fallow systems on other African soils. Subsequent conceptually less comprehensive, but more detailed, investigations clarify points made and provide additional information. In particular, the 1970s droughts in the Sahel region prompted intensive study of grazing and cultivation systems in that semi-arid region. Similar studies began in the 1990s in arid Namibia.

*Forest Systems.* According to Nye and Greenland (1960), the moist evergreen forest common to coastal Liberia and Sierra Leone (see Figure 6.2) occurred on soils that were extremely weathered, had very low cation exchange capacity (CEC — the ability to retain exchangeable cations, such as the bases calcium, magnesium, potassium, sodium, as well as non-basic aluminium), and low pHs (a measure of acidity — low is acid). Soils under the drier semi-deciduous forest common to Ghana were richer — higher pHs (less acid) and had more bases to support plant growth. An analysis of the acid soils of the evergreen forest showed that the amounts of all exchangeable nutrients, except phosphorus, in the top 29 cm. of soil were considerably less than the amounts in the vegetation of mature forest fallows. In contrast, the vegetation of drier Miombo woodlands (east, central and southern Africa) and thickets stored much less calcium and magnesium than the soil, and comparable amounts of potassium and phosphorus.

Detailed study showed that when plots in either the evergreen or semi-deciduous forests were cleared and burned, great changes took place in terms of soil chemistry, but unless wood was heaped, prolonging burning, the top 5 cm. of soil were little affected by heat (Nye and Greenland 1960, pp. 71–3). The resulting ash not only produced an influx of soil nutrients, but also sufficient basic cations to raise the soil pH (making it less acid). On acid soils, the change in pH was particularly significant. Burning initially reduced populations of soil microorganisms, including those that transform nitrogen, but was soon followed by a rapid increase in numbers, resulting in increased amounts of nitrogen in a plant-available form. Although carbon, nitrogen and sulphur from the fallow and forest litter were lost in the burning, the soil humus was not burned, so nutrients stored there were retained (Nye and Greenland 1960, p. 10). That the nitrogen lost in burning was not of great consequence had been shown by studies of green manure in the 1930s (reported by Sampson and Crowther 1943, cited in Richards 1985, p. 29). When incorporation of fresh green manure was compared to incorporating its ashes after burning, no difference was found.

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9 Vansina (1990) and Klieman (2003) note that recent research in the Central African rainforest points to greater diversity than previously imagined. See discussion of African soil maps.
On the acid, highly weathered soils of the West African moist evergreen forest, cropping could only be supported for one and a half to two years; a ten-year fallow was required to restore fertility. The relatively more fertile soils of the drier semi-deciduous forest could support crop production for three years, followed by an eight-year fallow. It was only early in the first year that the soil surface was affected by planting crops in either type of forest. During that time, in both systems, the soil of the cleared space was bare. With the first rains, seeds were planted in the surface soil (which was rich in organic matter and worm castings), with a digging stick – causing minimal soil disturbance. Annual grains and perennial crops were planted as an intercrop. Until the crops grew, the soil’s surface was exposed to heavy rains that could destroy the structure of both exposed aggregated soil particles and worm castings, and ash could float away in runoff. Sheet or rill erosion could also occur. However, within four weeks the crop plants (and, likely, weeds) had produced a canopy that covered and protected the soil surface. In subsequent years the soil was never bare, as perennial crops were harvested and there was no replanting (Nye and Greenland 1960, pp. 3, 4).

Since animals were not kept by forest dwellers, the non-soil sources of soil fertility were, primarily, the decomposition of organic matter and additions from rainfall, dust, lightning, and the fixation of atmospheric nitrogen by microorganisms. The major losses from the system were considered to be due to leaching of nutrients below the rooting zone, removals in run-off water, the volatilisation of nitrogen by microorganisms, and of nitrogen and sulphur through oxidation when organic matter was burned. Nye and Greenland concluded that forest crop-fallow systems were nearly a closed cycle and, therefore, efficient and sustainable (Nye and Greenland 1960, pp. 43, 44). The system as described does not suggest modification of soil properties beyond temporary changes in the soil’s chemistry (plant nutrients) and microbial populations. More recent international agroforestry research reviewed by Kass et al. (1999) supports these conclusions.

The Central African rain forests (modern Rwanda, Burundi, Uganda, Democratic Republic of Congo, Cameroon, Equatorial Guinea, Gabon and Congo Republic) have been occupied by human beings for millennia (Sayer et al. 1992, p. 43). The earliest evidence is for isolated groups of stone tool-using hunter-gatherers living on hilltops and near running water from 38,050–33,050 BC, during the Ndjilian humid phase, when Gabon’s forest refuges were first formed. This was followed by 23,000 years of lower rainfall and temperatures associated with the Leopoldian era climate shift, when forest cover shrank and savannas expanded. During the subsequent humid Kibangian era (from 10,050 BC), the forest expanded to its current size, and residents produced small, less heavy stone tools and engaged in medium-distance trade (Klieman 2003, pp. 37, 40). The meagre evidence for subsistence suggests a reliance on wild food. However, at archaeological sites in the Ituri rain forest dating back 10,000 years, there are remains of the
oil-producing plant *Canarium schweinfurthii*, and later sites containing oil palm (*Elaeis guineensis*). The presence of these plants has been cited as evidence of possible early plant management (Casey 2005, p. 234). However, Casey points out, modern foragers use these plants, and lightning strikes and windfalls can open up spaces in forests providing the light required for oil palm survival (Casey 2005, p. 234, 235). Heeding Neumann's caution about assuming agricultural activities from evidence of cultivated plants, it is not reasonable to conclude that these were farming communities.

There is evidence of soil knowledge among ancient rainforest residents. Giles-Vernick's (2002) account of the knowledge system of the Mpiemu hunter-gather-farmers of the Central African Republic's Sangha River Basin, makes clear that local environmental knowledge, including soil knowledge, was part of their identity. Central to becoming a person in Mpiemu culture was the transmission of knowledge from one generation to the next. Giles-Vernick could only trace the Mpiemu's presence back 150 years, but her informants claimed an ancient origin for their knowledge, a time when lives lived in grasslands combined with those of the forest (Giles-Vernick 2002, pp. 49, 56, 57).

Vansina (1990) describes the process of multi-generational experimentation in West African forests that began 5000 years ago, leading to more sedentary lifeways and, ultimately, the agricultural systems of Bantu speakers based on yams, gourds, castor bean, black-eyed peas, and the *Voandzeia* groundnut (Klieman 2003, p. 41). These agriculturists began to move into the Central African rainforest along rivers, and by the middle of the second millennium BC had established many communities in the western equatorial forest. These settlements were involved with trade networks that carried ceramics by the fourth century BC, but it isn't until 500 BC that there is evidence of slash-and-burn agriculture (Klieman 2003, pp. 40, 55). Sayer et al. (1992), concurring with Vansina (1990), make clear that all parts of Africa's tropical rainforest are now used by local residents, and that there is no area of forest that has not had a long history of human use.

According to Vansina (1990) the selective use of plants and animals by dispersed hunter-gatherers did not significantly alter rainforest dynamics, but the arrival of settlers who farmed did. Farming populations were kept low, he asserts, because large populations cut down so many trees that the supportive habitat was destroyed. Vansina's concern was for flora and fauna, and not soil. However, aside from the (unstudied) consequences of ceramics production, there is no evidence of soil disturbance – but none has been sought. Given Nye and Greenland’s evidence of crop-fallow rotation systems in moist evergreen forests producing only temporary changes in soil properties, and noting the low density of human populations in the past, it could be argued that with respect to crop production, moist evergreen forest dwellers in the past were nothing more than participants in, and users of, an
almost closed nutrient cycling system, and did not significantly alter soil properties or soil bodies.

This might not have been the case in the drier woodlands of central Africa. The Bemba, who inhabit northern Zambia’s Miombo woodland, named their crop-fallow rotation system *chitemene*. *Chitemene* involves burning on a new field not only the trees cut in the process of clearing, but also branches and brush cut from adjacent land. The resulting intensive burning heated the top 2.5–5 cm of soil, with the result that soil structure improved (Nye and Greenland 1960, p. 71).

Soil properties were changed in the chitemene system for the short and medium term. Along with the expected initial transfer of nutrients from vegetation to soil, Stromgaard (1986) found that burning increased the sandy soils’ ability to retain cations (cation exchange capacity, or CEC) for as long as 16 years after the burn, when the *chitemene* cycle could begin again. While the amount of basic cations (calcium, magnesium and potassium) retained in the soil might be considered to be low, they were essential for regeneration of the fallow vegetation. Stromgaard (1986) also documented the encroachment of grasses during a crop/fallow cycle, noting that the dense root systems prevented cultivation. Invasive grasses of the Hyparrhenia family secrete a toxin that suppresses the growth of nitrifying bacteria, thus reducing the amount of nitrogen available in the soil and retarding the regeneration of woody species (Stromgaard 1986, p. 104).

