# People and cattle: agents of ecological change in a dry montane forest, Samburu District, Kenya

Phillida C. Chenevix Trench

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To Mum and Arthur

## Abstract

In this thesis, I investigate the ecological impact of Samburu pastoralists and their cattle in an area of dry montane forest on the Lerroki Plateau in Samburu District, Kenya.

The thesis focuses on the effects of cattle on tree species diversity and closed canopy forest cover inside the Leroghi Forest Reserve. The importance of the closed canopy forest to cattle during dry periods is demonstrated by means of cattle censuses, cattle follows, faecal pellet surveys and informal interviews. A variety of ecological methodologies were employed to compare plant population structure and diversity in areas of forest under varying intensities of cattle use. Little evidence of long term changes in the overall population structure or diversity of tree species was found in association with cattle grazing. Interpretation of aerial photographs from 1963 and 1993 found no evidence of forest degradation or retreat under grazing pressure.

Multi-round surveys found little difference in frequency of general wild resource use by local communities in relation to the socio-economic status of the sub-household. However, the frequency of collection of marketable forest products was significantly higher in those villages with easier access to the main market at the District capital, Maralal. Comparison of aerial photographs found the degree of forest degradation and clearance over the last thirty years correlated positively with proximity to Maralal. The main exception was a large area of closed canopy forest north of Maralal which had been destroyed by fire in the 1980's. These findings show that commercial extraction is a more important influence than cattle on forest structure and composition.

These results have important implications for forest managers in dryland areas. The success of forest conservation within the Leroghi Forest Reserve has its roots in shared management objectives of the local pastoral community and the Forest Department, and the absence of long term damage to forest by cattle using the forests during the dry season. It is the absence of shared management objectives that threatens the long term survival of the forests located outside the reserve.

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The views and opinions expressed in and conclusions reached in this thesis are those of the author alone and do not necessarily represent the individual or collective views of the supporting or funding organisations. The maps are provided for the reader and do not imply judgement of the legal status of the boundaries shown

# 1. Introduction

## *1.1 Summary*

Forest grazing by cattle has been restricted or banned by successive Administrations in Kenya over the last 60 years. The justification for these restrictions has been concern over the impacts of cattle grazing on forest ecology. However, data on the actual impacts of cattle on closed canopy forest in East Africa is practically non-existent. Trampling and browsing by cattle can increase mortality in tree seedlings (e.g. Adams, 1975). However, cattle grazing and browsing can also reduce the build up of biomass in the herbaceous layer, which in turn reduces the frequency and severity of forest fire (e.g. Lamprey, 1985). Dry zone forests provide a vital source of water and fodder for cattle during dry periods and droughts. Banning or severely restricting cattle grazing may have serious consequences not only for the forest, but also for pastoral communities reliant on forest areas for dry season grazing.

This thesis looks at closed canopy forest use by an agro-pastoral community in northern Kenya, and the effects of this use on forest health and diversity as well as on people's livelihoods. The focus of this study is the use of closed canopy forest by cattle and the effects of cattle on plant species diversity and forest cover. However, other types of wild resource use which may affect forest cover were also quantified to establish whether these could explain the observed pattern of changes in forest cover seen across the Plateau.

The study started as a part of the Kenya Indigenous Forest Conservation Project (KIFCON), jointly funded by the British Overseas Development Administration and the Government of Kenya, a project deeply concerned about the rate at which indigenous forest cover is declining throughout Kenya. The project identified excision and commercial extraction as the major causes of this decline. However, socio-economic surveys within forest adjacent communities also raised concern at the levels of use of forest products by individuals and households, in spite of legislation restricting this use (KIFCON, 1994a).

The question of ecological sustainability of forest resource use at a local level has been the subject of many studies and is at the heart of this thesis. The importance of forests as a source of a wide variety of products and services for local communities, particularly where economic status is low, is well established. The future supply of these vital goods and services depends on the current levels of use being within the levels of replacement. Ecological sustainability of forest resource use, however, is poorly understood given the complexity of the forest systems themselves and the different types of uses made of them.

The site for the study was the Lerroki Plateau in the south west corner of Samburu District, Kenya. A multi-disciplinary and comparative approach was used to assess the levels and potential impact of livestock and human resource utilisation of closed canopy forest on the Plateau. The study made use of the fact that an area of forest within the Leroghi Forest Reserve[1] had been used almost exclusively for cattle grazing and watering over the last 60 years. Ecological surveys in this and a control area of little or no forest grazing were used to establish the effects of cattle on forest structure and diversity. Socio-economic surveys at household level in villages adjacent to the forest reserve established overall levels of wild resource use and the involvement of households in the marketing of wild resources as a function of economic status and location (relative to the market at the district capital, Maralal). Finally, the extent and spatial distribution of changes in vegetation cover over the past 30 years was established using aerial photographs and used to assess the long term implications of cattle and human activities on vegetation cover.

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[1] The spelling of Lerroki has been left as its colonial equivalent (Leroghi) in the case of the forest reserve throughout this thesis, since that is how the reserve is generally listed. For all other uses, Lerroki is preferred. The word '*lorroki*' means a high altitude area (Heine *et al.*, 1988) in Samburu.

### *1.2 The structure of the thesis*

The next section of this chapter briefly reviews the current literature on the management and ecology of dry montane forests, plant-herbivore interactions within forest ecosystems and the problems associated with impact assessments in a complex multispecies forest system. Given the multi-disciplinary approach of this study, more detailed literature reviews are presented in the course of the thesis. The hypotheses to be tested in the course of this thesis are then stated before concluding the present chapter.

Chapter two introduces the study site and outlines the methodologies and the general approach used in the course of the study. Chapter three examines the historical and contemporary evidence for cattle grazing within closed canopy forest on Lerroki. The results of vegetation surveys assessing the impacts of cattle herbivory on forest structure and diversity, over and above the effects of wild herbivore herbivory, are presented in chapter four. Chapters five and six look at the socio-economic aspects of forest use. Chapter five examines socio-economic differences within and between the study villages located adjacent to the forest reserve at different distances from the market at Maralal. Chapter six looks at wild resource use in each of the villages, examining differences in levels and objectives of wild resource use and evaluating the current importance of closed canopy forest as a source of wild products. Chapter seven presents the results of aerial photograph interpretation from 1963 and 1993 which are used to quantify changes in forest cover. These changes are interpreted in the light of the results from the ecological and sociological surveys. Finally Chapter eight brings together the evidence for sustainability of forest resource use and assesses the implications of the findings of this research for forest management in a pastoral, or agro-pastoral, setting

### *1.3 Contextual framework*

#### 1.3.1 Dry Montane Forest in Kenya

The area under closed canopy indigenous forest in Kenya totals approximately 2.2 million hectares. Sixteen percent of this forest, about 193,000ha, is situated within Kenya's rangelands, areas defined by low moisture availability with less than 1,000mm mean annual rainfall (KIFCON, 1994a). These rangelands cover 88% of Kenya's total land area and are home to 4.4 million people, 5.7 million cattle and 11.3 million sheep and goats[2], representing less than 20% of Kenya's human population, 52% of Kenya's cattle, and 79% of Kenya's small stock (de Leeuw *et al.*, 1991). The closed canopy forest covers just 0.4% of the total area of rangelands and is generally limited to small islands at high altitude on isolated hills and mountains, surrounded by lower altitude arid to semi-arid bushland.

These dry montane forests are typically dominated by *Podocarpus*, *Olea* and *Juniperus* species (Langdale-Brown *et al.*, 1974). The *Podocarpus-Juniperus* forest found on the Lerroki Plateau and to the west on the Matthew's Range is at the centre of the known range for this association which stretches from the Nyika Plateau in Malawi, $10^0$ south of the Equator, through Tanzania and Kenya to the Red Sea Hills, $15^0$ North of the Equator in Ethiopia (Hall, 1984). *Juniperus procera* is a pioneer species, commonly found (in association with *Olea europeana*, ssp *africana*) as a broad fringe surrounding the wetter *Podocarpus* dominated forests at higher altitudes (Friis, 1992). *J. procera* is prominent in early successional stages, and rarely features within climax forest, regeneration being highly light dependent (Hall, 1984). There is some evidence that fire may also be a prerequisite for *J. procera* regeneration (Wimbush, 1937), although seedling survival and recruitment to a mature phase depends on freedom from fire for the first five to ten years of growth (Hall, 1984). Forest expansion, therefore, is likely to take the form of *J. procera* reaching maturity in the absence of fire, possibly protected from fire by surrounding fire tolerant shrub species (Puyravaud *et al.*, 1994) and being replaced by *Podocarpus gracilior* and other broad leafed species associated with this forest type.

#### 1.3.2 Forests, savannas and disequilibrium

The importance of biotic interactions in determining vegetation and mammalian biomass in areas of low and irregular rainfall has been increasingly called into question

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[2] figures are for 1986, taken from de Leeuw *et al.*, 1991

over the past decade (Ellis & Swift, 1988; Behnke & Scoones, 1994). High coefficients of variation in mean annual rainfall in areas where primary productivity is essentially limited by moisture availability (Coe *et al.*, 1976) can create a highly erratic, *disequilibrial* system, driven more by stochastic abiotic events than by biotic interactions (Caughley *et al.*, 1987). Frequent droughts and population fluctuations "prevent plants and animals from developing closely coupled interactions.. and ecosystems seldom reach a climatically determined equilibrium point" (Ellis, 1994: 38). The theory of disequilibrium has had important implications for rangeland ecology, both economically and ecologically (Westoby, 1979; Warren & Agnew, 1988; Ellis & Swift, 1988; Sandford 1982; Homewood & Rodgers, 1991). However, there has been little discussion relating the implications of high coefficients of variation for rainfall for woodland and forest communities, where the lifespan of individuals can extend across a wide range of environmental conditions (Moss, 1996).

In his study of *Acacia tortilis* woodland in Marsabit District, Kenya, Moss developed a model which compared the importance of biotic and abiotic processes in herbaceous and woody vegetation types, incorporating the fact that the susceptibility of an individual tree will vary at different life stages (Figure 1-1). In an area of high climatic variability, frequent droughts are likely to override the effects of biotic interactions, such as herbivory by livestock, on herbaceous species and the youngest life stages of tree species as predicted by Ellis (1994) above. However, as the life history of tree species advance, adaptations to short term drought and high levels of competition for water decrease the susceptibility of individual plants to climatic variation, and the influence of herbivory and plant-plant competition and interactions play a more important role in determining germinant and sapling survival (Moss, 1996). Herbivory tends to only affect individual trees up to a certain height beyond which the leaves are out of reach of browsers (Pellew, 1983). (The main exception to this is debarking, which can affect a tree at any age.) Once a tree has reached maturity, the main threats to the tree are anthropogenic, either through direct tree felling or fire (assuming most fires are man induced).

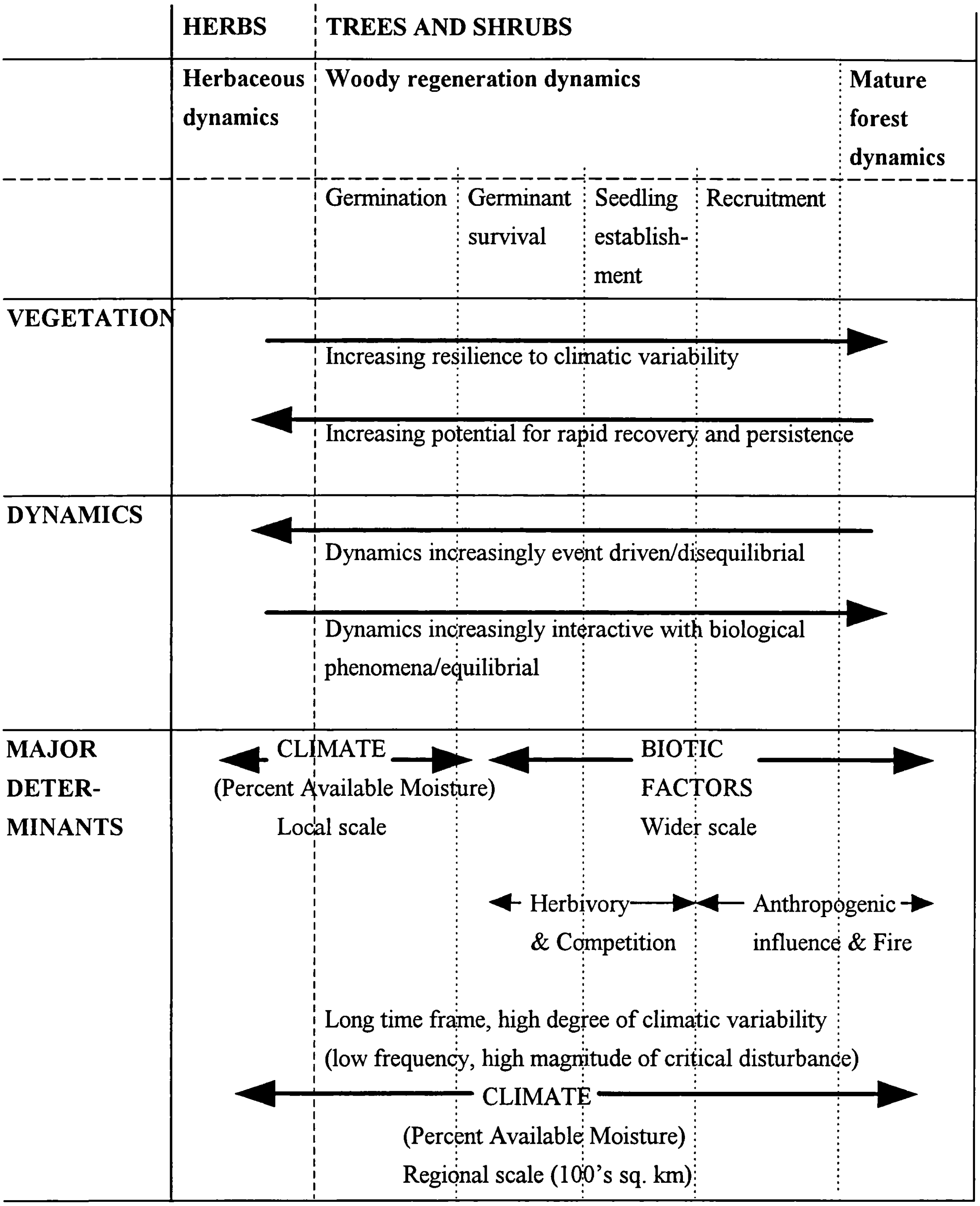


**Figure 1-1** Model describing the major determinants of herbaceous and woody vegetation dynamics, taking into account the change in susceptibility of individual woody plants to biotic and abiotic factors in the course of their life history. Modified from Moss (1996).