Stromgaard (1986) argued that the area cleared for a field and the surrounding land from which tree branches were cut must be viewed as components of a system consisting of an intensively farmed ‘infield’ and an ‘outfield’ exploited at low intensity (Stromgaard 1986, p. 97). The *chitemene* system concentrates nutrients from a given areas’ vegetation in a smaller space, and improves that soil’s ability to retain them. It also facilitates the growth of grass plants which affect the microbial environment. If these changes persisted over time, then *chitemene* could be considered to transform the properties of the soils on which it was practised. This form of cultivation is practised in most parts of the plateau in north-western and north-eastern Zambia (Moore and Vaughn 1994).

*Savanna Systems*. Although savanna vegetation is far more extensive than moist tropical forest, human relations with savanna soils are less clear. By definition, savanna soils occur where rainfall is too low to support a closed-canopy forest (See Figure 6.2). They are, therefore, less weathered and tend to have higher pHs and nutrient supplies. Perhaps surprisingly, soil organic matter levels of savanna topsoils were found to be lower than those under forest cover.10 Rotational use of savanna soils for cropping has followed some of the principles and practices of forest systems,

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10 Plant roots and associated microbial communities, not aboveground growth, are the major source of soil organic matter (Bolinder et al. 1999).
but there are significant divergences. As in forest systems, low intensity burning did not affect soil temperatures below the surface 5 cm. of soil, but intense burns did (Nye and Greenland 1960, p. 11). The annual low intensity burning of the savanna was a mechanism for returning nutrients to the soil but, since grasses do not increase their store of nutrients year by year as forests do, when savanna vegetation was burned, fewer nutrients were deposited on the soil surface than when a field was cleared from forest (Nye and Greenland 1960, p. 36). The rapidity of annual burns and its positive effects on vegetation have been noted by recent researchers (Laris 2004; Wardell et al. 2004).

Parallels cannot be drawn between the values of mature forest and mature savanna. When cleared, old savanna not only had distinctly lower nitrogen levels than mature forests, but also less than savanna of two to six years. Nye and Greenland argued that because the long dry season meant that only annual crops could be planted in savanna regions, the soil was left bare each year after harvest. Additionally, surface soils had to be disturbed for planting because of the need to remove grass roots, and remained uncovered until crop canopies developed. Finally, plant cover was slow to establish when the fallow period began because of a scarcity of suckers and established seedlings (Nye and Greenland 1960, p. 124). This lack of cover, they argued, exposed savanna soils to erosion by water and wind. If eroded enough to expose subsoils containing plinthite, a very hard surface could form.

More recent research suggests that at the very least, dry-season soil was covered by weeds and unharvested plant parts (stover). In the moist high-grass savanna, as in the evergreen moist forest, livestock was limited by tsetse fly’s trypanosomiasis, so manure was not part of the nutrient cycling system; soil fertility was maintained exclusively by fallow management. However, in the drier tall and short bunch grass savanna, where there were no tsetse flies, herds of cattle, sheep and goats were significant components of soil fertility management (Nye and Greenland 1960, p. 4). Hoffman et al. (2001, p. 268) described precise and careful management of post harvest stover and weeds for livestock grazing during the dry season in semi-arid northwest Nigeria. Grazing stock converted high carbon organic matter (stover) into more plant-available forms of nutrients and deposited them as urine and manure. The stubble mulch resulting from grazing protected the soil’s surface. Fields in the study area (Kano close-settled zone) were only disturbed and bare at the onset of the rainy season, when roots had been dug and burned. Both resident livestock and those of pastoralists grazed the fields. So valued is manure for soil fertility maintenance that farmers in semi-arid West Africa have traditionally arranged with migratory pastoralists to corral their herds for a fixed number of nights on their fields (Williams 1999, pp. 17, 18). These arrangements were especially important for farmers without large numbers of livestock.

Detailed research presented in a series of papers by Powell et al. (1996, 1998) and Ikpe et al. (1999) investigated the role of livestock in maintaining soil
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fertility in the Sahel. Their experiments showed that while manure was important, it was the deposition of urine that had the most significant and long-term effects on subsequent crop yields. The research was carried out on a Labucherri soil, which is very low in organic matter content, has predominantly kaolinitic clays (very low ability to supply nutrients), and is poorly buffered (cannot easily resist acid-base changes). The addition of urine caused two major nutrient changes in this soil. As expected, levels of nitrogen in various forms increased. Surprisingly, levels of phosphorus also increased. Since there is virtually no phosphorus in urine, the researchers theorised that when the urine raised soil pH (the soils became less acid) during the first week, phosphorus dissolved out of the aluminium-iron complexes in the kaolinitic clays and became available to plants (Ikpe et al. 1999). Technically speaking, phosphorus was released when the structure of soil particles was ruptured. This process can be understood either as nutrient cycling – shifting phosphorus from unavailable to available forms in the soil – or destructive ‘mining’, since the release of phosphorus involves the destruction of individual soil particles. Powell et al. (1996) argue that cattle grazing a rangeland represent a closed nutrient-cycling system, but when grazed on rangeland by day and pastured on cropland by night, livestock are the ‘principal vectors of nutrient transfer across the landscape’ (Powell et al. 1996, p. 148; Powell et al. 1998, p. 260).

The Gourmantché people in the southern Sudano-Sahelian (900 mm mean annual rainfall) and more northern Sahelian (600 mm mean annual rainfall) regions of eastern Burkina Faso were found to have complex understandings of nutrient cycling systems, the role of organic matter, and the relative importance of water and soil fertility to crop production in a region with highly variable rainfall amounts and distribution (Niemeijer and Mazzucato 2003). The area consists primarily of flat to gently undulating peneplain with ‘occasional lateritic hills’. Most of the soils have low fertility and low levels of organic matter; many are shallow, gravelly or have ‘lateritic formations’. They can also crust, seal or become hard. The vegetation ranges from savanna woodlands in the south to tree and bush savannas in the north. The Gourmantché believe that the landscape is shaped by erosion, sedimentation and the transformation of organic matter. They think that erosion could be a source of soil fertility, as well as create gullies that could, over time, become a valley. They also think that few cultivable soils are inherently good; water relations – not soil chemical or physical properties – determine a soil’s utility. A soil in a water collecting spot would be good in a drier year, and bad in a wetter one. No soil would be good in a drought. Soil fertility is understood to be a function of organic matter, and distinctions are made based upon its source, location (on top of, or in, the soil) and degree of decomposition. Darker soil colours are associated with organic matter so decomposed that it is no longer visible. Gourmantché farmers believe that plants consume organic matter from the soil, and that repeated cropping reduces soil fertility, making soils lighter in colour. They also realise that too much organic
matter or manure limits crop production. While livestock are appreciated for the manure they produce, their trampling is associated with decreased ground cover and subsequent erosion, as well as with soil crusting and compaction. Because the Gourmantché farmers see a relationship between organic matter additions and soil fertility, they believe that there cannot be an irreversible loss of soil fertility. In dry years, when vegetation is sparse, soil organic matter levels decline, but in wetter years with more luxuriant growth, the levels increase again. Farmers, they believe, can work within this continuum of vegetation supply (and manure) to maintain soil fertility.

c. Soil Conservation Practices

Where topography and rainfall created a need for water control or the prevention of soil movement, locally evolved, specialist techniques developed, including the construction of mounds, ridges, pits and terraces (Sutton 1984, pp. 30–33; Grove and Sutton 1989, p. 115). Mounding and ridging, usually prepared by hoe, were components of agricultural systems in regions of medium rainfall, especially on lighter soils (Sutton 1989, p. 101). These techniques emerged from crop production needs. One function was the prevention of soil erosion in savanna soils. However, Nye and Greenland found mounding and ridging to accelerate erosion in forest areas of West Africa (Sutton 1989, p. 101; Nye and Greenland 1960, pp. 89–90).

A variation of this system is pit construction on steep slopes in the Matengo Hills of Tanzania. A series of pits constructed across and down the slope collect water for slow infiltration, preventing erosive overland flow (for description and photograph see Temu and Bisanda 1996). This pitting system was a variant on shifting cultivation. First observed as a coherent system by European visitors in the 1890s, pitted fields in the late twentieth century were cultivated for 4–6 years, and then left to fallow for 2–10 years.