This model is defined for a semi-arid environment. In the context of the Lerroki Plateau, as altitude increases and water availability stabilises due to both higher rainfall and a more stable microclimate under the forest canopy, the importance of biotic factors in determining the herbaceous layer and seedling regeneration and survival will increase, shifting the whole system to the right. Anthropogenic influences and fire will remain the major determinant in the mature woodland or forest. However, herbivory will play a greater role in determining the nature of the vegetation in the long term for two reasons: the area is strongly seasonal with a long dry season, and the degree to which biomass in the herbaceous layer is allowed to build up will ultimately determine the severity of forest fire when it does occur (Stott, 1985); and the more stable micro-climate within the forest canopy will buffer germinants from short term external climatic variation, allowing the effects of herbivory to play a more important role in limiting regenerant growth and survival.

### 1.3.3 Cattle and closed canopy forests

The impact of cattle on closed canopy forest forms the main focus of this thesis, and is therefore introduced in some detail here.

Cattle may affect forest ecology directly and indirectly (Crawley 1983). Direct effects include: mechanical damage to the plant by trampling and browsing; alteration of the soil structure and properties by trampling, faeces and urine; and seed dispersal in faeces and carried on the animals' coat. Indirect effects may result from a reduction in the herbaceous layer, leading to reduced frequency and severity of fire outbreaks, and reduced competition for light, moisture and soil nutrients between herbaceous plants and young seedlings (Lamprey, 1985).

In the longer term herbivory influences forest ecology indirectly by affecting the competitiveness of plant species (Crawley 1983), thereby altering species abundance and possibly vegetation formation. This is most obvious where different plant species show different levels of grazing tolerance. Selective grazing of a dominant species can allow less dominant species to flourish while non-selective grazing will suppress grazing intolerant species and give grazing tolerant species the competitive edge (Huston, 1994). Cattle can also affect soil properties, for example where nutrients are concentrated in night enclosures (Reid and Ellis, 1995), which may alter the recruitment potential of different individual species. Initial changes in species composition due to such herbivore-plant interactions can have a knock-on effect on plant species competitiveness due to changing plant-plant interactions.

These direct and indirect effects, positive and negative, will counter-balance one another and may or may not lead to forest degradation and/or retreat in the long run. Section 1.3.7 below describes the ways in which this study used a combination of methods and approaches, together with the results of past studies, to determine the long term impact of cattle (as well as other human activities) within a complex multi-species indigenous forest. A more detailed review of the ways in which cattle can affect closed canopy forest and the implications for forest biodiversity and structure is described in chapter four.

Finally, the forest complex on the Lerroki Plateau contains many wild herbivores as well as cattle: elephants, buffalo, waterbuck, bushbuck and eland were all sighted in the forest during the course of the study. These other herbivores will also be affecting the vegetation through the various mechanisms described in this section. It is important to differentiate between the impacts of cattle and the impacts of other herbivores before management decisions on cattle grazing in forests are made (cf. Homewood & Rodgers, 1991 in Ngorongoro Conservation Area).

### 1.3.4 Cattle, Forests and Forest Administration

An assumption that cattle cause long term degradation of forests through trampling and browsing has led to a policy of excluding cattle from forested areas on the part of the various Administrations in Africa (Kenya Land Commission, 1933; Chenevix-Trench, 1964). The degree of exclusion has varied, from imposing limits on the total number of cattle allowed into the forest or the time the forest is open to cattle grazing (e.g. immediately after independence when the forest was open all year round to a quota of 6,000 cattle (Bronner, 1992)), to total bans on forest grazing such as the one which, with some local exceptions, is in place in Kenya today following a Presidential Decree in 1986.

The exclusion of pastoral communities from forests was concordant with the general policy pursued with respect to pastoral communities in East Africa from the beginning of the colonial period. Pastoralists were perceived as irrational and irresponsible: irrational in building up individual herd sizes to a point beyond their needs and the carrying capacity of the land; irresponsible in allowing open access to natural resources thereby creating the "tragedy of the commons" scenario proposed by Hardin (1968). These perceptions provided the basis for a policy of alienation of resource ownership, imposition of boundaries, restriction of movement and destocking (Sandford, 1982; Homewood & Rodgers, 1987).

The perceptions are changing. The applicability of the concept of carrying capacity in the context of arid and semi-arid areas has been increasingly questioned and a strategy of opportunistic grazing is now believed to make optimum use of the pastoral resource (e.g. Sandford, 1982; Behnke and Scoones, 1994; Niamir, 1990). Similarly, the accusation of irresponsibility has been replaced with the view that "herders in Africa had effective and sometimes sophisticated systems of land tenure that have been increasingly undermined" (Moorehead 1994: 39).

The effects of the policies, however, are still apparent. These include the breakdown of traditional natural resource management structures, reduction in access to grazing lands by appropriation of grazing land for other purposes such as cultivation, and increased sedentarization and involvement in agriculture and the monetary economy (UNSO/UNDP 1994). These changes have created new demands on local natural resources (Sperling & Galaty, 1990; Perlov, 1984).

### 1.3.5 Communities and closed canopy forests

The discussion so far has focused on cattle and closed canopy forests. Forests are also a source of a wide variety of products that are used day to day by the rural communities living around them (e.g. KIFCON, 1994; Koppell, 1992; Brokensha & Riley, 1989; FAO, 1991; Cunningham, 1993; Nepstad & Schwartzman, 1992; Carter, 1996; Hughes, 1987; Evers, 1994; Abbot, 1996; Fairhead & Leach, 1994; Kiwasila & Odgaard, 1991). Forests provide both woody products, such as timber for construction, firewood and charcoal, and other non-wood forest products such as medicinal plant products, fodder, honey, fibrous plants used for rope, etc.. Many of these products are extracted for commercial purposes, both at the local household level and at the larger scale of commercial businesses. In the absence of large scale commercial extraction of forest products on the Lerroki Plateau, this study focuses on household use of forest products, both wood and non-wood, for subsistence and for sale.

Management and sustainability of forest resource use has been the subject of many studies and, more recently, development initiatives (e.g. KIFCON, 1994; Poffenberger, 1995; Arnold, 1987). Sustainability of use will depend ultimately on those factors which determine the levels at which resources are extracted (Cunningham, 1993). Levels of resource use have been related to wealth, market demands and effectiveness of control of forest resource use (Bromley, 1995; Koppell, 1992; Shepherd, 1992; Sikana *et al.*, 1993; Scoones *et al.*, 1994; Chambers & Leach, 1987). The importance of wealth and market access in determining wild resource use is reviewed in chapters five and six. The problems associated with measuring sustainability of forest resource use are discussed in the next two sections.

### 1.3.6 Forest management

Sustainability of resource use has been closely linked to issues of management and tenure (Western & Wright, 1994; Lynch & Alcorn, 1994; Shepherd, 1992; Niamir, 1990). The importance of local value of forest products and services in the development of indigenous forest management structures is illustrated among the Maasai of Loita Hills by Emerton (1995). Fundamental to the question of forest conservation, and the 'success' or otherwise of forest management strategies, is the stated objective(s) of the management system (Carter, 1996; Bromley, 1995; Warren & Agnew, 1988).

In single species plantations, the management objectives are clear: maximise productivity of the selected tree species. In the United States, for example, grazing of cattle and sheep in plantations has for years provided a useful means of weeding, reducing fire risks and maximising productivity by utilising natural or enhanced forage production (Adams 1975).

In natural, multi-species forest stands, the management objectives may vary considerably, with the current emphasis placed on the conservation of biodiversity (e.g. Western & Wright, 1994; Dobson, 1995). Conservation of natural ecosystems is to a large extent based on our understanding of ecology, and recent shifts in ecological paradigms have had implications for resource management. In the past, natural resource management was based on the concept of stable climax communities. More recent ecological research has questioned this approach (Dublin, 1995; Behnke & Scoones, 1994; Norton-Griffiths 1979, Caughley 1976), suggesting that a stable climax community is an exception and ecosystems with multiple stable states are the rule in arid and semi-arid areas. With multiple stable states, in any one area there is a number of different climax communities possible, depending on a variety of biotic and abiotic factors, such as the ratio of grazers/browsers, or the regular occurrence of fire (Dublin *et al.*, 1990). This raises the question of whether conservation policy should be to *preserve* the ecosystem in its current state as far as possible, or to allow the ecosystem to respond to internal pressures and change.

The importance of management objectives in shaping management practices is clearly illustrated in Adams (1975) in his discussion of Ellis' work in 1964. Ellis found that protection from forest grazing caused a reversion of valuable eucalyptus stands to a "less desirable rain forest ecosystem" in Tasmania.

Management objectives will vary considerably among different interest groups (Bromley, 1995; Carter, 1996). The desire to protect the forest on the Lerroki Plateau for its water catchment properties prompted the colonial administration to gazette the Leroghi Forest Reserve in 1936. Permanent water sources on the plateau are few and rainfall water stored in forested areas provides the only source of water in the dry season (Spencer, 1973; Bronner, 1990). However, since that period the desire to conserve biodiversity has become of international concern and the conservation of diversity is now among the stated objectives of the Kenyan Forest Department (KIFCON, 1994).

For the Samburu, the forest is a source of woody products, dry season grazing and has a cultural significance, forest glades being important sites for ceremonies (Chieni & Spencer, 1993). The importance of forested areas as a source of dry season water and fodder for cattle, and the significance of their destruction is a major concern to the Samburu, who have a saying: "*one should treat a tree like one treats a cow*"[3]. If access to cattle grazing is denied, closed canopy forest loses a major part of its value to the local communities (cf. Emerton, 1995).

### 1.3.7 Measuring sustainability

The complexity of indigenous forest systems makes it very difficult to determine long term effects of forest use (Hall & Bawa, 1992; Crawley, 1983). The difficulty in establishing ecologically sustainable levels of resource use is further complicated by the wide range of uses people make of the forest and the ultimate destination of these resources (e.g. whether for subsistence or for commercial purposes) (Cunningham, 1992).

Because of the difficulties of assessing ecological impacts in complex systems, most impact assessment studies focus on single species (Hall & Bawa, 1992). Even within single species stands, tree recruitment, growth and mortality are highly variable depending on a vast array of biotic and abiotic conditions. In a complex, multi-species system, tree species must compete with each other for limited resources and this competitiveness may differ radically in response to specific resource uses such as herbivory or timber extraction. Field experiments which determine the effects of a specific resource use on individual species cannot predict how those changes will affect the forest species composition as a whole.

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[3] Heine *et al.* (1988) also quote an informant as saying "trees are prettier than grass, but if there is no grass there is no life", reflecting the greater importance of grass to pastoral communities as a source of fodder.

Relating the results from single species field experiments to complex, multi-species ecosystems, ultimately lies at the core of all ecological research (May, 1976). If management of natural systems is to have a basis in ecological principles, it is essential to extend our understanding of simple interactions to complex ecological systems.

This thesis uses a multi-disciplinary and comparative approach in an attempt to develop an understanding of the factors that affect dry montane forest in the long term. A comparative approach is plagued by the problem of drawing causal conclusions on the basis of correlations in an environment where there are a myriad of variables that can influence vegetation patterns. Using data from a range of disciplines (socio-economic, ecological and geographical), evidence for causal relationships can be built up through a process of triangulation (e.g. Fairhead & Leach, 1994; Lambin, 1994).

This process of triangulation combines deductive and inductive approaches to develop hypotheses and a means of testing them (Kent & Coker, 1992). For example:

1. past research on herbivory on single species provided a background to the mechanisms by which cattle could be affecting species competitiveness and hence stand structure (leading to the deductive creation of hypotheses);

2. large herbivore faecal pellet surveys, together with interviews with elders determined how cattle use forest resources in the area of study and identified areas of known cattle grazing intensity (an inductive approach, collecting descriptive data to relate the hypotheses created to the current environment and to determine ways of testing the hypotheses); and finally

3. vegetation surveys in sites carefully selected on the basis of the results of (2) above identified how cattle were affecting their environment. These results were tested using evidence for long term changes in vegetation cover from aerial photographs (both examples of deductive hypothesis testing).

The approach is modelled in Figure 1-2 below.