Agricultural terracing was not widespread in Africa, Sutton (1984, pp. 30–33; 1989, p. 102) argued, because there was no need for it in most places. Soil movement could often be controlled with vegetation and timing of agricultural operations, or with non-permanent structures. In the west Cameroon Highlands, the traditional distribution of cultivated land into fallow, trees, and pasture promoted stability. If rills were discovered in cultivated fields, the land was covered with brush or returned to pasture. Trees maintained in the fallow area broke the slope length, thus inhibiting erosion. When this vegetative management system changed under late twentieth century pressures, rapid erosion resulted (Temato and Olson 1997). Further north in Morocco’s Rif Mountains, shifting cultivation of grain together with arboriculture of raisins, figs and plums, olives or almonds (depending upon soil type), goat raising and charcoal production supported people for centuries in a dry Mediterranean climate. When the system was disrupted by twentieth century land re-allocation and forest protection, serious erosion began (Heusch 1981, pp.
For generations stone bunds or lines were constructed in Ethiopia's Harerge Highlands as needed on the contour, their spacing determined by the slope. In addition, soil bunds were constructed to control erosion at planting time. They were easily removed when crop cover protected the soil, structures were no longer needed, and weed control was essential. Most of these structures were temporary, but some persisted for as long as 20 years (Asrat et al. 1996, p. 160). Elsewhere in the Ethiopian Highlands, water control and erosion prevention were achieved by ditching. Farmers varied the position and depth of ditches in their fields each year to avoid gradual widening and deepening over time (Alamayehu 1996, p. 167).

Permanent stone terraces were constructed for use in conjunction with irrigation systems in hilly or mountainous locations. A terrace system at Engaruka, Tanzania, was abandoned approximately 300 years ago after 200 years of use (Sutton 1984, pp. 36–39; 1989, pp. 103, 107). At Konso, Ethiopia one has been in use for at least 400 years, and in the Atlas Mountains, individual dry stone terrace walls strengthened by tree roots or interwoven with tree trunks have been used for more than 100 years (Amborn 1989, p. 73; Hamza 1996, p. 46). Stone terraces have been constructed in the Mandara Mountains of northern Cameroon for generations as a component of water control management, along with ridging and drainage canals. However, they were not built as fixed, permanent structures, but rather are continually modified by adjustment of height of wall or even location on the slope (Hiol Hiol et al. 1996, pp. 196, 198).

In other locations, irrigation was not obviously the major purpose of terrace construction. The terraces abandoned at Nyanga, northern Zimbabwe, 200–300 years ago were not clearly connected to irrigation (Sutton 1984, pp. 33–36; 1989, p. 103; Grove, A.T. and Sutton 1989, p. 115), while those from 800–900 years ago in the Great Zimbabwe region of southern Africa appear to have been related to erosion control (Oliver 1991, p. 110). Stone-walled terraces have been used on steep slopes in Maku, Nigeria to create agricultural fields. Oral tradition states that terrace construction began as fortification of villages in the era of slave raids. Soil accumulated behind the walls was used as small fields, and did not form a continuous terrace system on the hillsides. Maintenance was, and is, crucial, as a break in the terrace wall could result in washed out crops (Igbokwe 1996, p. 223). Evidence of terracing constructed with stone walls also exists in Nigeria and Cameroon (West Africa); in Darfur and Kordofan provinces of Sudan; in Tanzania and Kenya Highlands; and in Nyanga, Zimbabwe 200–300 years ago – that were not for irrigation (Grove and Sutton 1989, pp. 115, 122; Sutton 1989, p. 103).

Whether or not these interventions changed soil properties can be debated. In some locations normal soil movement downslope was arrested, and the accumulated soil was used for crop production. Such an intervention is an example of the creation of man-made soil bodies. In other locations, interventions counteracted accelerated erosion associated with farming. Soil surfaces were disturbed by both
agricultural production and the construction of conservation structures, but there are no accounts of a landscape destroyed by agriculturally induced soil erosion before the arrival of Europeans.

d. Architecture/Urbanisation

Whether for building one-roomed house components, large mosques, markets or walls, soil as brick or plaster has been used for centuries in many parts of Africa (for photographs and descriptions of regional architectural styles see Denyer 1978). Not all soils are suitable for construction. It is only those with high concentrations of certain types of clays that make good bricks and plaster. This suggests that for as long as people have used soil for building, there has been a basic knowledge of soil textural properties, and an ability to distinguish one soil type from another. The excavation of these soils in sufficient quantity for construction undoubtedly resulted in local soil disturbance. The construction of one household’s buildings, however, was not as consequential as the creation of urban areas that not only disturbed soils they covered, but also stimulated extraction from – and use – of larger landscapes.

Although it has been described as the least urbanised continent,11 Africa actually has a long tradition of cities and towns. Since the architecture in many African settlements consisted of structures made from easily degraded materials such as straw, earth, or small trees, they were not easily preserved or recognised. With or without the monumental architecture associated with classical definitions of urbanity, concentrated settlements of human populations did exist in Africa, and did affect the larger landscape, including soils.

The Nile valley has a history of urbanisation dating from 3500 BC, and urban areas have existed along the Mediterranean Coast of Africa from 1200 BC (Lewis and Berry 1988, p. 97). Large-scale settlements existed in West Africa’s Inland Niger Delta from the first millennium AD. One such place, Jenné-jeno, began as a seasonal settlement in about 250 BC, covered 12 hectares by 100 AD, and grew to a permanent village of daubed pole-and-mat houses measuring 25 hectares by AD 400. From AD 400 – 900 Jenné-jeno occupied 33 hectares, with a cautiously estimated population of 3,200–6,400 in town, and a further 6,700–13,400 in nearby settlements. A massive wall of sun-dried cylindrical bricks enclosed the 33-hectare site (LaViolette and Fleisher 2005, pp. 328, 334). Continuous urban settlement in the Chad Basin dates back to the ninth century AD. Ngazaramo, the capital city from the fifteenth to early nineteenth century, was at its height in the seventeenth century. It covered about 1,500 ha and contained a quarter of a million people.

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11 Until the 1980s, Northern Hemisphere conventions about – and definitions of – cities and urban areas largely excluded Africa’s urban reality and past from consideration. For discussion, see LaViolette and Fleisher 2005.
In 1658 Ngazagarmo reportedly had four mosques and 666 roads cleared and widened (Denyer 1978, p. 35). In the Sahara desert a chain of cities stretched from Tekrar in the west through Audoghast, Timbuktu and Gao to Agadez in the east from the tenth to the fifteenth centuries (Denyer 1978, p. 31). Further south, along the northern limits of the tsetse fly, a second line of cities developed that included Segou, Djenne, Ouagadougou, Katsina and Kano. From this line of Hausa urban areas south, many towns had extensive walls enclosing not only buildings but also open land (Denyer 1978, p. 33). The Yoruba cities of Western Nigeria, which probably date from the fifteenth century, had town centres consisting of a palace, a market and a temple with its sacred grove of trees (Denyer 1978, pp. 35, 36). Two main roads divided the city into quarters. Houses were built close together in family units, surrounding a well, rather than along a defined street (Lewis and Berry 1988, p. 350). According to Lloyd (1967, p. 220), Ibadan and Abeokuta were surrounded by hamlets from which the farming community commuted, while Ijebu Ode was surrounded by more than 100 permanent villages. Lloyd noted the ‘antiquity of the villages’ in the mid-1960s.

On the East African coast, the town of Rhapta (in modern Tanzania) was reported by Ptolemy to have ‘grown from an emporium to a metropolis’ by AD 300 (Chami 1996, p. 16). A series of towns and villages based on local, regional and long-distance trade dating from the eighth to the eighteenth centuries dotted the coast from modern Somalia to Mozambique (LaViolette and Fleisher 2005, p. 339). Building materials ranged from stone to earth-and-thatch, and populations from more than 5,000 to 15,000 people (LaViolette and Fleisher 2005, p. 340). The towns tended to be arranged around a well or market, not along streets, and household units included garden areas for domestic food production (Lewis and Berry 1988, p. 351). The merchants in these towns controlled local, regional and international trade, and thus the towns were connected to the larger landscape and inland settlements by paths and roads.