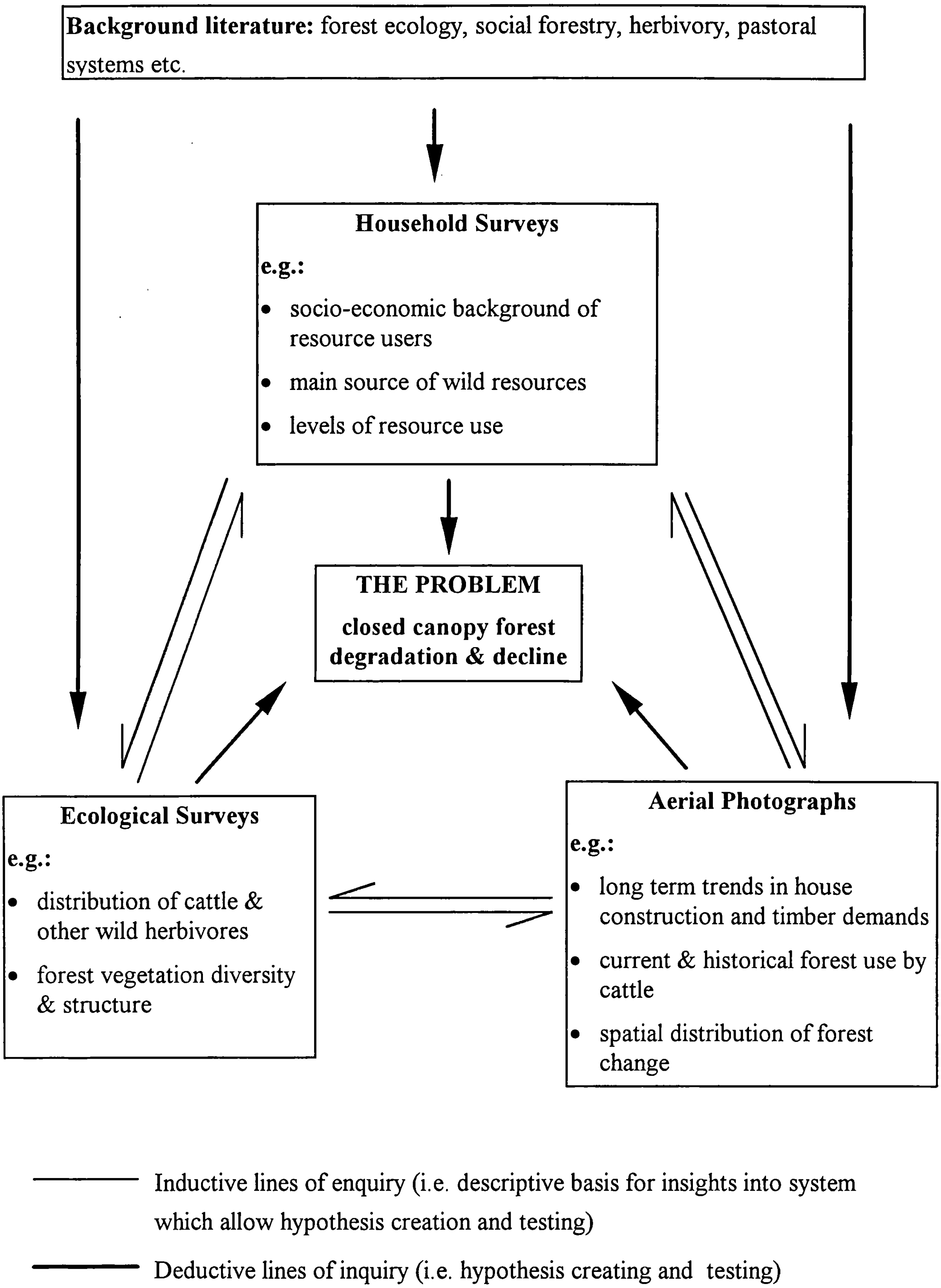



**Figure 1-2** Model describing multi-disciplinary approach of study, drawing on deductive and inductive lines of inquiry to create and test hypotheses.

Given the complexity of both the ecological and social systems this study was investigating, there will inevitably be factors, biotic and abiotic, that may affect the system but that have not been included in the present study. However, using the approach described above, the study has been able to highlight important relationships between pastoral communities and closed canopy forest resources. In addition, the results suggested a number of important areas for future research which are discussed in the course of the thesis.

Finally, it should be emphasised that this study was concerned primarily with closed canopy forest. As such, factors such as forest encroachment are seen as positive indicators of forest health. To the pastoralist, forest encroachment may well be at the cost of valuable grassland, thereby threatening productivity. The importance of management priorities in determining what may or may not be acceptable uses of any ecosystem has been introduced above. Defining management priorities that satisfy as far as possible the interests of all stake holders (in this case, forest managers and the local community) in the context of the Lerroki Plateau will be discussed in the final chapter of this thesis.

### *1.4 Hypotheses and predictions to be tested*

In summary, this study aims to establish the extent to which local communities use the closed canopy forest on the Lerroki Plateau as a source of fodder and water for their livestock as well as other goods and services and the long term impacts of this use on forest vigour. A variety of ecological, socio-economic and historical data are used to assess the following hypotheses:

**Hypothesis 1**. Closed canopy forest is a vital source of dry season grazing and water for a population of cattle disproportionate to its area.

**Prediction 1.** Cattle density within closed canopy forest is highest in the dry season. Cattle using the forest in the dry season originate from areas beyond the immediate environs of the forest itself

**Hypothesis 2**. Trampling and browsing damage to tree seedlings by cattle cause long term forest senescence, ultimately leading to reduction in closed canopy forest cover.

**Prediction 2**. Density of seedlings, young recruits and mature trees is reduced in areas of high cattle grazing and browsing intensity. The area of closed canopy forest cover will have declined in areas subject to cattle grazing.

**Hypothesis 3**. Levels of wild resource use depend on access to market and household economic status.

**Prediction 3**. Wild resource use increases with decline in economic status and ease in access to markets for wild produce. The two factors are likely to interact and therefore cannot be considered independently of each other.

**Hypothesis 4** Extraction of forest resources at the household level is beyond levels of sustainability resulting in a gradual decline in closed canopy forest cover throughout the Lerroki Plateau.

**Prediction 4**. Closed canopy forest cover will have declined around communities throughout the plateau. If the findings are consistent with hypothesis three, then decline will be most acute in areas where economic status is lowest and access to market is highest.

The thesis focuses on closed canopy forest within a gazetted Forest Reserve, held in trust by the State and managed by the Kenya Forest Department. However, aerial photographs analysed in the course of the study covered areas inside and outside the reserve allowing a comparison of resource use and sustainability under differing tenure and management systems.

The results of the thesis have important implications for pastoral groups and forest managers in these dry zone areas, providing a scientific basis for decisions relating to forest management in pastoral areas. Of particular interest is the important role cattle play in the long term conservation of dry montane forests, long recognised by the pastoralists themselves as well as many forest managers

### *1.5 Conclusion*

This chapter has introduced the overlying objectives and hypothesis of the present thesis. The study uses a multi-disciplinary approach to evaluate the impact of cattle and other human activities on forest ecology and cover. The literature review in this chapter provides a background to dryland forest ecology and management, plant herbivore interactions and some of the problems associated with assessing the impacts of resource use in complex, multi-species ecosystems. Given the broad scope of the study, more comprehensive reviews on forest grazing, the impacts of cattle on forest ecology, the range of wild resource use and the importance of forests to local communities are provided in the course of the thesis within the relevant chapters.

# 2. Study sites, methodology and approach

## 2.1 Introduction

The focus area for this study is the Lerroki Plateau in Samburu District. This chapter describes the Lerroki Plateau in terms of its climate, topography, population, vegetation and land use within the context of the District as a whole. The specific study sites around the plateau are then described in more detail followed by a brief outline of the methodology and overall approach taken by the study.

Spatial variation in climate and rainfall across the Lerroki Plateau affects vegetation patterns and potential land use. Historical events and changes in land tenure have tended to restrict access to the most productive areas which have had considerable implications for the local communities. This chapter describes in some detail the communities living on the plateau both today and in the recent past, and the competing uses made of its land and natural resources. The description takes an historical approach, given the importance of past events in defining current distribution and use of land and natural resources. The current study focuses on the use of closed canopy forest by cattle. This chapter therefore includes a brief description of the forests found throughout the Plateau, as well as a section describing long term trends in livestock populations.

## 2.2 The Lerroki Plateau

### 2.2.1 Introduction

Samburu District (Figure 2-1) lies between $36^0$ and $38^0$ North and $0.5^0$ and $2.5^0$ East, bordered by Turkana District to the west, Marsabit District to the north-east, Isiolo District to the south east, Laikipia District to the south and Baringo District to the south west. The district covers an area of roughly 20,808km$^2$, most of which is arid or semi-arid: 80% of the district receives less than 300mm rainfall on average per annum (GoK, 1992), with temperatures often exceeding $32^0$C (Fumagalli, 1977) and a further 12% of the district receives less than 850mm per annum (GoK, 1992). The majority of the population is Samburu, traditionally a pastoral group, largely dependent on cattle and small stock for their livelihood.

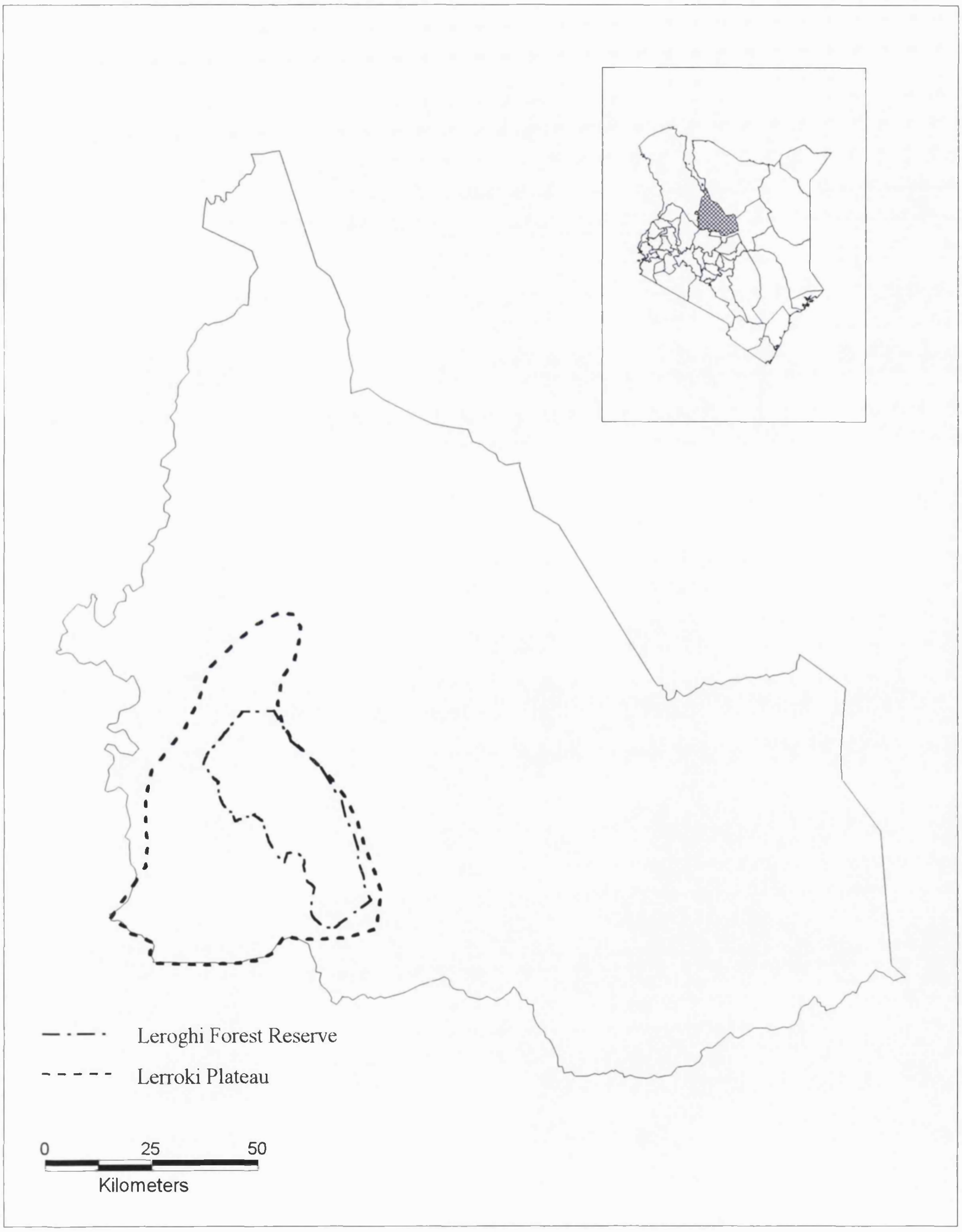
The Lerroki Plateau has been described as the "environmental bank" of Samburu District (Bellerive Foundation, 1993). Situated in the south west corner of the district and covering around 2,900 $km^2$, roughly 13% of the District area, the Plateau has higher and more reliable annual rainfall (500-1200mm), cooler temperatures (mean annual temperature of $15^0$C - $18^0$C) and more fertile soils than found in the hostile arid and semi-arid lowland plains. Around 50% of the district's population live permanently on the plateau and traditionally the area was used by many of the remaining 50% as a source of grazing and water resources during periods of drought. Since the early 1970s, however, East Coast Fever has become endemic on the plateau and the area is now avoided by cattle from the lowland parts of the District (Sperling, 1987; *pers obs.*). The growth of Maralal, the district headquarters, as an important trading centre, changes in land tenure, changes in land use practices, and population growth are just some of the factors which may affect the Plateau's natural resources

### 2.2.2 Topography and soil

The Lerroki Plateau is a high level plateau built by repeated floods of lava from the Rift Valley. Starting at a height of around 1,800m at the south western tip of the District, the plateau rises gently to the north from Suguta Marmar to reach a height of 2,700m at Poror towards the northern end of the plateau. To the west and north, the plateau drops dramatically to the Suguta Valley and the Marti Plateau respectively. To the east, the Lerroki Plateau is bordered by a chain of mountains running north-south, the Karissia Hills.

The soils have developed from undifferentiated Basement System rocks, predominantly gneisses, and are a complex of well-drained, shallow black to very dark brown, acid humic friable loams (classified as Ranker) and well-drained, moderately deep, dark brown, friable clay loams with a very thick acid humic topsoil (humic Cambisols) (Soembroek *et al.* 1982).

**Figure 2-1 Map showing Samburu District and the approximate boundaries of the Lerroki Plateau and the Leroghi Forest Reserve (Inset shows the location of Samburu District within Kenya**



### 2.2.3 Climate

The total land area of Kenya has been defined under a system of agro-climatic zones which reflect moisture availability (taking both total mean annual rainfall and potential evapotranspiration into account) and temperature (Sombroek *et al.*, 1982). The classification system is described in Table 2.1 and the area within each zone for Samburu District as a whole and the Lerroki Plateau is mapped in Figure 2-2 and summarised in Table 2.2.

**Table 2.1** Agro-climatic zones of Kenya's Rangelands[a]

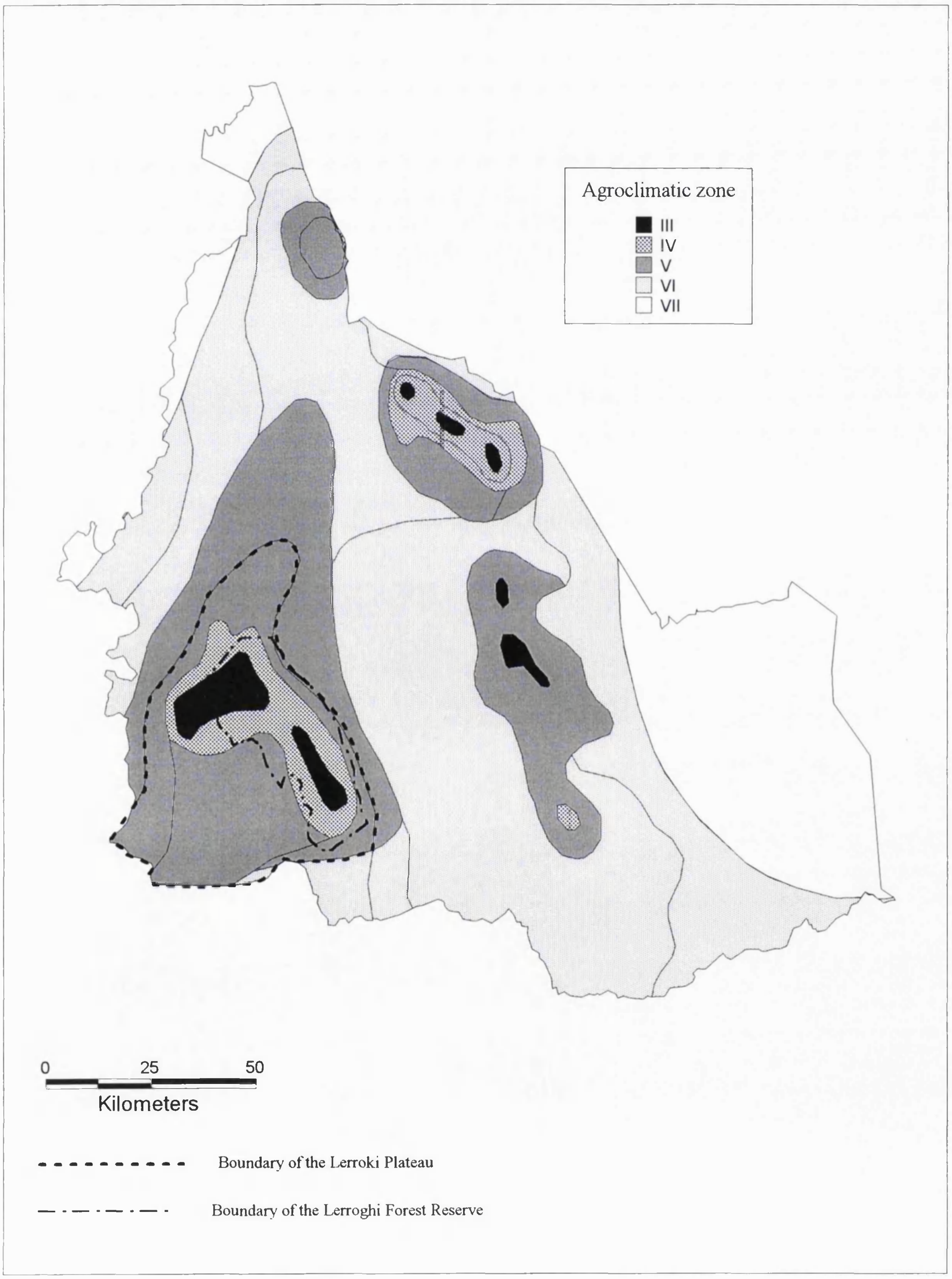
| Agro-climatic Zone | Classification | Mean annual rainfall (mm) | Moisture index |
|---|---|---|---|
| III | Semi-humid | 800-1400 | 50-65% |
| IV | Semi-humid-arid | 600-1100 | 40-50% |
| V | Semi-arid | 450-900 | 25-50% |
| VI | Arid | 300-550 | 15-25% |
| VI | Very arid. | 150-350 | <15% |

[a]From Sombroek *et al.*, 1982
Moisture index = annual rainfall expressed as a percentage of potential evaporation

**Table 2.2** Agro-climatic zones in Samburu District and on the Lerroki Plateau

| | Samburu District | | Lerroki Plateau | | |
|---|---|---|---|---|---|
| **Agro-climatic Zone** | **Total Area ($km^2$)** | **Percent of total area** | **Area ($km^2$)** | **Percent of total area of Lerroki** | **Percent of total area of zone for the District** |
| III | 50,506 | 2 | 33,909 | 12 | 67 |
| IV | 121,297 | 6 | 67,814 | 23 | 56 |
| V | 585,188 | 27 | 192,025 | 65 | 33 |
| VI | 1,018,262 | 48 | 0 | | |
| VI | 364,956 | 17 | 0 | | |
| **Total area** | **2,140,209** | **100** | **293,748** | **100** | |

**Figure 2-2 Map showing agroclimatic zones in Samburu District, showing approximate boundary of the Lerroki Plateau and the Leroghi Forest Reserve**



Agricultural potential is high in Zone III and marginal in Zone IV. Closed canopy forest is found only in zone III and in riverine areas of zones IV and V. Sixty seven percent of the total area of Samburu District within agro-climatic zone III and 56% of the total area within agro-climatic zone IV lies on the Lerroki Plateau. In total 59% of the District's high potential and marginal agricultural land is on the Plateau.

Mean annual rainfall is positively correlated with altitude. Thus, mean annual rainfall varies from 500mm on the lower land to the south and west of the plateau to 1,200mm[1] in the highest areas around the hills to the east and north. (GoK, 1992). The areas within agro-climatic zone III shown in Figure 2-2 are, without exception, areas of highland, with the Matthew's Range to the east of Lerroki, and the Ndoto Mountains to the north east[2].

Below c.800mm, primary production is directly correlated to rainfall (Coe *et al.* 1976, Deshmukh, 1984). When the mean annual rainfall is lower than 800mm and the coefficient of variation[3] (CV) is greater than 30%, the area's climate and primary productivity is better described in terms of its variability than by its average measures (Caughley *et al.*, 1987; Sullivan, 1994). Figure 2-3 below gives an indication of the variability in rainfall from year to year at two sites in the area of study: Poror and Maralal Forest Stations (Figure 2-8). The means are 551mm and 596mm and the coefficients of variation are 35.6% and 34.2% respectively. These data suggest high variability in forage availability both seasonally and inter-annually on the lower slopes of the Plateau within agro-climatic zones IV and V. However such high CV's may not apply to the higher parts of the plateau which support the closed canopy forest and fall within Agro-climatic zone III. The median annual rainfall in the forested highlands is 800-1,000mm (GoK 1991), higher than that of the areas discussed by both Coe *et al.* (1987) and Deshmukh (1984). The forest on these highest areas is

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[1] Rainfall only exceeds 1,000mm in the very highest parts of the plateau. The majority of the plateau receives less than 900mm.

[2] These other mountainous areas found in the District, are also typified by dry montane forests at the highest altitudes and a higher productivity than the district average (e.g. Synott 1979, Bronner 1992). However, they typically rise more steeply from the drier lowlands than with the case of the Lerroki Plateau, with a smaller area on the lower slopes suitable for cultivation.

[3] the standard deviation expressed as a percentage of the mean. (Kent and Coker 1992 p 123)

characterised by lichens suggesting a relatively permanently moist atmosphere. There is no significant long term trend in mean annual rainfall between 1971 and 1988.

Rainfall in the District as a whole follows two distinct patterns: to the north and east a bimodal pattern with distinct peaks in April and November; and to the west and south (including the Plateau) more or less constant rainfall from April to November with less distinct peaks in April and July/August (Spencer, 1973).

The existence of two distinct rainfall patterns within the district and variation in rainfall levels with altitude leads to recognised annual patterns of livestock movement, both altitudinal and latitudinal, which herds tend to follow in the search for grazing and water (described in Sperling, 1987: 75). Prior to the outbreak of East Coast Fever in the late 1970s, cattle from lowland areas to the north and east would use the rangeland on the Lerroki Plateau during their dry season from June to September, sometimes remaining until February before returning to their base settlements. The plateau is currently avoided by cattle from the lowlands due to the risk of disease (Sperling, 1987, discussions with elders in the course of this study).

With the exception of drought years, there is generally forage to be found somewhere on the plateau and as a result, the inhabitants of Lerroki tend to remain on the plateau all year round, moving relatively small distances into the grasslands and forest at higher altitudes during the dry season, compared with those living in the lowlands. During severe drought, cattle may be taken west to the Matthew's Range (DMP, 1993, *pers obs.*).

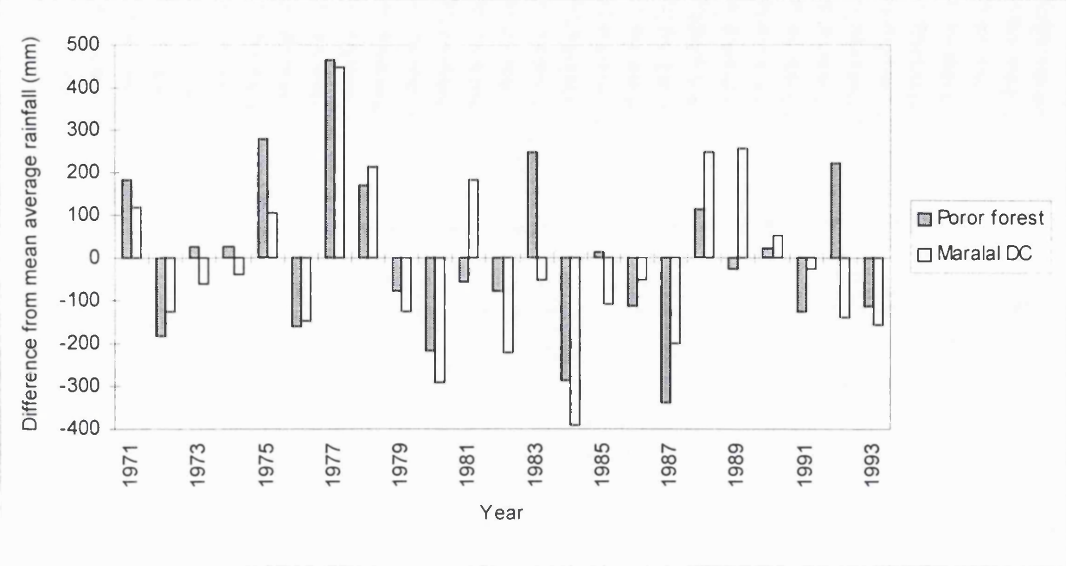


**Figure 2-3** Annual rainfall at Poror Forest Station and Maralal District Commission Office in mm, 1971-1993, (mean for Poror Forest Station, 551mm, CV, 35.6%; mean for Maralal Forest Station, 596mm, CV, 34.2%)

The highly localised variability in rainfall is also clearly demonstrated in Figure 2-3, with considerable differences between Poror and Maralal (just 18km apart) within the same year on occasion. During the course of this study, one of the study sites was receiving heavy showers in March/April while the other remained completely dry for a further 6 weeks, just 10km away. Nearly all the livestock from Lpartuk (the latter village) had been transferred to other areas - many to Ngorika ( the former village).

Despite high inter-annual variation in rainfall, the Samburu do recognise distinct seasons. In field discussion, elders were reluctant to pin these seasons to particular calendar months. However, the results of these discussions concur with those given by Sperling (1987) and Fumagalli (1977). These are shown in Figure 2-4.

**Figure 2-4.** The Samburu Seasons[4]

| Month | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Rain** | | | | | | | | | | | | |
| Lorroki | | | *Lngerngerwa* -------------> | | | | *Lorikine* ---------------------> | | | *Ltumorin*----------------> | | |
| Lowlands | | | *Lngerngerwa* -------------> | | | | | | | *Ltumorin*----------------> | | |
| **Showers** | | | | | | | | | | | | |
| (Lorroki) | *Rurume*[5] | *Somiso ooibor*[6] | *Somiso oorok*[7] | | | *Nkokwai* | | | | | | |
| **Dry** | | | | | | | | | | | | |
| Lorroki | *Lamei Dorrop*[8] -------------> | | | | | | | | | | | |
| Lowlands | *Lamei Dorrop* ---------------> | | | | | *Lamei odo*[9] -------------------------------------------> | | | | | | |

[4] adapted from Sperling 1987

[5] Occasional thunderstorms

[6] lit. "White showers" - occasional showers (Fumagalli, 1977)

[7] lit. "Black showers" - occasional showers (Fumagalli, 1977)

[8] lit. "Short hunger" (Fumagalli, 1977) [9] lit. "long hunger" (Fumagalli, 1977)

### 2.2.4 Economic Environment

Samburu District is characterised by limited infrastructure and commercial activity. The District as a whole covers approximately 20,808km$^2$, and contains a total of 1,532.6 km of classified road of which only 6km are paved (Sperling 1987). Economic activity is concentrated in the administrative centres, the District capital, Maralal, being of greatest importance, with a population of around 15,000 (14% of the District total, GoK 1994). Commerce is largely restricted to the retail and catering trade, with small retail shops, butchers, a few wholesalers, small hotels and beer bars, and other assorted enterprises dominating the market place. Both in the urban centres and in rural areas, these enterprises are dominated by non-Samburu ethnic groups, mainly Somali, Kikuyu and Meru. In Maralal in 1992 only three shops in the town were run by Samburu, all butchers (*pers obs.*).

The Lerroki Plateau, with Maralal at its heart, contains most of the infrastructural improvements and administrative services as well as agricultural land. However, two relatively new sources of capital are resulting in pockets of investment elsewhere: Samburu soldiers returning from service with the UN troops in places such as Namibia and Yugoslavia; and non-governmental organisations such as OXFAM. Baragoi town, the administrative centre of Baragoi Division 120km north of Maralal, has a thriving shopping centre, with a new street (Bosnia Street) and several new NGO project headquarters built of the local granite stone since 1991. With the exception of the administrative buildings, the two secondary schools, the hospital and missionary buildings, and a few shops, Maralal is built almost entirely from *Juniperus procera* ("*ltarakwai*" in the local Maa dialect).

### 2.2.5 The Population

Samburu District was formally defined by the British colonial administration in 1947. While the majority of the Samburu population live within Samburu District, in 1989 an estimated 24% of the Samburu population lived outside the District, mainly in neighbouring Districts or the urban centres of Nakuru and Nairobi (GoK, 1994).

The current population of Samburu District is estimated to be 108,884 (1989 National Census). However, this population is not evenly distributed throughout the District.

The District is divided into six administrative divisions: Lorroki, Karissia, Baragoi, Nyiro (South Horr), Wamba and Waso. Table 2.3 summarises the distribution of the district population between the divisions. The Lerroki Plateau dominates both Lerroki and Karissia Divisions.