In southern Africa, cattle-keeping and farming populations on the Zimbabwean plateau built settlements from the first millennium AD. Buildings were made from stone and from coursed earth, called daga. In time, political states developed, based upon cattle-keeping and the gold trade, with major settlements at places such as Mapungubwe, Khami, Danangombe, and Great Zimbabwe (Beach, D.N. 1984). These thirteenth–fifteenth-century cities are renowned for their monumental stone structures, but daga housing also existed (LaViolette and Fleisher 2005, pp. 236–7). North of the Orange River in modern South Africa, eighteenth-century Tswana people lived in concentrated settlements while operating an extensive land use system. European travellers in the early nineteenth century reported that the Tlhaping (a Tswana speaking group) capital was the same size as the colonial settlement of Cape Town (Jacobs 2003, p. 45).
No matter what their construction materials, African urban areas affected the soils they occupied as well as the surrounding landscape. Soil surfaces were covered, roads and paths were created, water was drawn, used and disposed of, and waste was discarded. The result was soil compaction, disruption of soil water relations, and pollution. Increased demands were placed on food-producing areas to supplement urban gardens. If soil was used for construction, quarries had to be dug, and when a building was no longer used, the soil had to be either reused or disposed.

e. Mining

More obviously disruptive of soil than agriculture, livestock production or urban areas is mining. Holes or tunnels in the ground or in stream banks are dug to extract desired minerals or soil types. Not only does the removal of the desired material cause disruption of the soil, but purification can result in large quantities of discarded waste. For millennia Africans have mined iron and copper for tools, ornaments, currencies and ritual objects, and salt and clays for nutritional, medicinal or ritual use. Small- and large-scale mining and metal working centres existed throughout Africa, producing ore and finished products for local use as well as for regional and long-distance, international and intercontinental trade networks. Mining was a major source of wealth for African empires and kingdoms (Tráore 1994 cited in Hilson 2002, p. 154).

Metallurgy. Minerals can be collected from the soil’s surface, retrieved from stream beds, or excavated from beneath the ground. Once mined, mineral ores must be separated (smelted) from non-ore materials by heating. Smelting results in some pure metal and much larger quantities of waste, called slag, that is usually deposited on the soil surface. To produce finished objects, the metal must be forged – heated and worked. Since each of these processes has potential to affect soils directly or indirectly, it is important to have an idea of their nature and extent.

Iron, copper and gold were the primary metals mined and processed in Africa – lead and tin to a lesser extent (Childs and Herbert 2005, pp. 281, 282). The centres of mining and skilled craftsmanship developed in areas rich in ores, from which regional and global trade networks spread. Among Africans iron was the most commonly used metal (both for domestic and ritual use), and in many societies copper was more valued than gold. Copper-poor West Africa imported it across the Sahara in about the twelfth century AD (Childs and Herbert 2005, p. 290). At approximately the same time, gold, whose primary demand was non-African, was being exported to the Arab and Indian Ocean worlds. The substantial trade with Europe came later (Childs and Herbert 2005, p. 287). Hilson (2002, p. 153) suggests that gold was first mined intensively from Archaen greenstone belts in modern Zimbabwe, Botswana, Tanzania, Mozambique and South Africa.
African metal workers knew a great deal about the properties of metal. They produced not only wrought iron and cast iron, but also low- to medium-carbon steel. Steel production requires the manipulation of conditions inside smelting furnaces (for descriptions of the great array of furnaces and unique African furnace design that eliminated the need for a bellows see Childs and Herbert 2005, p. 284). In southeast Nigeria, the lost-wax casting process was highly perfected. Central and southern African smiths made copper and iron wire by both hammering and drawing (Childs and Herbert 2005, p. 286).

The development of Africa’s sophisticated metallurgy traditions, like those of pastoralism and agriculture, does not conform to patterns identified by European archaeologists. There was no Bronze Age in Africa, and evidence points to the smelting of iron before copper (Childs and Herbert 2005, pp. 227, 228). Radiocarbon dates of wood (the primary fuel in smelting) from scattered sites around the continent going back to the second millennium BC, confirm metalworking to be an ancient African activity. Rather than finding evidence of iron working as an imported skill, calibrated radiocarbon dates from about 800–400 BC at archaeological sites in Niger, Nigeria, Gabon, Cameroon, the Central Africa Republic, and the Great Lakes supports the possibility of independent invention. However, there are not enough data to chart the spread of ironworking across the Africa (Childs and Herbert 2005, p. 280). Everything to do with metallurgy had soil consequences.

**Mines.** Most obviously, metals must be removed from the soils containing them. Knowledge of soil properties – both the staining of surface soils and the kinds of vegetation supported – was used by ancient prospectors to locate ore deposits (Childs and Herbert 2005, p. 282). Since iron is so common in Africa – from deposits on individual soil particles (as mentioned earlier) to concentrations of ore – there should be no surprise that it was the most widely and continuously mined mineral. Ironworkers were able to distinguish between lower and higher grade ores, and only used oxides such as haematite, magnetite and limonite (Childs and Herbert 2005, p. 282). The greatest number of less frequently occurring copper deposits are in central and southern Africa. With the exception of Zambia’s Copperbelt that was identified with twentieth century prospecting technology, almost all of the known sub-Saharan copper deposits were worked by miners in the pre-colonial era (Childs and Herbert 2005, p. 282). Although gold is widespread throughout the continent in both alluvial and reef forms, the earliest archaeological evidence for its use is not until the seventh and eighth century AD at Jenné-jeno (West Africa) and in elite burial sites at Mapungubwe, near the Limpopo River in southern Africa, dated to 12

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12 Lost-wax or *cire perdue* casting ‘involves making a model of the object to be cast in wax, then enveloping it in clay. When the wax is melted in an oven, the metal is run in to take the exact shape of the “lost” wax’ (Childs and Herbert 2005, p. 286)
Establishing the history of mining has been complicated by the fact that modern mines have been dug on top of ancient mining sites. The most common type of mine was a shallow pit or shaft dug with hoes or digging sticks. In some locations, mines consisted of holes dug into hills, creating caves, which were used until they collapsed (Tlou and Campbell 1984, pp. 42, 43). In central Africa, some open-cast copper mines were very large. A pit in Katanga, Democratic Republic of Congo was ¾ of a mile long and 600–1000 feet wide, which compares favourably to modern pits made with steam shovels. In nearby Kanshani, Zambia, an area 7,000 yards in diameter had been excavated. Surveyors have calculated that over the centuries of mining, thousands of tons of malachite were removed (Childs and Herbert 2005, p. 283). A lot of gold mined came from alluvial (river) deposits and was panned (Tlou and Campbell 1984, p. 42).

Deep mines were required for both copper and gold in central and southern Africa’s hard rock areas, particularly in Zimbabwe and South Africa. By AD 750, specialised mining communities had developed in southern Africa and underground mines were dug. Gold mining is thought to have begun in Zimbabwe around AD 900, and in northeast Botswana soon after (Tlou and Campbell 1984, p. 42).

In preparation for digging underground mines, fires were set to fracture surface materials, followed by digging shafts with iron picks and hammer stones (Childs and Herbert 2005, p. 283).

The deepest shaft found in Botswana measured 26 metres, a seventeenth-century Zimbabwean copper mine had shafts that extended down 60 feet, and a gold mine’s descended 180 feet (Tlou and Campbell 1984, p. 42, Childs and Herbert 2005, p. 283). Shaft depths were limited by an area’s water table – there was no ancient technology for pumping. Once shafts had been dug, miners descended by rope to dig ore, which was sent back to the surface in baskets (Childs and Herbert 2005, p. 283).

Smelting and smithing. Along with mining, large-scale iron production centres existed throughout the continent. In West Africa, the best known are the Middle Senegal Valley, Futa Jalon in Guinea, Mema in Mali, Yatenga in Burkina Faso, the Bassar region of western Togo, Hausa-speaking regions in Niger and northern Nigeria, and the Ndop Plain of Cameroon. There were also major centres in Central Africa (the Batékè plateaux of Gabon and Congo), the Great Lakes region of Rwanda/Burundi, Tanzania, and Malawi; the Shona-speaking region of Zimbabwe; and Phalaborwa in South Africa’s eastern Transvaal (Childs and Herbert 2005, pp. 283–4). The technology of iron smelting reached Botswana approximately 2000 years ago (Tlou and Campbell 1984, p. 42), and has existed in Kondoa Irangi, central Tanzania, for a thousand years or more (Mapunda 2003). Evidence has been
found of cultural affiliations between ironworkers of central and coastal Tanzania from the first century BC to AD 200 (Chami 1996, p. 16). Iron and copper mining and smelting in northern Zimbabwe date from about AD 200 (Tlou and Campbell 1984, p. 42). Where processing or refining of the minerals occurs near the mining site, waste products, or slag, are left behind. The assumption has been that slag was left in place, and could be used to determine the extent of metal working at a given location. However, at least some Africans practised recycling. Slag was used to temper Late Iron and pottery in East Africa, and was also used for house foundations (Childs and Herbert 2005, p. 286).

The environmental history of ancient African metallurgy has yet to be thoroughly researched and written. Mining is a ‘migratory’ industry, because it moves on when a given mineral has been removed, leaving a disturbed landscape behind (Hilson 2002). From a soil perspective, mining can disrupt soil topography and water movement, leave concentrations of non-soil materials which may be toxic to life processes, and stimulate erosion processes. Sedimentation of nearby waterways is a frequent consequence of small-scale mining, because soil washes away from piles left by digging, or is rinsed out to purify mineral ores. Holes and trenches resulting from quarrying can stimulate drainage of water from surrounding soil, as well as retain water – and toxins – that can percolate into (recharge) drier surrounding soils. Mining soils from river sediments not only disturbs the river’s bed, but also can result in depositions of sand and other soil particles on river banks and in flood plains.

On-going research in Kondola Irangi, in the centre of Tanzania, is addressing the question of whether ironworking was a causative factor in the area’s massive gully erosion (Mapunda 2003). Quarrying was not involved in mining operations – sand ore washed down by the Intela and Baura Rivers was collected and smelted. It is the smelting and smithing processes that have been posited as inducing erosion because the required high heat would have come from burning large amounts of wood. This fuel need, it has been argued, caused deforestation that exposed soil, resulting in catastrophic erosion. But Mapunda (2003) argues that local inhabitants knew that all trees did not burn equally, so only specific species capable of producing sufficient heat were harvested. Accordingly, although certain species could have been endangered or eliminated, the area would not have been denuded of vegetation, so soils would not have been exposed to erosive forces because of smelting. Childs and Herbert (2005, p. 294) support this line of logic by suggesting that the disappearance of slow-burning hardwoods was a major factor in the decline of African iron-smelting.

f. Medicine

Geophagy, the eating of earth, has been common in Africa for centuries for medicinal and ritual purposes. Clays from Uzalla, Nigeria that are sold widely in
markets across West Africa, have a mineral composition similar to clays used in the commercial pharmaceutical Kaopectate, the commonly used anti-diarrhoeal remedy (Aufreiter et al. 1997, p. 293). Geophagy has been widely documented in pregnant women, and theorised as being a source of iron (Abrahams 1997). As well as providing a nutritional supplement, clays can also help with detoxification. Eight samples of edible clays from Gabon, Kenya, Nigeria, Togo, Zambia and the Democratic Republic of Congo (former Zaire) were analysed for their contents of calcium, copper, iron, magnesium, manganese and zinc and detoxification capacities. The samples were found to be able to provide nutritionally significant amounts, and could, therefore, serve as a mineral supplement (Johns and Duquette 1991, pp. 450,454). In addition, because they were all kaolin clays, they could serve the same function as Kaopectate. A clay recovered from an archaeological site occupied by ancestors of Homo sapiens was found to have nutritional and detoxification capacities that were identical to those of edible clays used in Africa in the 1990s (Johns and Duquette 1991, p. 455).

Very specific medicinal mining of clays has, therefore, been carried out since the beginnings of human history. The extent and significance of this not been assessed, perhaps due to the taboo which industrial societies attach to the worldwide historical (and modern) practice of eating earth.

g. Art and Ritual

In the Middle and Upper Pleistocene there was regular symbolic use of pigments. Archaeologists have found examples of pigments shaped into pencils, and of symbols inscribed onto pieces of pigment (Marean and Assefa 2005, p. 120). The earliest mines in Botswana date to 33,000 years ago when haematite (red ochre) and specularite (an iron ore) were dug, ground to a powder, and mixed with fat, blood, egg-white or honey to make paint for use in rock art or body decoration (Tlou and Campbell 1984, p. 42). Cave paintings using soil as pigments are also commonly found in Lesotho. Elsewhere, soil, particularly clay, was excavated to make washes with a range of colours to be used as a kind of makeup – covering all or parts of the body – or for building decoration. In the eighth–fifteenth-century Kongo kingdom, clay was associated with the land of the dead, which was called the white clay world. Clays were used in funerary art to decorate wooden sculptures and to make terra cotta stelas. Because earth from burial sites was considered to relate to the spirits of those buried there, traditional healers combined burial site earths with botanical and other materials to make medicines. White clay also symbolised innocence and purity, so it was used to anoint the winner of a lawsuit (Thompson and Cornet 1981, pp. 30, 31, 37, 40).

Documentation of the use of soil for art and ritual practices is scattered in anthropological literature, and has not been the subject of inquiry from an environmental perspective. But in Africa, as elsewhere, soil helped make art possible.
AFRICAN SOIL IN THE PRESENCE OF EUROPEANS

Unbeknownst to them, when Europeans arrived in Africa as explorers, missionaries, traders or settlers, they typified Beach's environmental pioneers encountering a 'new, misunderstood environment' (Beach, T. 1998, p. 400). They knew nothing about the soils, vegetation or climates they encountered, and had little idea of ecosystem interactions. Their traditional agricultural, livestock and forest management systems had been developed in humid, temperate, glacially rejuvenated Europe, yet the Europeans were certain of these systems' suitability to tropical and sub-tropical Africa. For some, the African landscapes appeared to be deficient and, to most, the indigenous land use systems seemed inefficient or unproductive. Whether they arrived with settlers, missionaries, merchants or officials, European agricultural and land management technologies and practices changed vegetative cover and altered soil properties. Although the Europeans carried out many of the same activities Africans had before them, they did so on a larger scale, with more invasive techniques and powerful technologies, and their economic system demanded that mostly closed cycling systems be opened.

a. Agricultural Production and Soil Conservation

The ‘differentness’ of African soils became apparent soon after European land use practices were applied. The inherently low soil fertility and weak soil structures of most West African soils confounded efforts to increase yields through the application of ‘superior’ European management techniques (Richards 1986 provides West African examples). Adams (1992, pp. 103, 105), among others, describes some of the larger agricultural projects that failed, including the Tanganyika (modern Tanzania) Groundnut Scheme in which there was an attempt to use surplus World War Two Sherman tanks to clear stumps and plough the land. Soil compaction clearly resulted from this endeavour. Over time, the plantation managers of West Africa, settled farmers and ranchers of East and Southern Africa, and various government agencies introduced agricultural chemicals – fertilisers, pesticides, insecticides, nematicides – as well as agricultural equipment and machinery. Some of these changed soil chemical and physical properties temporarily, while others had long-term effects. A review of the African agricultural modernisation and development literature is, however, beyond the scope of this chapter.

In Southern Africa, it was the erosive nature of the soils that initially attracted attention. Soil erosion was first described around European establishments: on mission stations and agricultural experiment stations, as well as on farms, plantations and ranches (Roland 1938, pp. 7, 8; Tempany 1949, pp. 63–4; Ross 1963, p. 11; Beinart 1984, p. 54; Nyamapfene 1987, p. 2; Showers 1989, p. 267; Showers 2005, p. 143). European farming practices included ploughing large acreages of land and planting annual crops in rows. Ploughing increases soils’ susceptibility to erosion.
because it creates channels in fields in which water can collect or flow, reduces soil organic matter levels, weakens aggregated soil particles, compacts subsoil to form a dense layer (plough pan), can physically shift soil particles downslope, and results in a more exposed soil surface than does hoeing.\(^1\) European livestock management resulted in overstocked pastures and the concentration of animals around corrals and watering holes, which caused soil compaction (see discussion of compaction above under African grazing systems). These land use practices were associated with soil erosion (Hailey 1938, p. 1080; Tempany 1949, p. 1; Jacks and Whyte 1938, p. 71; Ross 1963, p. 12; McIlwane 1941 in Nyampafene 1987, p. 2). As Africans adopted European practices, erosion began to occur on their land as well.

Soil erosion in Southern Africa cannot be discussed in isolation from the great disturbance in the landscape caused by the arrival of new groups of land users from Europe who perceived much of the region as unused or empty, and claimed it for their own purposes. As the number of settler farmers increased, the land available to Africans decreased. Treaties signed in the late nineteenth century effectively transferred most of the land used by the Swazi people in the Transvaal Republic (north of the Vaal River in modern South Africa) to settlers (Swaziland Col. An. Rept. 1956, p. 17), and the rich farmland of the Basotho (modern Lesotho) to the Afrikaner farmers of the Orange Free State (modern Free State Province, South Africa) (Germond 1967, p. 308). Large blocks of land with the highest rainfall in the Bechuanaland Protectorate (modern Botswana) were declared Crown Lands available for European settlement (Tlou and Campbell 1984, p. 181). Laws passed in South Africa in 1913 and 1936 crowded the African population onto 13 per cent of the territory, giving the tiny European population control of the remaining 87 per cent of the land (Platzky and Walker 1985, p. 92), including the most favourable agricultural regions of the country. In Southern Rhodesia (modern Zimbabwe), Native Reserves were formally created for Africans in 1913 on marginal land with infertile soils and low rainfall (Mpofu 1987, p. 2), again leaving the more favoured land in the hands of European settlers.