**Table 2.3.** Changes in population of Samburu District, 1969-1989

| **Division** | **area km$^2$** | **1969** | | **1979** | | **1989** | |
|---|---|---|---|---|---|---|---|
| | | Popn | Density | Popn | Density | Popn | Density |
| **Lorroki/ Karissia** | 4,048 | 29,835 | 7.37 | 34,753 | 8.59 | 49,560 | 12.24 |
| **Baragoi/ Nyiro** | 6,793 | 19,702 | 2.9 | 23,391 | 3.44 | 30,881 | 4.55 |
| **Wamba/ Waso** | 9,967 | 19,982 | 2 | 18,764* | 1.88 | 28,443 | 2.85 |
| **Total** | 20,808 | 69,519 | 3.34 | 76,908 | 3.7 | 108,884 | 5.23 |

(Source: RoK. Ministry of Planning and National Development 1986 & 1994)
* This decrease can be attributed to out-migration caused by insecurity (Were & Ssenyonga 1986)

Of the total 1989 population, 46% are resident in Lerroki and Karissia Divisions which cover just 19% of the district area, giving a population density for the area of 12.24 people/km$^2$ compared with the overall population density for the District of 5.23 people/km$^2$. The rural population of the Lerroki and Karissia Divisions can be estimated by removing the figures for Maralal Town and neighbouring Ledero. Even without these urban areas, the population density for the two divisions remains much higher than that of the District as a whole at 9.17 people/km$^2$. (All these values are low compared with the national average of 41.7 people/km$^2$.).

Table 2.4 details the rates of population growth over a twenty year period from 1969-1989 across the District.

**Table 2.4.** Annual rates of increase in the population of Samburu District, 1969-1989

| **Division** | **1969-1979** | **1979-1989** | **1969-1989** |
|---|---|---|---|
| **Lorroki/Karissia** | 1.54% | 3.61% | 2.57% |
| **Baragoi/Nyiro** | 1.73% | 2.82% | 2.27% |
| **Wamba/Waso** | -0.63% | 4.25% | 1.78% |
| **Total** | 1.02% | 3.54% | 2.27% |

Over the last 20 years the overall population has been growing at a slower rate than the national average (2.27% compared to the national average of around 3%)). However, the situation has changed within the last decade, with an overall growth rate of 3.54 for the district as a whole. The very high growth rate in Wamba and Waso Divisions from 1979 to 1989 can be accounted for by the return of many inhabitants who had fled due to insecurity during and immediately following the Shifta war of the 1960s (Oba, 1990). The high growth rate around Lerroki and Karissia Divisions, however, are, at least in part, due to immigration of non-Samburu, both rural and urban (Fratkin, 1994). In 1969, 85% of the total population of Samburu District were Samburu; in 1989, the proportion had fallen to 75%.

There are four indigenous ethnic groups in Samburu District: the Samburu, the Ariaal Rendille, the Dorobo[9] and the Turkana (Were 1986). In 1989, the Samburu formed 75% of the total population of the District, with Turkana (15%), Kikuyu (2.8%), Kalenjin (1.5%) and Rendille (1.25%) being the only other ethnic groups representing more than 1% of the total (GoK, 1994).

The two groups included in this study are the Samburu and the Turkana. The Samburu have traditional rights to the natural resources on the plateau and land rights may only be obtained by non-Samburu through marriage or by officially leasing the land. Most of the non-Samburu in the district (with the possible exception of the Rendille and some Turkana in the north around Baragoi) have settled in the area around Maralal Town in order to benefit from the employment and market possibilities of the town. With no real rights to land within Samburu District, many of these non-Samburu (particularly the Turkana) have essentially refugee status.

For the purposes of this study, discussion of traditional institutions and natural resource management focuses on the Samburu. Samburu leaders in the area control access to both gazetted and ungazetted forest areas (unless the outsider approaches the

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[9] The Dorobo (also "Ndorobo") refers to an economic mode and should not be used as an ethnic referent (Sperling 1979). Ndorobo refers to communities of hunter gatherers, frequently associated with a forest environment. These communities may have a broad ethnic base, being a refuge state in times of poverty or famine. In Samburu District, the Dorobo are mainly found in the Ndoto and Matthew's mountain ranges, although a recent initiative from the Forest Department has expelled many of the communities from within the Forest Reserves found in those areas.

Forest Department directly). Non-Samburu are allowed access to the forests by the Samburu for resources such as wood for fuel, charcoal and carving, but not to graze livestock there. Thus, while non-Samburu may have a significant impact on forest resources (e.g. through demand for products for building in Maralal and for fuel), management of these resources is controlled by the Samburu elders from each area.

### 2.2.6 Pastoralists and paradigm shifts

The Samburu have been studied extensively by a number of anthropologists. In particular: Spencer (1965 and 1973) has described in detail the social relationships within Samburu society; Sperling (1987) provides a description of distribution and management of labour, particularly with respect to livestock management; Sobania (1979, 1980 & 1993) examines in detail the history of the Samburu in the context of the area east of Lake Turkana; and Fumagalli (1977) has reviewed a vast amount of colonial archival material and provides an extensive account of post-colonial government policy. All of the above accounts focus on the drier areas of the Samburu territory, and tend not refer in any depth to the Lerroki Plateau, with the main exception of Fumagalli who makes considerable reference to government policy on the plateau from the 1940s.

Samburu society is strongly hierarchical, divided both by descent and by age. Spencer has described the society as a gerontocracy (Spencer 1965 and 1973), but this conclusion has more recently been questioned as being an oversimplification of the real situation, with women and young men playing a more positive role than was previously attributed to them (Fumagalli 1977, von Mitzlaff 1988). The division of labour and responsibility for the management of natural resources are to a large extent dictated by age and sex, however, the segmentary descent system is important politically and spatially. A detailed description of the Samburu society can be found in Spencer (1965 and 1973).

The Samburu are a Maa-speaking, Nilo-Hamitic ethnic group, thought to be closely related to the Maasai of Southern Kenya and Northern Tanzania, and the Il Chamus of northern Kenya (Spencer 1973). The Samburu are thought to have splintered from the main Maasai groups in the 19th century, in the period when many pastoralists groups were becoming increasingly specialised under "zebu cow power" (Lamphear, 1993).

The evolution of these "new pastoralists", highly specialised in livestock rearing and apparently highly exclusive, is thought to have been strengthened by a "cultural exclusivity" whereby agricultural activity was scorned as was hunting and foraging (Galaty, 1993). However, the reality of this apparent exclusivity has been questioned. The stereotype of a purely pastoral community was probably achieved by most people only in good times with changing economic practises representing "complex responses to realities and opportunities" (Sperling & Galaty, 1990; Berntsen, 1979). Shifting in and out of agriculture has been an adaptive response of most pastoral groups in Kenya as has the complete absorption of other ethnic groups (e.g. Anderson, 1988, Spear & Waller, 1993). As a rule, however, this shifting in and out of agriculture was accomplished by a change in geographical location and, in some cases, in identity. For example, Waller (1988:94) describes the two choices open to pastoralists in times of environmental and economic stress as "either to remain where they were and attempt to subsist on what stock they had while, if possible, acquiring more through raids or exchanges; or to shift and take up hunting and/or cultivating as a temporary expedient". Waller goes on to suggest that this shift was, in the case of the Maasai, cultural as well as economic. "Ethnic boundaries had previously been drawn so as to discriminate between those who had access to stock and those who did not...many who had moved across the boundaries of pastoralism in ways, such as hunting and foraging, which appeared to transgress norms of behaviour.. compromised their claims to a Maasai identity" (Waller, 1988:108). Waller is describing the response of the Maasai to a disastrous period of drought and disease at the end of the 19th century. The epidemics and droughts of this time also affected the Samburu, many of whom moved to the forested areas or to the Baringo area and 'became' Ndorobo or were accepted into the Il Chamus society as a source of labour respectively (Anderson, 1988). Those Samburu who were able to build up new herds returned to Samburu land, while many families stayed with the new communities and within a few generations became fully integrated into that group (Galaty, 1993). In the same way, many authors report extensive integration of other ethnic groups into the Samburu during other periods, with the complete absorption of Samburu culture and traditions (Spencer, 1973; Sperling, 1984; Sobania, 1980).

To this day, Samburu are typically viewed as "specialist" pastoralists, relying almost entirely on milk, blood and honey both for sustenance and for exchange for other products such as cereals, sugar, tea and beads (Sperling & Galaty, 1990). Cattle are still held to be the most important type of livestock in terms of wealth in the Samburu culture, although small stock have always played an important role in the livestock economy (Sperling 1987, Sobania, 1993)[10].

However, most Samburu on the Lerroki Plateau also now cultivate a small farm, mainly for subsistence (this study, see also Perlov, 1987). This represents an apparent shift from the past in that the Samburu are practising agriculture or agro-pastoralism on a large scale *in situ* within the main Samburu community, maintaining at the same time their essentially pastoral Samburu identity. Discussion with elders from the area suggest that maize and vegetables were first grown on the Plateau during the World War II: prior to that "the only crop grown by the Samburu was tobacco, used to purchase smallstock" (elder, Angata Nanyukie Group Ranch, 1994). Economic need due to widespread loss of cattle to disease and drought has resulted in a widespread shift to an agro-pastoral Samburu economy. Samburu from the lowland plains refer to the Samburu on the Lerroki Plateau as "*wazungu Samburu*", meaning 'European Samburu' reflecting the traditional scorn held by pastoralists for agriculturalists who violate the land through cultivation.

This shift is not unique to the Samburu. Similar trends have been documented for the Orma, the Rendille and the Boran, among others, as a result of a long term government policy of sedentarisation, highly localised availability of services, and/or economic necessity (Hogg, 1987; Kelly, 1990; O'Leary, 1990; Oba, 1990; 1994; Toulmin, 1983; Coppock, 1993). Economic necessity may initially have been the driving force behind the recent shift towards cultivation among pastoralists. However, many wealthy pastoralists have followed suit using investment in agriculture as a means of supporting their large herds (Little, 1985). Grandin *et al.* (1991) suggest that sedentarisation and individualisation of production among the Kenyan Maasai stems from the desire to stake a claim to the land should sub-division

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[10] In the drier parts of the District and where range conditions are thought to have deteriorated, camels are being promoted by a number of development organisations.

into individually owned land plots occur (discussed further below). It is too early to tell how permanent this shift will be.

### 2.2.7 The Samburu and the Lerroki Plateau

While the Samburu occupy the Lerroki Plateau at present, the history of northern Kenya is one of movement and shifting alliances and the Samburu occupancy of the Plateau dates back only to the 1920s.

For most of the 19th century, the Plateau was occupied by the Maa-speaking Laikipiak Maasai[11], who dominated a vast area covering the entire Laikipia Plateau, north of Mt. Kenya, up to the El Barta Plains north of Lerroki. During the late 1880's, the Laikipiak Maasai were beaten in a series of battles with the Purko Maasai who moved in to occupy Laikipia and Lerroki (Spencer, 1973; Sobania, 1980). The weakened Laikipiak, driven northwards, continued to raid their Samburu and Rendille neighbours until they were finally so weakened and defeated in battle by the Rendille that they "were finished" as a group, killed or absorbed into the surviving ethnic groups (Sobania, 1993, Lamphear, 1993).

A Samburu elder from Angata Nanyukie Group Ranch related the tale behind a glade called "Lantangatan" in the Leroghi Forest Reserve originating from this period:

> "Lerroki was occupied by the Laikipiak until a fight between the [Purko] Maasai and the Samburu and the Laikipiak during the time of the *Lmarikon* age set (1879-92). The Laikipiak Maasai had stationed their moran[12] at Morijo, Poror and Loikas to defend the old men, women and children who were hiding in the forest. The Maasai [Purko] came from the south and the Samburu came from the north from Nyiro and when the moran saw they were beaten they fled leaving the people in the forest defenceless. "*Lantangat*" is the Samburu name for a ceremony held when a woman dies, "*Lantangatan*" is

[11] According to Spencer (1973 p 150), the Lerroki Plateau was inhabited by the Samburu during the *Kipayang* age-set of 1823. The Kenya Land Commission (1933) also suggests that the "Samburu and the Laikipiak Maasai at one time lived together on Lerroki, but as a result of a quarrel, the Laikipiak attacked the Samburu and the latter were driven to El Barta and Nyiro".

[12] The moran are unmarried men from a warrior age class. For full definition, see Spencer (1965; 1984)

"the place where many women died". From that time no-one has lived in the forest except in times of very bad drought."

Given the state of the Samburu at this stage in their history, it seems unlikely that the Samburu had a great role to play in defeating the Laikipiak at Lantangatan and according to the Kenya Land Commission (1933), the Samburu "took no part in that war".

The years from the late 1870s to the turn of the century are known as "*Emutai*"- the disaster. Starting with a smallpox epidemic in 1875, the Samburu suffered from a succession of drought, and contagious bovine pleuro pneumonia (CBPP), and rinderpest outbreaks. During the rinderpest outbreak, the Samburu are thought to have suffered cattle losses of up to 90% (Sobania, 1980). The survival response of the Samburu was one of dispersal. Some associated themselves with, and frequently married into, neighbouring ethnic groups that had suffered less from the outbreaks, such as the Elmolo, the Rendille and the Dassenech. Others retreated to a Dorobo existence in the forests of Mts. Nyiro and Kulal and the Ndoto's, living on wild fruits and honey, and many resorting to stealing (Sobania 1980; Waruinge, 1986). Many men worked for the Rendille, whose herds of cattle, camels and smallstock had been left practically untouched by rinderpest. These men received smallstock as payment which were gradually accumulated to restore the lost livestock herds. The recovery of the Samburu was helped by an outbreak of small-pox among the Rendille in 1895 which left too few people to care for and guard the extensive herds. The Rendille were suddenly heavily dependent on their previously poor neighbours, the Samburu, who suffered less from the small-pox outbreak because of the resistance built up from previous exposure in the '70s. The Samburu were thus able to build up their herds much faster than would otherwise have been possible both from payment for herding services (in the form of livestock) and from raiding (Sobania, 1980).

It is possible that some Samburu moved from Nyiro to Lerroki immediately following the *Emutai* and the story related above certainly suggests there were good relations between the occupying Purko Maasai and the Samburu. An elder living at Angata Nanyukie in 1994 and belonging to the *Lmaricho* age set, (circumcised between 1912 and 1923) recounted that before he moved to Lerroki when he was a boy there were

Laikipiak living at Lantangatan and he remembered seeing some Laikipiak and their cattle around the forest.