The result was the thorough disruption of indigenous land use systems. Although details and dates vary from nation to nation, the overall form is of systems that had supported societies for generations and centuries, if not millenia, had their land bases seriously reduced. Indigenous land use systems were extensive, requiring large amounts of land. When confined to a smaller area, the African systems no longer functioned well (Basutoland Dept. Ag. An. Rept. 1930, p. 9; Nyampafene 1987, pp. 1, 2; Swaziland Col. An. Rept. 1946, p. 14; Swaziland Col. An. Rpt. 1950, p. 7; Swaziland Col. An. Rept. 1952, p. 52; Weinmann 1975, p. 200). First

\(^1\) For references and discussion of the consequences of ploughing on rangeland and of erosion associated with ploughing see Showers 2005, pp. 19–22.
there was no surplus, and then not enough for self-sufficiency. This process resulted in increasing – and inevitably unbearable – pressures on the landscape; pressures that resulted in the cultivation of marginal land, overuse of pastures, deforestation and soil erosion. In many areas accelerated soil erosion had been an unknown and unnamed concept. By the end of the nineteenth century, ‘overcrowding’ or ‘over-population’ of people and their livestock was identified as the major cause of erosion in most countries of southern Africa. A land problem created by the arrival of European settlers led to the erosion problem.

The earliest discussion of accelerated soil erosion occurred in South Africa’s Cape Colony (Beinart 1984, pp. 54, 55). Apprehension about soil conditions was not unique to this colony. In the adjacent Protectorate of Basutoland (modern Lesotho), missionaries and government officials had expressed particular concern about gullies along roads and paths, and on government and missionary land (Showers 1989; Showers 2005). Further north in the colony of Southern Rhodesia (modern Zimbabwe) and the Nyasaland Protectorate (modern Malawi), officials worried about erosion on European farms. Tobacco and cotton fields and tea estates were reportedly particularly under threat (Nyasaland Dept. Ag. An. Rept. 1924, p. 5). In Nyasaland by the mid-1910s, both Europeans and Africans believed that each other’s land use practices had caused an ecological crisis (Mlia 1987, p. 4), including an increase in soil erosion.

During the 1920s regional awareness of soil erosion as a problem that could be controlled and prevented resulted in a number of government and professional publications, conferences and exchange among government officers in South Africa, Southern Rhodesia (modern Zimbabwe) and Nyasaland (modern Malawi) (Report of Select Committee 1914; Torrance 1919; Showers forthcoming). The release of the South African Drought Investigation Commission’s report in 1923 confirmed that European land management practices were causing the destruction of the soil and hydrological regimes, and that erosion was a national problem.

The 1920s also marked the beginning of systematic and sustained investigations of the southern African environment. Experiment stations were established initially to identify the best crops, varieties, and management practices for European settlers. Regional departments of agriculture became increasingly interested in identifying practices to limit ‘surface wash’ (sheet erosion) because it was understood to be linked to losses of soil fertility. Sheet – not gully – erosion was the major concern in most places (Showers forthcoming). A government research programme to characterise Nyasaland’s soils was implemented in the mid-1920s. Beginning in 1924, soils were surveyed and samples were taken for chemical and physical analysis. The results were used to construct an erosivity index (susceptibility of a soil to erode). Both the physical and chemical properties of major Nyasaland soils and the erosivity index were published in the 1930 Department of Agriculture Annual Report (Nyasaland Dept. Ag. An. Rept. 1925, p. 26; 1930, p. 21). It was
also noted that soils with a distinct textural change were most susceptible to erosion. In the 1930s and 1940s increasing official concern about soil erosion was reflected in an increase in government and professional publications; research to understand erosion processes; and programmes for farmers and ranchers, in an attempt to prevent erosion, or mitigate its consequences by restoring eroded land (Showers 1989; Showers forthcoming).

Europeans settled as farmers and ranchers in modern South Africa, Swaziland, Botswana (Bechuanaland), Zimbabwe (Southern Rhodesia) and Malawi (Nyasaland). Most were literate, and had access to both regional publications and professional and social contacts with government officials. However, these land users did not appear to share official concern about soil erosion’s threat to the future of the landscape. Although European farmers in Southern Rhodesia were visited by the Agricultural Engineer to advise on soil conservation in the late 1920s, in 1938 only two districts had over 40 per cent of the cultivated land protected by contour ridges (S. Rhodesia An. Rept. 1929, p. 12; S. Rhodesia An. Rept. 1930, p. 39; S. Rhodesia An. Rept. 1931, p. 13; S. Rhodesia Dept. Ag. and Lands An. Rept. 1939, p. 28; S. Rhodesia Dept. Ag. and Lands An. Rept. 1939, p. 3). The 1939 report of the Commission to Enquire into the Preservation of the Natural Resources stated that soil erosion was still a serious problem on European farmland (McIlwaine 1939). By the end of 1940, less than three per cent of white farmers in South Africa had elected to participate in government programmes to build conservation works on their land because ‘only a minority of farmers and a very small percentage of townspeople’ were concerned about soil erosion (Chief, Div. Soil and Veld Cons.1941; Ross 1963, p. 19). Despite the creation of a Natural Resources Board in Swaziland, meetings, and advice to employ conservation techniques, the government had to resort to fines to enforce reclamation and erosion control measures on European farms in the mid-1950s (Swaziland An. Rept. 1953, p. 15; Swaziland An. Rept. 1955, p. 15; Swaziland An. Rept. 1958, p. 17).

African farmers were equally uninterested in the Departments of Agriculture’s soil conservation techniques. Their lack of enthusiasm for the various methods was noted in South Africa, Basutoland, Swaziland and Southern Rhodesia (Engineer to Chief Native Commissioner 1941; Basutoland Dept. Ag. An. Rept. 1937/38, p. 76; Basutoland Dept. Ag. An. Rept. 1938/39, p. 77; Basutoland Dept. Ag. An. Rept. 1948, p. 31; Weinmann 1975, p. 206; Swaziland Col. An. Rept. 1950, p. 7; Swaziland Col. An. Rept. 1951, p. 5; Swaziland Col. An. Rept. 1954, p. 4). However, African land users did not have a choice about the adoption of these conservation practices. Colonial officials decided what would be best for ‘African land’ and for Africans. Each colonial government devised a programme that it felt suited its colony’s unique conditions. Most included some kind of engineering structures, like diversion ditches and terraces (which were referred to as contour banks, ridges or bunds), grass strips and mechanisms for the regulation of grazing.
In the 1940s and 1950s major state-sponsored soil conservation campaigns were implemented throughout Africa, particularly in British Africa, and most especially in those regions with European settlers. While most programmes were optional for Europeans, they were mandatory for Africans. Three basic approaches were taken: structure building (contour banks, bunds, terraces), vegetation management, and livestock/grazing control. The purpose of structure building was to change the surface hydrology of the soils, since soil erosion was thought to result from surface wash (sheet erosion). Basutoland, where the first state-sponsored national soil conservation programme in Africa was implemented, went from having an estimated 10 per cent of its landscape threatened by gullies when the programme began in 1936, to being one of the most gullied nations in the world by the 1970s. Conservation structures, untested for local conditions and modified to minimise costs, were implemented by non-professionals throughout the lowlands. Previously dispersed overland flow was collected and concentrated, creating rills, gullies and tunnelling (internal erosion), ultimately changing the hydrology of the soils (Showers 1989; Showers 2005). In Southern Rhodesia, beginning in the 1950s, the soil was disturbed as conservation works were dug and, as in Basutoland, erosion was increased by their inappropriate design. The mandatory conservation programme was so offensive to the rural population that it was one of the reasons given for supporting the guerrilla war to create independent Zimbabwe (Showers 1994). Kenyan farmers also resisted terracing in the late 1930s and 1940s (Carswell 2003, pp. 3, 4; Mackenzie 1998). In Tanganyika (modern Tanzania), a programme of bench terrace construction in the 1950s produced riots, and hillside ridges were so fiercely resisted that they had to be abandoned (Carswell 2003, pp. 3, 4). Vegetative approaches to soil conservation were less disruptive – to soil and to societies. Grass strips, which mimic the function of savanna vegetation, had been mandatory in Swaziland’s 1949 conservation programme, but were embraced by farmers as essential for crop production and continued voluntarily, with modifications, in the late twentieth century (Showers 1994; Osunade and Reij 1996, p. 4). Where vegetative and structural measures were consistent with existing local practice, they were accepted, as in Kigezi, south-western Uganda (Carswell 2003).

Soil conservation structures clearly changed soil hydrology and, in some cases, permanently transformed or destroyed soil bodies. Construction disturbed soil profiles, and increased erosion removed soil. Soil water relations were changed when water ponded behind structures causing soils to become waterlogged. The new source of soil water increased internal drainage of the soils. In some instances erosion by tunnelling (piping) was initiated when newly developed rills and gullies provided outlets for water moving within the soil. In Basutoland, soils became irreversibly drier as they were drained by the developing network of tunnels (or pipes) and gullies.
Africans have not been passive in the face of the social, economic and environmental changes that occurred with the arrival of Europeans and their technologies. They made changes in their land use practices. In many places, as fallowing periods were constrained or eliminated, they were replaced by manuring. During the 1990s this process was studied in the semi-arid region of West Africa (including significant parts of Burkina Faso, Chad, Gambia, Mali, Mauritania, Niger and Senegal), where soils are inherently low in plant nutrients, soil organic matter and water retention capacity (Williams 1999, pp. 15, 17). Manure and fallow, not fertiliser, were the major means of maintaining soil fertility. Manure was applied either by hand-spreading on fields, or by corralling stock on a field at night. Except on small fields, manure was placed on specific spots within a field deemed to need nutrients rather than the whole field. Over time, each area of the field received a manure application. The farmers’ belief that manure had long-term effects and was not needed each year (Williams 1999) has been confirmed in studies such as by Powell et al. (1998). Research has shown that manure augments soil organic matter contents, raises soil pH, improves cation exchange capacity (CEC) and water-holding capacity of soils. When used in combination with inorganic fertiliser, especially nitrogen, it reduces the fertiliser’s negative effects, particularly acidification, and increases removal of nutrients other than those supplied by the fertiliser (Williams 1999, p. 15). However, not every farmer was found to have access to as much manure as s/he would like (Powell et al. 1998, p. 260; Williams 1999, p. 19).

When livestock are kept in stalls, as is advocated for modern production systems, instead of corralled on a field as in traditional systems, urine is lost through runoff from the barn and in seepage. The remaining manure must be handled, stored and transported before spreading on fields. Researchers warn that the result of such a switch in management practices could reduce the amounts and types of nutrients available for recycling and increase nutrient losses, thus jeopardising the long term productivity of the soil (Powell et al. 1998, p. 260).

b. Livestock Management

European methods of livestock management involved concentrated use of grazing areas. Fences contained the animals, and there were limited locations for the stock to drink. This approach produced overstocked pastures and heavy animal traffic around corrals and watering holes – all of which reportedly caused soil erosion (Hailey 1938, p. 1080; Tempany 1949, p. 1; Jacks and Whyte 1938, p. 71; Ross 1963, p. 12). As Europeans claimed land for farms and ranches, first in southern Africa and then in East Africa (Kenya in particular), African grazing areas were reduced and pastures became overgrazed. Ward et al. (2000) addressed concerns about ‘land degradation’ on a communal ranching area in arid Namibia. Otjimbingwe’s mean annual rainfall of 165.4 mm precludes crop production; livelihoods
could only come from livestock management. Using archival materials (including photographs) and oral histories as well as soil and vegetational sampling, the researchers concluded that it was rainfall, not stock numbers or management, that determined the condition of the landscape. Even around watering points used for 150 years, changes in soil quality (as measured by soil nitrogen, phosphorus, organic carbon, and water-holding capacity by bioassay) could not be detected (Ward et al. 2000, p. 351).

c. Architecture/Urbanisation

European urban areas in Africa were established for reasons of commerce, transportation or administration, and also grew up around mining and industrial enterprises. Some were expansions of existing African settlements, while others were completely new. As with African settlements before them, European towns affected soil by covering it, quarrying it for use in construction, and stimulating the creation of roads and paths. Many European buildings were constructed with brick or cement, which required local quarrying operations. Waste management also affected soils.

Transportation to and from urban areas posed problems of compaction and drainage. As unimproved roads became too rutted, wagons – and later automobiles and trucks – created new tracks in the grass alongside the existing one. In this way, small paths became large, rutted, eroding spaces (Kruger 1882 in Germond 1967, p. 407; Assistant Engineer, 1934). Faulty road and railway drainage systems also caused gully erosion in South Africa, Basutoland and Southern Rhodesia (Watt 1913; Stewart 1917; S. A. Dept. Ag. and For. 1941, p. 18; Hailey 1938, p. 1058; Jacks and Whyte 1938, p. 70; Pentz 1940, p. 4; Proc. Conf. Soil Erosion 1945; Showers 1989, pp. 270, 275; Phiri 2003, p. 12; Showers 2005, pp. 143, 150–1) and railway construction’s demand for wooden sleepers encouraged deforestation and subsequent erosion, especially in savanna regions that did not have many trees.

Municipal waste disposal – domestic and industrial – was generally understood to be a process of removal. Treatment was rarely a consideration. Sewage and industrial effluents were dumped in streams and the ocean; abandoned quarries were used as disposal sites, and, in some semi-arid regions, liquid waste was simply dumped on the ground. Most urban areas were built with septic, rather than centralised water borne, sewage systems. The septic systems overwhelmed the soils, resulting in subsoil pollution (for discussion and tables of African urban and industrial waste disposal and pollution see Showers 2002).

Phiri (2003) assessed the environmental impact of the establishment and growth of the Southern Rhodesian town of Umtali (modern Mutare, Zimbabwe). Established as a base from which gold mining operations could be expanded, Umtali displaced an indigenous African population to other, less productive land, which ultimately became overused. As mines were dug, soil was disturbed directly
and indirectly. To prospect for gold, miners burned the grass for easier access to the earth, and no attention was paid to maintaining soil cover against erosion. The combined mining and urbanisation processes led to deforestation: trees were cut for timbers in the mines, sleepers for the expanding railway track, and for construction. Erosion resulted (Phiri 2003, p. 6).

As mining operations encroached on the original site of Old Umtali, the town was moved and expanded to New Umtali. Soils were again disturbed as buildings were built, and roads laid. A new town with new and better buildings required more wood and of higher grade. Brick was a desired building material, so large scale soil excavation began for brick making. The new town’s roads were not well constructed, and drained badly. Domestic, milling and mining wastes posed disposal problems that were never properly resolved. Soil disruption and erosion, waste accumulation, and pollution accompanied Umtali’s development. As modern Mutare, it faced the same problems in 1995 – although on a different scale – that Old and New Umtali had in the late nineteenth and early twentieth centuries.

d. Mining

It was the 1867 discovery of diamonds in northern Cape Colony, South Africa that triggered the ‘mineral revolution’, despite coal having been found in Natal Colony in the 1840s (Wilson and Thompson 1971, p. 11). Large-scale European mining in Africa began with diamonds, but it was institutionalised as a component of economic development when the Witwatersrand was proclaimed a gold mining area in 1886 (Wilson and Thompson 1971, p. 13). Although Southern Africa has Africa’s greatest concentration of non-petroleum minerals, by the end of the twentieth century every African country had large- and small-scale mines (Griffiths 1984, p. 126). In the 1920s and 1930s mining operations began around the continent, including small-scale gold mines in Cameroon, mines for iron and diamonds in Sierra Leone, diamonds on the west coast of southern Africa, and copper in Zambia (Desmet and Cowling 1999, p. 35; Grove, A.T. 1970, p. 109; Mobbs 1998; Lewis and Berry 1988, p. 369). A further wave of mine development occurred in the 1960s and 1970s, as African nations gained independence. Mining activities disturb surface soils, and create sources of pollution, dispersed by water and wind to surrounding soils undisturbed by actual mining operations (Lewis and Berry 1988, p. 367).