> "There were many, many Laikipiak cattle around - it was them that cleared the bush".

The main occupancy of Lerroki by the Samburu, however, took place from 1910 to 1920, largely as a result of Colonial interference in the area starting at the beginning of this century.

At the turn of the century, British settlers were hungry for land and in 1911, the Laikipia Plateau to the south of Lerroki was opened to European settlers. The "northern Maasai", including the Purko Maasai, were evicted in the same year and moved to reserves in the south and Lerroki was left unoccupied (Kenya Land Commission, 1933; Waller, 1992). The Samburu moved in rapidly. Captain Stigand met Samburu along the foothills immediately north of the Lerroki Escarpment in 1909 and expeditions in the following years found them shifting further and further south. By 1920 it was thought that 50% of the Samburu population were occupying the plateau (Fumagalli, 1977; Kenya Land Commission, 1933), although this was disputed by European farmers who claimed the "Samburu make comparatively little use of the Lerokki Plateau for their cattle, particularly of the higher parts".

It was not long before the European settlers, having "occupied" most of Laikipia, began to turn their attention to Lerroki. Clearly the area had potential and in 1927 the Governor, Sir Edward Grigg, in a public meeting at Barsaloi, informed the Samburu that Lerroki did not belong to them and never would (Fumagalli, 1977). The Samburu rebelled and began to raid ranches on Laikipia in protest. Fortunately, the District Commissioner at the time was sympathetic to the needs of the Samburu and finally, in 1933, the Kenya Land Commission recommended that the Plateau should be reserved for Samburu use and occupation. The reasons behind the decision were given as threefold: the British Administration had already reduced Samburu access to dry season grazing by removing them from Mt. Marsabit and Laikipia; there was no alternative area that could provide an adequate exchange; and finally, the area was thought to be prone to tsetse fly and therefore of limited development potential (Kenya Land Commission, 1933).

The Samburu had been assured access to Lerroki, but there were conditions: the Land Commission also recommended that the forested area on Lerroki should be gazetted and brought under crown control and the number of cattle on the Plateau was to be reduced to 40,000.

### *2.2.7.1 The Lerroki Grazing schemes*

The comparative approach taken by this study relies on a thorough understanding of historical use of the forests, particularly for cattle grazing. Prior to colonial interventions on the area, there is no doubt that the Samburu, and prior to them the Purko Maasai and the Laikipiak Maasai, kept cattle on the Plateau and would have used the forest for dry season grazing. Since the Kenya Land Commission report of 1933, there have been a series of grazing schemes on the Plateau, controlling grazing intensity both inside and outside the reserve. These have been reviewed extensively by Fumagalli (1977) and Helland (1980).

Following the creation of the forest reserve in 1933, when the entire gazetted area was officially closed to cattle grazing, the Colonial Administration initiated a series of grazing schemes on the Lerroki Plateau aimed at preventing what they perceived as inevitable and severe land degradation. These grazing schemes included destocking and the control of animal movements and the complete banning of small stock within protected areas (Helland, 1980). Initially, 7 locations were demarcated across the Plateau, one or more of which was to be closed each year for recovery (Sobania 1980).

The restricted grazing measures were consistently rejected and ignored by the Samburu but despite the resistance, a District Commissioner reported in 1937 that vegetation cover on Lerroki had improved greatly following the first two years of grazing control (Bronner, 1990). In 1939 the Samburu removed the forest boundary pegs as a sign of protest to the loss of forest grazing. They were given permission to graze in return for a communal payment to the administration and their guarantee to co-operate with the proposed culling program which would reduce the number of livestock on the Plateau to the recommended 40,000 units. The new grazing controls were now enforced, with fines for offenders who exceeded their quotas. (In 1940 culling was again proposed but never imposed since the estimated number of cattle on the plateau was only 34,000 (Sobania 1980).

Destocking was heavily opposed from its inception in 1933 and, following the murder of several Europeans in Laikipia, a Levy Force was imposed in 1934 and the carrying of spears was prohibited. Unreliable rainfall made strict rotational grazing impossible and during World War II, destocking schemes were put on hold. The main drive towards destocking started again in 1942, when the Provincial Commissioner announced the introduction of branding. By 1944, grazing controls were in practice and being enforced to some extent, but the branding scheme was still not implemented. Bronner (1990) writes that in 1945 the Samburu actually changed their attitude towards the schemes and wanted cattle branding, the move being described as a "mental revolution". However, according to Fumagalli (1977), in 1949, a group of Samburu elders, backed by the administration employed Government 'headmen', met at Kisima to explicitly request the abolition of the Lerroki grazing rules.

The Provincial Commissioner responded by summoning the elders and informing them that the orders had already been given for the "branding operations to start". A Levy Force was brought in and the operation was completed within three months. In 1950, just one year later, the administration published the "Memorandum on Problems, Policy and Planning for Agriculture in Native Areas", applauding the success of the grazing control measures and promoting total sedentarization of nomads and individual ownership. New grazing controls were introduced by the District Commissioner under which the D.C. would issue permits for a limited number of livestock to graze in the controlled areas, reserving his right to close an area whenever he considered it necessary. The Plateau was divided into blocks with a strict system of rotation. A series of water holes and dams were proposed as a solution to watering problems created by restricting animal movement (African Land Development Board, 1956). The system proceeded to change almost as regularly as the District Commissioner and by 1959 the Plateau had become a "checker board" of 237 grazing blocks. (Fumagalli, 1977). The grazing schemes continued throughout the next decade, spreading in area throughout the District having been extended to the lowlands in 1947. By 1961 they covered a third of the area of the District and 1,500 sq. miles were being rested at any given time in addition to the 1,683 sq. miles of gazetted forest reserve (Helland, 1980).

The schemes were never accepted or popular (Sobania 1980). Patchy rainfall, typical of arid and semi-arid areas, made it practically impossible to enforce strict control when rain was falling on a restricted area leaving the 'open' areas dry. The situation was made worse by the large numbers of wildlife that were allowed to roam, unhindered, grazing the best pastures in the restricted areas before the eyes of the Samburu. Destocking regulations effectively shifted the distribution of livestock throughout the District resulting in overcrowding in the uncontrolled, low potential areas as members of the schemes off-loaded their excess stock to relatives in the uncontrolled areas (Helland, 1980). This created severe problems of soil erosion and land degradation in these areas. Trespassing was a major problem and, with the schemes covering such a massive area, they became practically impossible to enforce. Ultimately the schemes were doomed. Severe drought in 1960/61 forced the administration to suspend the controls and when KANU came into power at Independence in 1962 the schemes were immediately abolished. Access was granted for permanent grazing in the Forest Reserve of around 6,000 mature cattle at this time as a sign of goodwill (Bronner, 1990).

By 1966 there were again concerns on the part of the Administration about degradation and overgrazing and in 1969 access for permanent grazing in the Forest Reserve was once again abolished. These rules were gradually relaxed until 1984 when a total forest grazing ban was again imposed following a Presidential Decree. Once again the ban was heavily opposed by the local Samburu community and there were several serious fires as a result of arson in the forest reserve during the eighties. The Forest Department negotiated with the elders as a result of which dry season grazing was again allowed and Forest Fire Committees were established in all the group ranches surrounding the forest reserve responsible for reporting fire outbreaks and enlisting assistance in the event of a fire occurring. Since the establishment of these committees in 1991, there have been few fires and none as serious as those seen in the previous decade (L. Lenkaak, Forest Officer, Lerroki Division). Fires will be most severe in dry years following abnormally wet years (Dublin, 1991). The low occurrence of fire in 1993 which was abnormally dry following 1992 (a relatively wet year, Figure 2-3) is testament to the success of the scheme. As before, the primary objective of forest policy is to protect and preserve the water catchment.

### 2.2.8 Land tenure on the Lerroki Plateau

Land use and vegetation on Lerroki are closely linked with tenure and state intervention in the area (c.f. Oba, 1994). In the arid and semi-arid conditions of northern Kenya, the major concern of pastoral communities is access to grazing and water. Where rainfall is unpredictable and patchy, access to forage can only be assured by moving. From 1933, the colonial administration played an increasingly interventionist role in the District, most notably in terms of the gazettement of a number of Forest Reserves (both on the Plateau in 1936 and on Mt. Nyiro, the Matthew's Range and the Ndoto's in 1956) and the introduction of grazing schemes. Since independence, the Land (Group Representative) Act of 1968 saw the introduction of group ranches throughout much of Kenya's rangelands including Samburu and more recently there has been a shift towards individually owned plots in some of these Group Ranches. All of these events have had implications for the local communities by changing access rights to land across the plateau.

Theoretically, traditional Samburu customary law states that the entire Samburu domain belongs to all Samburu collectively, the main exception being Mt. Nyiro, over which the *Masula* clan have priority. In reality, long term usufruct rights have given the local inhabitants of a particular area privileged access to that area and outsiders traditionally require the consent of the primary users (Potkanski, 1993). Outsiders using these "primary user areas" (Sperling 1987: 78) without permission would run the risk of being cursed by the resident elders (Sperling 1987, Spencer 1965, Sobania 1980), although in reality, primary local users are always prepared to allow access to grazing and browsing resources so as to ensure reciprocal access during drought periods (Potkanski, 1993). Institutionalisation of regular users leads to secondary user rights. Customary primary user rights have become an important issue recently with the trend towards individual ownership of land in many pastoral areas (Oba, 1990; Baxter, 1990; Potkanski, 1993)

Traditional access to water operates in the same way as access to land, with primary and secondary users. In the case of water-holes, however, which require labour to establish and maintain, the primary user group refers to just one official user, who may have dug the well or be descended from those who dug it, and who remains individually responsible for its maintenance. Secondary users may include agnates, affines and friends (Potkanski, 1993; *pers obs.*).

During the colonial period, the area of the district not gazetted for forest reserves was divided into administrative blocks under the leadership of government appointed chiefs and sub-chiefs. The same system of "primary user areas" operated during this time, although permission to graze in the area could be requested from the chief or sub-chief as well as the local groups of elders. (Sperling 1987). Legally, however, the land was held in trust by the County Council under an open access system. This was considered by the authorities of the time to lead to accelerated land degradation and to be an impediment to development, and in 1972, a program of land adjudication was started in Samburu District under which previously communal land was divided into Group Ranches. Outside Maralal Town, land today can roughly be divided into four types according to tenure: group ranches; smaller private holdings - the product of recently sub-divided group ranches; large private ranches; and State owned Forest and Game Reserves. In 1989 there were seventeen large private ranches in the area owned and managed by individuals, 20 group ranches, and 3 'ex'-group ranches now adjudicated into individual small holdings.

#### *2.2.8.1 The Forest Reserve*

The Leroghi Forest Reserve covers an area of 91,790ha, approximately 23% of the Lerroki/Karissia Divisions. In addition to the forest reserve, there are two small wildlife reserves. The Forest Reserve was gazetted in 1936, with the express purpose of protecting the area's water catchment properties as well as the vegetation (Kenya Land Commission, 1933). The Reserve is managed by the Forest Department of the Ministry of Environment and Natural Resources, and comes under the District Forest Officer and the Lerroki Forest Officer based in Maralal. Use of the forest and its resources is subject to The Forests Act (1964), which prohibits any person to, among others, "fell, cut, burn, injure or remove any forest produce" or to "depasture cattle or allow any cattle to be therein", unless a licence is granted to do so. Livestock grazing in gazetted forests was again prohibited nationally by Presidential Decree in 1984.

Figure 2-2 shows the boundaries of the gazetted areas within the District as a whole, including the Leroghi Forest Reserve and the two wildlife reserves. The area of each agro-climatic zone occupied by the reserve and the proportion that this represents of the Plateau as a whole is summarised in Table 2.5.

In 1947, when Samburu was constituted as a District, the policy for forest management was laid out for the first time as "preserving and improving the existing trees and protective cover" and "from the point of view of water supply". This was revised in 1954 when it was written that the Samburu had "no right in a legal sense" to Lerroki Forest and the primary objective was protection of forest and maintenance and improvement of water catchment and supplies. In other words, grazing and all other activities were of secondary importance (Fumagalli 1977).

**Table 2.5** Area of agroclimatic zones occupied by the Leroghi Forest Reserve

| Zone | Area of each zone within the Leroghi Forest Reserve (ha) | Proportion of the total area of each zone on the Plateau occupied by the Forest Reserve |
|---|---|---|
| III (Semi-humid) | 25,195 | 74% |
| IV (Semi-humid - Semi arid) | 47,769 | 70% |
| V (Semi-arid) | 20,646 | 11% |

The figures in Table 2.5 clearly show the extent to which the creation of the Leroghi Forest Reserve in 1936 alienated the vast majority of the high potential and medium potential agricultural land on the plateau from the local Samburu population. Less than 30 % of the Reserve is under closed canopy forest, the remainder being primarily grassland and shrub, and limited dry season grazing has been permitted under pressure from the pastoralists (KIFCON, 1994). This controlled grazing is considered by the local forest officers to be very useful to the Forest Department in controlling the build up of dry undergrowth which is a serious fire hazard (L. Lenkaak, Forest Officer, Lerroki Division, *pers comm).*

### *2.2.8.2 Group ranches, private ranches and the shift towards individual ownership of plots*

Group ranches were first established in Kajiado District in the south of Kenya in the 1960s under the Land (Group Representatives) Act of 1968. Under this act freehold title deeds to a legally defined area of land were allocated to the primary users within each area as a collective group (Grandin, 1991). All land in the group ranch is shared by all registered members and in theory a member is allowed to establish a manyatta or shamba, or to graze his livestock, anywhere in the ranch. In reality, the system of primary user areas still applies within the group ranches (*pers obs.*, Potkanski, 1993). In Samburu District, the group ranches are still held in Trust by the County Council (GoK, 1986)

The theory and practice behind group ranches are discussed extensively by Helland (1980), Raikes (1981), Galaty (1980; 1994), Davis (1970) and Campbell (1993). In summary, group ranches were intended to act as a vehicle for technical innovation. By privatising land ownership and limiting movement, it would be easier to target pastoralist groups for state programmes and the land could be used as capital to back loans for structural improvements such as water development, livestock dipping and handling equipment, and breed improvement. In practise these objectives were not fulfilled due in part to a combination of ecological non-viability and lack of social cohesion within the ranches (Grandin, 1991; Galaty, 1980).