When minerals are quarried, the unwanted material surrounding the minerals (tailings) is discarded in piles. This can involve a considerable amount of soil; northern Botswana’s rich Orapa Mine produces 0.89 carats of diamonds for every ton of soil excavated (Lewis and Berry 1988, p. 367). In South Africa, until the 1920s, tailings from the increasingly deep and urban Witwatersrand gold mines were deposited in dry form on so-called ‘sand dumps’; after 1921 the deposits were slurries on ‘slimes dams’ (Groves 1974, p. 296). By the mid 1970s the Witwatersrand alone
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had 1,200 ha of sand dumps and 6,800 ha of slimes dams (Groves 1974, p. 296). Until stabilisation measures began to be taken in the mid-1960s, dust blew at such a rate from these dams and dumps that visibility was sometimes reduced to 10 metres (Groves 1974, p. 296). The dust settled on soils in surrounding areas. Tailings piles also produced sulphuric acid, which travelled in rainwater runoff to surrounding soil and water courses. On South Africa’s arid southwest coast, opencast mining for diamonds since 1929 has resulted in large overburden dumps and other disturbed areas (Desmet and Cowling 1999, p. 35). In contrast to the acidic (low pH) tailings from gold mines, these overburden dumps are composed of dune sands and marine deposits with high pHs and high salt contents (Desmet and Cowling 1999, p. 35). Left on their own, the slimes dams, sand dumps and overburden dumps were not completely revegetated. In the mid-1960s attention turned to stabilising the urban tailings piles, but only recently has attention turned to the rural arid overburden dumps, some of which have remained bare since the 1970s (Desmet and Cowling 1999, p. 36). By 1990 South Africa had 450 mine dumps (Koch et al. 1990, p. 49). For photographs of mines in the Orange River catchment, including coastal diamond mines, see the South African Department of Water Affairs Orange River website at http://www.dwaf.gov.za/orange/Low_Orange.htm.

In Northern Rhodesia (modern Zambia), copper mining began in 1921. From 1921 to 1957, when hydroelectricity became available, the surrounding forest was cleared to fuel the thermal power stations supplying the mines. Some 118,857 hectares were cleared between 1947 and 1964. Not only did this disrupt the local shifting cultivation system by removing land for fallow, but it also changed the water balance of the soil (Lewis and Berry 1988, pp. 370, 371). The mines themselves produced huge open pits and tailings piles, and the refining process released copper and lead into the air, which settled on the surrounding landscape (Lewis and Berry 1988, p. 371).

Southern Africa’s mining industry is, perhaps, the biggest and best documented, but the processes are the same around the continent. Mining operations make holes and generate waste, they require large amounts of electricity and water for operation, and they require a population of workers. Mines are, as Phiri (2003) pointed out, an agent of urbanisation, and create all of the environmental effects of any urban centre.

e. Trade

African local, regional and intercontinental importing and exporting has an ancient history. Ceramics, metal ore and finished metal products were widely circulated. Livestock played a significant role in transport and as objects of trade. Shaw (1995) discussed camels in Roman North Africa and the Sahara, and Kreike (2004) outlined the extensive local and long-distance cattle trade in the late-eighteenth and nineteenth centuries carried out by the Ovakwanyama, residents of the Ovambo
flood plain (modern northern Namibia and southern Angola). In contrast to pre-colonial economies in Africa, those constructed by Europeans placed increasingly heavy pressures on soils. With the sale of agricultural and livestock products, nutrient cycling systems were broken, and replacements were not always made. As industrial processes increased the demand for both the amount and kind of minerals, prospecting and mining expanded, magnifying the effects on soil discussed above. Urban and industrial areas required power, which resulted in rich alluvial soils being submerged by hydroelectric dams (Showers 2001). Finally, increased trade required increased infrastructure – from transportation to urbanisation – with its attendant soil effects.

AFRICAN SOILS AS HISTORICAL BODIES

African soils are historical bodies. They enter the twenty-first century with a long history of interaction with climate, topography, parent material, time and organisms – the factors of soil formation (Figure 6.3) (Buol et al. 1975; Buol et al. 2003, pp. 122–3). It is interactions with organisms, especially human organisms, that is the least understood, and the source of many of Roe’s (1991, 1995) ‘crisis narratives’. Can people be considered as participants in essential nutrient cycles, like mound-building termites or deep-rooted grasses cycling nutrients from down in the soil profile to surface deposition as litter? Do they participate in soil formation – creating new soil bodies or contributing new properties to existing soil profiles? Do they participate in soil destruction – the permanent change of soils. And if so, do new soils result?

Answers to all of these questions seem to be both yes and no, depending on location and time. Since human beings have lived all over the African continent for thousands of years, it is difficult to imagine soil conditions without any human interaction. Based on the information presented, in pre-European Africa, arguments can be made for both savanna and forest dwellers as being participants in fairly closed nutrient cycling systems that did not disrupt soils. Human interventions in these nutrient cycling systems certainly modified temporarily, if they did not transform permanently, soil properties. Roads and paths caused soil compaction that transformed soil water relations locally. Soil creation could arguably have occurred in those scattered locations where terraces or other surface water diversion devices resulted in the collection of soil particles, or where organic matter (as household refuse or deliberate fertilisation) was consistently added to a specific place. Soil destruction would most obviously have occurred where quarrying for minerals or special soils resulted in large holes. Although perhaps significant locally, quarrying is unlikely to have had a regional impact.

It is the use of fire in shifting cultivation or livestock management that provokes great debate. From a soil perspective, the significance of fire is its heat, and the result
of burning is the return of nutrients from vegetation to soil in the form of ash. As mentioned above, fires that burned quickly did not affect soil below the top 5 cm. under either forest or savanna. Soil properties did change, however, when wood was deliberately piled to create an intense heat, as in the chitemene system. The cation exchange capacity was increased, and could persist for as long as 16 years. Burning in this instance could be considered to be a temporary transforming process – for the increased CEC would not persist long after cessation of the burning sequence. From a soil chemical perspective, burning produced ash that released cations and anions into the soil solution. This affected the acidity of soils (making them less acid), and the nutrient availability to plants. The pH change, which affects soil microbial communities as well as plant roots, is temporary. However, the consequence of burning that receives the most attention is the loss from the soil-plant system of carbon, nitrogen and sulphur. If these losses can be compensated for over time by plants, micro-organisms, or rainfall and lightning (nitrogen), then burning can be seen as another aspect of nutrient cycling, without net loss.

There is no question that with the arrival of Europeans and their land use practices and technologies, soils changed dramatically in some places. European settlers and plantation owners displaced Africans from land, thus limiting previously unbounded extensive land use systems and increasing human and livestock populations on the remaining land. This concentration had implications for the stability of fallow systems and the stimulation of soil erosion, as discussed earlier. The newly arrived technologies were untested on African soils (although arguments have been made for the pre-European rejection of ploughs in favour of less soil-disturbing ‘digging sticks’ by Africans living on structurally fragile soils of West Africa). Whether employed by Europeans or Africans, the new agricultural technologies brought change. Certainly the soil conservation ideas imported from the United States in the early twentieth century proved to be highly destructive to many of the soils they were meant to protect. (See Showers 2005 and forthcoming for discussion of soil conservation technology transfer from USA to southern Africa.)

Each landscape was affected differently, but in places, soil textures, structures, chemistry and hydrology were changed – some irreversibly. As population densities increased and urban areas were created or expanded, soil cover was altered; ploughs, monocrops and continuous cultivation lowered soil organic matter levels and nutrient supplies; and agricultural chemicals (synthetic fertilisers, pesticides, herbicides) changed soil chemistries and microbial populations temporarily or permanently. Soil hydrologies were changed by mining operations, compaction and cover associated with urban areas and roads, and by gullies. Soils lost surfaces through erosion. Mines and industries released toxins to the soil environment, some of which persist for years, as do many agricultural chemicals. Soil was the object of concern only when it presented a problem, such as when it eroded, produced lower than expected yields, or failed to accept all of the waste products deposited on or into it. Soil
conservation was seen as a technology that could remedy land shortage and allow the persistence of certain European practices, rather than an expression of concern about soil bodies themselves. It is obvious that soil properties, and in some places entire soil bodies, were changed substantially in the twentieth century.

A true history of African soils will have to be many histories, with each region’s soils considered. Documentation will be needed to show the mechanism(s) by which a particular soil body has been changed. Analysis must consider whether the changes identified were permanent or temporary in nature, as well as whether they are reversible or irreversible. A tool for distancing researchers from the logics of dominant narratives (crisis or otherwise) is historical environmental impact assessment (HEIA), which focuses attention on landscape dynamics and facilitates the use of data from a wide variety of sources (Showers 1996). Given the tremendous paucity of information about most of the African continent, local soil knowledge systems ought to be major sources. Even when there are simply no data, and no sources can be imagined, the temptation to extrapolate or generalise must be resisted. Clear statements of gaps are more useful than projections and assumptions. ‘No information’ is a kind of data, sometimes the only legitimate kind.

The twenty-first century dawns on an Africa with different soil conditions than at the start of the twentieth century, and knowledge of Africa’s soils remains incomplete – including its history in detail. Proper histories of African soils could make a useful contribution to addressing the very real soil concerns of the twenty-first century.

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