The Land Adjudication Department arrived in Samburu District in 1972 with the remit of establishing a system of group ranches as had been started in the Maasai areas in the south. The first five group ranches were allocated in 1973 and by 1983, 65% of the district was adjudicated to private owners or grazing co-operatives (Bronner 1990).

In two group ranches in the south west of the plateau, a considerable area of each ranch has been collectively leased to commercial wheat farmers who come from outside the district. These farmers, while potentially increasing pressure on the plateau's resources by restricting access to extensive areas of land, are not considered major users of the forests (Fratkin, 1994).

Shambas, small 0.5ha to 2ha plots often surrounded by fencing made of cedar posts and/or branches from small trees and shrubs, are scattered throughout the group ranches and separated by extensive areas of grassland and shrub or forest (Figure 2-5). While the land is being cultivated, the cultivator has usufruct rights to the shamba and all food grown in it. As soon as s/he moves away to another area even within the group ranch, the land becomes communal again. The same rules apply to trees that are planted. In the past this is thought to have dissuaded people from planting trees. Today, trees are being planted by some as a way of establishing user rights to a particular area in the hope that if the land is adjudicated they will have first rights to the title deeds of that particular area (Samburu elder, Ngorika, *pers comm.*).

A trend towards the division of group ranches into privately owned individual plots, started in Maasai land to the south, has also begun in Samburu District (Fratkin, 1994; Galaty, 1993; 1994). The process has already been completed in two group ranches on the Lerroki Plateau, is currently underway in several of the group ranches and is under discussion in others. In the areas where adjudication has taken place, much of the land has been leased to a few individuals and companies and converted to large scale wheat cultivation. The owners of the land, previously registered members of the group ranches, have kept small patches of their individual plots for subsistence cultivation and are keeping most of their stock with friends or relatives in other parts of the Division or District. Grandin *et al.* (1991) propose the growing trend towards sedentarisation and individualisation of production stems from a desire to stake a claim in a piece of land should sub-division of group ranches into individually owned plots occur (also Campbell, 1993).

**Figure 2-5** Photograph showing scattered encampments with shambas at Ngorika

In the two adjudicated ranches, most forest resources were limited to small areas of riverine forest and shrub. These areas were parcelled out with the rest of the land and are now used and managed by the individuals in whose land they fell. In the group ranches now in the process of transition to individual holdings there are extensive areas of forest currently under management of the group ranch. It is not clear what will happen to these areas in the future. If they are parcelled out as before it is likely that much of this forest will be cleared.

Of the private ranches, many are maintained as cattle and smallstock ranches. However, there is a continuing shift towards wheat cultivation which has proved to be very profitable in the area.

### 2.2.9 Land use on Lerroki

In summary, current land use on the plateau is a combination of: large scale commercial wheat farming carried out by a few non-Samburu on land leased from individual Samburu or from Group Ranches; small scale farming (0.25 - 2ha) on individually owned or group owned land, mainly at a subsistence level; open rangeland, owned communally or individually, used for cattle and small stock rearing; gazetted forest and, to a lesser extent, wildlife reserves; and closed canopy forest and bush land within individually or group owned ranches.

The majority of the plateau is still open rangeland and forest. Vegetation on the plateau varies with altitude, from open Acacia woodland and grassland at the lowest altitudes to the south, becoming evergreen bush and grassland in the ranches north of Maralal, and gradually changing to dry montane forest vegetation at the highest altitudes and along river valleys. Almost a quarter of the Lerroki Plateau at the highest altitudes is gazetted as forest (and to a much smaller extent, wildlife) reserve. The Forest reserve occupies most of the area of the plateau within agro-climatic zone III. A large proportion of the forest reserve is not actually closed canopy forest: aerial photograph interpretation reported in this study, suggests less than 25% of the reserve is actually forested, the remainder being grassland, shrub and bush. Outside the reserve, forest is limited to river valleys, although forest cover is still quite extensive.

Large scale wheat farming is still expanding in the area, with grassland and shrubland being leased and converted by companies or individuals. These operations are intensively managed, using planes to apply pesticides, herbicides and fertilisers and combine harvesters to prepare the harvest for transportation to Nakuru where the wheat is processed. Profit margins are reportedly high.

There has been a gradual increase in small scale cultivation on the Lerroki Plateau by the Samburu over the last 60 years. During discussions with elders from the area in the course of this study, it was established that maize and vegetable cultivation by Samburu on the Lerroki Plateau started during the 1940s. Prior to that, only tobacco had been cultivated, which was used to purchase smallstock. This is supported by historical evidence from annual colonial reports (e.g. Kenya Native Affairs Report, 1936). Since the late 1960s, a decline in livestock numbers due to drought and disease (discussed in detail below) has increased people's reliance on cultivated produce (cf. Bayer & Waters-Bayer, 1994). In the area of study, 98% of the households interviewed had a small shamba where they grow maize, potatoes, beans and vegetables for home consumption and occasionally for sale. These shambas are cultivated by hand (no-one in the study villages had ploughs) and are usually the responsibility of the women of the household (*pers obs*). Cultivation in this area is risky, however, due to the high variability in rainfall. During the course of the study, relief food was distributed in the area more or less continuously following the failed harvest in 1993.

### 2.2.10 **The Lerroki Forests**

The main forested areas of the Lerroki Plateau are to be found within the gazetted Forest Reserve, under the management of the Forest Department. In addition, there is a considerable amount of forest to be found within the group and private ranches. This latter forest tends to be patchy, mainly occurring along drainage channels, and from general observation, has in many areas cases been degraded through over-exploitation. Elephants are also reported by the local community to have caused much of the forest degradation in the ranches.

Forested areas are of great ecological and economic importance in this area where water is scarce. The Plateau is one of the main sources of water in the Uaso Nyiro river, the longest and biggest perennial stream in Samburu District, and nearly all of the permanent water holes on the Plateau are to be found in forested river beds. In addition to its role in conserving the water catchment, the Forest Reserve, as mentioned above, is used as a dry season refuge by the Samburu pastoralists to provide food and water for their cattle as well as a source of wild honey and medicine. Other forest products, such as fuelwood, poles and posts, animal fodder, water for the home as well as stock etc. tend to come from the forested areas outside the reserve.

The forests found on the Plateau are typical dry montane forest, the main constituent species being the evergreens *Juniperus spp., Olea spp.* and *Podocarpus spp.*(Langdale-Brown *et al.,* 1974*).* There is some variation, however, between the forest found at the highest altitudes with the Forest Reserve and that found at lower altitudes in the group and private ranches.

KIFCON (1994b) found *Olea europeana* subspecies *africana* to be the most commonly occurring species in the Forest Reserve. The ten most common trees within the reserve according to this report are listed below in Table 2.6.

**Table 2.6** Table showing most common species within the Leroghi Forest Reserve[a]

| Species | Family | % all trees counted (>5cm dbh) (N=2,579) | Cumulative % of total all trees counted (>5cm dbh) |
|---|---|---|---|
| *Olea europeana* | Oleaceae | 26 | 26 |
| *Teclea simplicifolia* | Rutaceae | 8 | 34 |
| *Cassipourea malosana* | Rhizophoraceae | 8 | 42 |
| *Juniperus procera* | Cupressaceae | 7 | 49 |
| *Ehretia cymosa* | Boraginaceae | 6 | 55 |
| *Podocarpus falcatus* | Podocarpaceae | 6 | 61 |
| *Olea capensis* | Oleaceae | 5 | 66 |
| *Maytenus undata* | Celastraceae | 3 | 69 |
| *Xymalos monospora* | Monimiaceae | 2 | 71 |
| *Euclea divinorum* | Ebenaceae | 2 | 73 |

[a]source: KIFCON 1994b

If only trees of diameter at breast height greater than 20cm dbh are considered, *Olea europeana* remained the most common species, followed by *Podocarpus falcatus, Cassipourea malosana*, *Juniperus procera* and *Ehretia cymosa* (KIFCON, 1994b).

The lower forests outside the Reserve have not been extensively surveyed. However, from general observation it is clear that *Juniperus procera* is much more dominant in these forests, as are *Olea europeana*, *Euclea divinorum*, *Rhus natalensis* and *Carissa edulis*. A pilot survey in the communal forest at Lpartuk (Chenevix-Trench & Luvanda, 1994) looked at populations of four tree species identified as being of economic importance to the local community: *Olea europeana*, *Podocarpus gracilior; Juniperus procera;* and *Maytenus heterophylla.* Of the four species, *Olea europeana* was still the most abundant (68%), *Juniperus procera* came next (18%), followed by *Maytenus heterophylla* (12%) and lastly *Podocarpus gracilior* (2%).

*Juniperus* is a pioneer species which either grows in the shelter of bushes or in a dense stand following a fire (Lind & Morrison, 1974). Where forest is expanding over a long time period, *Juniperus* is gradually replaced by shade tolerant species and progressively older individual *Juniperus* trees are found further into the forest. There is some evidence that fire may be a prerequisite for *J. procera* regeneration (Wimbush, 1937), although seedling survival depends on freedom from fire for the first five to ten years of growth (Hall, 1984). This dependency on fire for regeneration can result in large single age stands which are gradually replaced by shade tolerant species.

It is interesting to note here a tendency in East African forests towards more tree species in the intermediate stages and fewer tree species in the earliest and latest successional stages due to dominance by a single species (Langdale-Brown *et al.* 1974). This tends to result in a "climax" dominated by a single species of great age/size. Langdale-Brown *et al.* also note a decrease in species diversity in East African forests from moist forests at medium altitudes towards harsher environments due to altitude, or drought (Langdale-Brown *et al.*, 1974).

Fire is potentially the greatest threat to dry zone forests such as those found on Lerroki (Lind & Morrison, 1974). Without adequate grazing there is a rapid build up of undergrowth during the rainy season which dries out and becomes a major fire hazard during drought (Norton-Griffiths, 1979). Fire is traditionally used by the Samburu to improve the quality of pastures and to reduce tick populations (vectors for a number of diseases, particularly East Coast Fever) (Waller & Homewood, 1997). Honey-hunters are also often accused of starting forest fires accidentally through carelessness (honey is traditionally extracted by smoking out the bees using uncontained fire sources, such as burning bearded lichens). Fire, whether caused accidentally or deliberately, due to human activities or natural phenomena such as lightning strikes, is a common occurrence around the Forest Reserve. The threat to the forest of fire appears to be well understood by the elders and since 1991, Forest Fire Committees have been set up in the group ranches adjacent to the Reserve to be responsible for preventing and reporting on forest fires. This has been welcomed by the communities who claimed that prior to this time any person reporting a fire or found in proximity (i.e. trying to put it out) would immediately be arrested on suspicion of causing the fire thereby discouraging anyone from actively trying to control fires when they did occur. The new system certainly seems to have had some success with very few outbreaks of fire occurring during the 1992/3 drought.

Repeated fire outbreaks has resulted in a large volume of dead standing and fallen cedar. By law, any standing timber, even dead, may not be felled without a license from the District Forest Officer. However, few people seem aware of this rule and this dead cedar appears from the forest use surveys to be the main source of firewood and building timber.

Since the 1970s there has been a rapid die-back in the *Juniperus* around Maralal and more recently reaching as far north as Lpartuk (Figure 2-6). The cause for the die-back is not clear, although a combination of factors have been proposed, including aphid attack, bark stripping by the local community, fungal attack, and a falling water table (Ciesla *et al.*, 1994).

**Figure 2-6** Photograph showing die-back in *Juniperus procera* by the side of the road, 2km north of Maralal.

The existence of closed canopy forest within different tenure regimes on the Lerroki Plateau creates the potential for multiple forest management objectives which could satisfy the priorities of the different stake holders on the plateau. Defining management objectives of forested areas more formally according to their tenure regime could help to ensure both the long term conservation of the closed canopy forest and biodiversity where such is the objective and the future supply of forest products where economic returns from sustainable forest use is the management goal. This is discussed further in chapter eight in the light of the results of this study.

### 2.2.11 Livestock on Lerroki

The importance of livestock to the Samburu people has been mentioned in the above discussion. In this section, trends in the livestock population of the District as a whole, and where possible on the Plateau itself, are presented and discussed.

The Samburu pastoral economy is based on cattle and smallstock. The former are important economically (for their milk, blood and meat) and socially (for example, bridewealth takes the form of cattle). Smallstock are becoming increasingly important as a form of banking as well as being an important source of meat. Donkeys are kept by some for transporting goods and water. Camels are increasing in importance, particularly in the drier areas, but are not suited to the cooler, wetter environment of Lerroki.

All Samburu on the Lerroki Plateau will tell you that the numbers of cattle have reduced drastically in the last 30 years, the reasons given being drought and, more frequently, disease, specifically "*lipis*", the Samburu name for what is thought to be East Coast Fever (ECF). In this section I shall examine the evidence for a reduction in livestock numbers and the potential causes.

Getting accurate measurements of livestock populations in pastoral areas is extremely difficult (ILCA 1983). Livestock populations are usually estimated in one of three ways: from aerial surveys, in which all herds within a designated strip are counted from a low flying aircraft and the total population estimated by extrapolation (Norton-Griffiths 1978); veterinary records, which record the number of livestock brought for inoculation during disease outbreaks; and ground census where the number of cattle in each person's herd may be counted or, more usually, numbers are asked of the owner. All three methods have drawbacks.

Aerial survey techniques are designed for randomly distributed populations and therefore require correction calculations when counting cattle populations that are generally clumped (Norton-Griffiths 1978). Aerial counts are also only reliable in very open country with little tree or bush cover, particularly in hot areas where animals tend to gather under trees for shade in the heat of the day. Surveys tend to take place in the early morning to control for this, but are recognised to be of limited value in high potential areas where woody cover is high (Inamdar, 1996). The problem of early morning flights leading to an under-representation of livestock (which may still be in their bomas) is acknowledged and aerial surveys over pastoral areas are often planned to take place later in the morning where possible (A. Inamdar, *pers comm.*).

Veterinary records depend on all owners taking their livestock for vaccination. While this may be required by law, frequently people will take only their best animals for inoculation, particularly where treatment is costly (Samburu District Veterinary Officer pers comm.)

Finally, in many cultures, to ask or to count the number of animals in a herd is extremely unreliable. This may be (1) for cultural reasons ( the Samburu and the Turkana believe that to count the number of cattle, or children, is to tempt fate (Dahl & Hjort, 1976)); (2) for practical reasons (where one man's herd is scattered over a wide area under different management units as may occur in Samburu (Spencer 1965) it may be impossible physically to count the herds); (3) for economic reasons (historical precedent such as the imposition of a tax based on cattle herd size by the British colonial administration (Kerven 1992) makes it economically unwise for any man to disclose the number of cattle he owns); (4) for political reasons (the distribution of free food rations in the area acts as another incentive for people to understate the number of livestock they own as it might precipitate more frequent food distribution if the area is thought of as being relatively poor); or (5) for reasons of scale (rapid fluctuations in livestock populations in any one area through death and migration, resulting from the pulse-like productivity typical of arid and semi-arid areas, tend to render counts at any one moment in time or place redundant). All data referring to livestock numbers must therefore be interpreted with caution and like should be compared to like: e.g. aerial survey results should be compared only with other aerial survey results. A summary of livestock population estimates is shown in Figure 2-7.

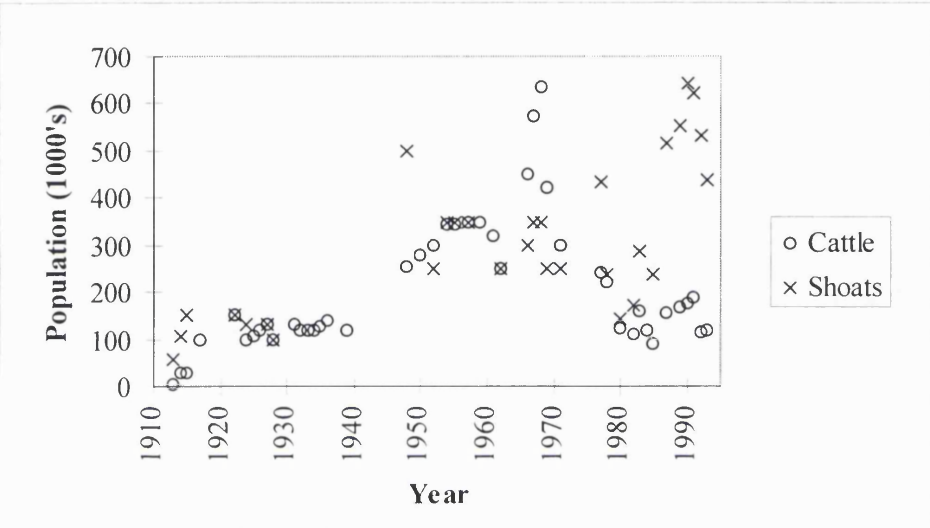


**Figure 2-7** Livestock populations for Samburu District, 1910-1993. Data and sources used in compiling the graph is given in Appendix 1.

In summary both cattle and small stock estimates were very low at the start of the century, following the rinderpest and contagious bovine pleuro pneumonia (CBPP) epidemics and droughts at the end of the nineteenth century described above. The graph shows a considerable and sustained rise in smallstock numbers, with a dip around 1980. The cattle population rose throughout the first half of the century, peaking at the end of the 60s[13]. Between 1969 and 1980 the cattle population crashed.

Uncorrected data from aerial census surveys (Table 2.7), show this decrease in cattle numbers and increase in the smallstock population since the late 1960s in more detail.

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[13] The Veterinary Department began inoculations for CBPP in Samburu in 1925 and for rinderpest in 1935 and 1943, largely out of fear of the diseases spreading to the settler areas to the south (Sobania 1979). In 1951 the Provincial Commissioner of the Northern Frontier District banned all animal inoculations in the district (Sobania 1979) as part of the destocking policy at the forefront of government policy in the area at the time which may explain the lack of herd growth during the 1950s.

**Table 2.7** Uncorrected cattle and smallstock estimates for Samburu Districts from Aerial Surveys, 1968-1993.

| Year (month) | Cattle | | Shoats | |
|---|---|---|---|---|
| | estimate | s.e. | estimate | s.e. |
| 1968[a] (August) | 448,261 | 57,479 | 318,453 | 73,337 |
| 1977[a] (Oct) | 222,465 | 60,151 | 358,731 | 65,214 |
| 1981[b] (Feb) | 105,247 | 47,148 | 198,835 | 29,727 |
| 1987[c] (Oct) | 146,041 | 19,881 | 460,280 | 48,199 |
| 1990[b] (Oct) | 168,088 | 26,229 | 409,745 | 58,177 |
| 1992[b] (Oct) | 117,395 | 17,307 | 430,948 | 37,837 |
| 1993[b] (Sept) | 116,523 | 22,193 | 549,579 | 103,704 |

[a]Watson 1972
[b]Raw data from DRSRS
[c]Peden 1984, from KREMU count, data unadjusted for observer's biases

The decline in cattle population since1968 is statistically significant ($F_{1,5} = 6.80$, $P<0.05$, $r^2 = 0.58$, population estimates were weighted to the inverse of their corresponding variances, Inamdar, 1996). The cause of this decrease, however, is open to some conjecture. The main reasons quoted by both Samburu and local veterinary officers are disease, particularly *Lipis* or ECF, and drought.

The trends in Table 2.7 correspond closely with drought years shown in Figure 2-3. Following the drought in 1971, cattle losses were estimated at 40% while drought in 1983/84 and 1990/1992 are both estimated to have caused cattle losses of 40 - 60% and smallstock losses of 20-30% (District Livestock Development Office Annual Reports).

However, this does not rule out the role played by ECF in depleting cattle numbers. The Samburu claim that ECF was unknown in their herds before the 1970s and official records indicate cattle losses of around 32% in 1979 due to ECF (District Livestock Development Office Annual Reports). Given the severity of the losses and the conviction that ECF is largely responsible, the disease will be considered here in more detail.

ECF is a tick borne disease, caused by the protozoa *Theileria parva* which is thought to have originated in buffalo populations in eastern Africa (Norval *et al.* 1992). Being a tick borne disease, it is ecosystemic, its epidemiology involving the ecology of the land and of the vector as well as that of the herd (Waller & Homewood, in press). The disease was first recognised in European herds at the turn of the century when two separate endemics were starting in southern and eastern Africa (Norval *et al.*, 1992). Prior to the endemic, ECF was unknown in southern Africa, however, Norval *et al.* (1992) cite research carried out in Uganda in the 1930s where the disease had been known "for generations". The research showed 80-90% infection rates in calves, with mortality between 10% and 40%. Similar reports are cited from Rwanda, Tanganyika, the Belgian Congo, Northern Rhodesia (Zambia) and Nyasaland (Malawi) (Norval *et al.* 1992 p47).

The spread of the disease in European stock is well documented. By 1910, a particularly virulent strain of the disease was prevalent in East Africa, seriously disrupting efforts to introduce the more susceptible European breeds. Control of the disease met with little success in East Africa, partly because researchers were unaware of the ability of cattle to become carriers of *T. parva* (Norval *et al.* 1992). Losses in the indigenous Boran and Zebu stock are less well known, but Norval *et al.* (1992) cite losses of "approximately half a million cattle" in the Maasai Reserve in 1919-20 "as a result of ECF, rinderpest and contagious bovine pleuro pneumonia".

It has been suggested (M. Rainy *pers comm.*) that Samburu cattle may have been naturally immune to ECF prior to the endemic seen in the European herds (also Waller, 1988 for Maasai cattle). Immunisation and dipping programs enforced during the latter part of the colonial period and early independence to prevent tick borne diseases could have reduced any naturally inherited immunity to the disease leaving herds vulnerable to infection, particularly when dipping programs became less strictly enforced. Waller & Homewood (in press) report the emergence of acaricide resistance among Maasai herds, following an extensive dipping programme in the 1960s, which lead to disease reservoirs and carriers within increasingly vulnerable herds. According to elders on the plateau, *Lipis* now tends to afflict calves and not adult cattle, an indication of an improvement in natural immunity which seems to support such a scenario.

A serological test to detect ECF antibodies was not found until 1972 and even today the great majority of mortalities pass officially unrecorded and undiagnosed. Few cases are brought to vets for accurate diagnosis since a cure for ECF costs around KSh 6,200 ( about £100 at 1995 exchange rates) compared to the purchasing price of a new young heifer of around KSh 8,000, and the disease works very rapidly, killing the cow in a few days. Evidence that supports the argument that ECF is relatively new to Lerroki is, therefore, circumstantial, and stems from the fact that prior to the 1970s the plateau provided dry season grazing to herds from the lowlands to the north and east. Sperling (1987: 74) states that "formerly, those in the Wamba lowlands migrated up to Lerroki to take advantage of the heavy rains and lush grazing in June, July and August. However, since East Coast Fever spread through the highlands in 1976, killing up to 60% of the cattle, lowlanders have deemed such a move too risky." This correlates with my own observations that cattle grazing in and around the forest all came from the areas on the plateau and the elders' claims that in the past cattle would come from as far as Baragoi and Wamba. Loss of livestock at the start of the 1970s due to drought may have contributed to the rise of East Coast Fever since fewer cattle would have resulted in a build up of long grass and a potential increase in tick populations (Waller, 1988).

Another potential drain on livestock populations is due to sale in response to cash needs to buy food and to pay for school fees. It is unlikely, however that that the sale of cattle for money would be enough to prevent the long term build up of herds for two reasons. Firstly, smallstock are much more readily sold for cash needs and despite a dip in the smallstock population in 1981, sheep and goat numbers have continued to rise. Secondly, Perlov (1983) found that most cattle sales involved selling old stock to purchase younger animals to rejuvenate the herd and replace losses due to disease and slaughter. Sales recorded within this study were well within the levels of expected herd growth.

The decrease in livestock numbers is of great significance when compared with the increase in human population over the same period. The number of Tropical Livestock Units per head (1 TLU = 250kg = 1 cattle or 11 shoats) has decreased from 6 in 1969 to 1.5 in 1989 - way below the minimum number needed to support a person on cattle products alone (estimated at around 10 cattle per person, Grandin, 1991; Dahl & Hjort, 1976).

## *2.3 The Study Sites*

The study focused on an area to the north of the Lerroki Plateau, around Maralal Town and the group ranches to its north, for both socio-economic and vegetation surveys. The villages and forest areas in which the surveys took place and the reasons for their selection are described here.

### 2.3.1 The study villages

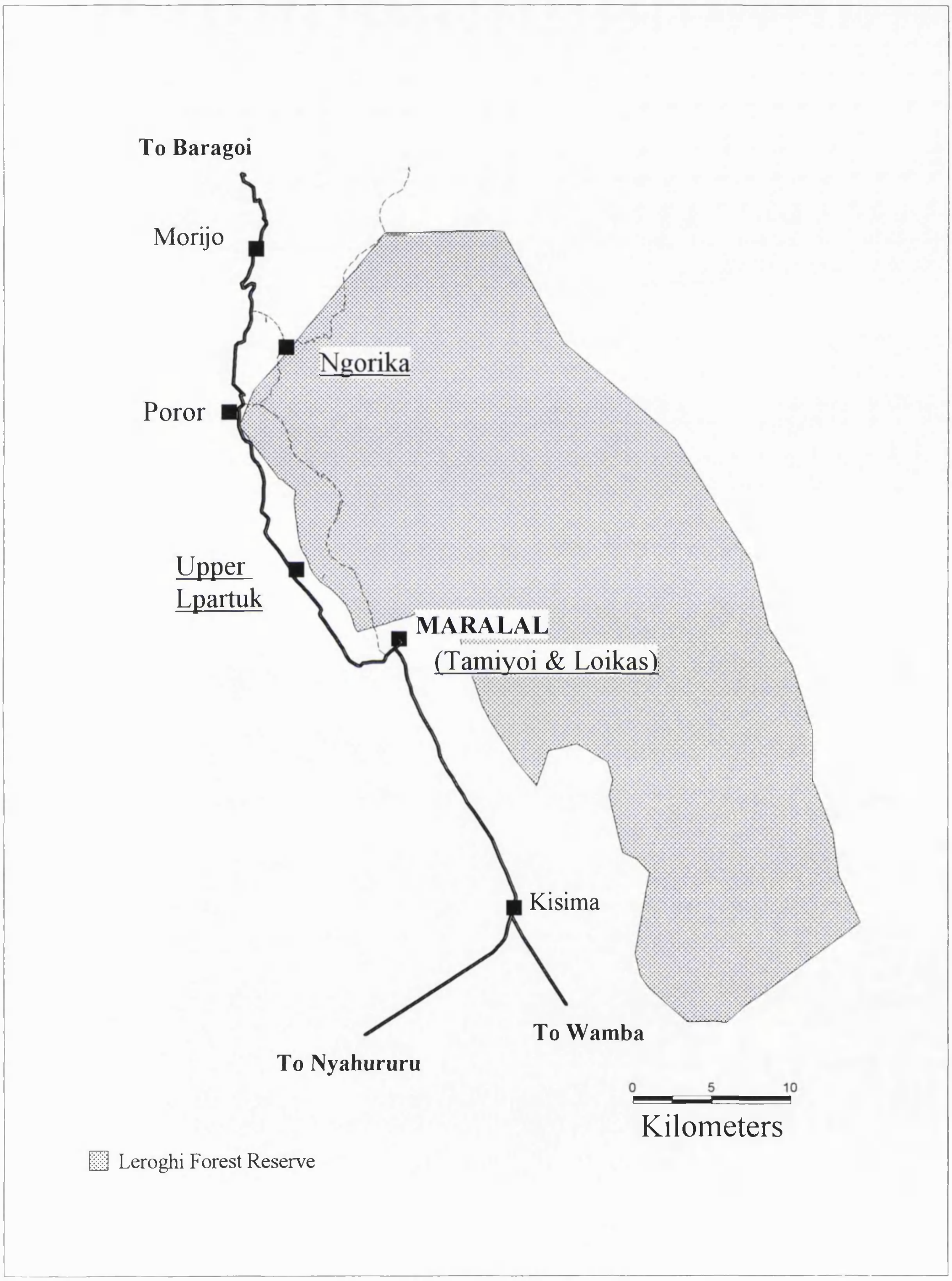
The Forest Act of 1964 renders much use of closed canopy forest in Kenya illegal (both inside and outside gazetted forest reserves). The study, therefore, focused on a few villages, which made it easier to gain the trust of the people and, it is hoped, improved the accuracy of the information gathered.

Two focus communities were selected (Figure 2-8): Ngorika village in Angata Nanyuki group ranch, and Upper Lpartuk in Lpartuk group ranch. The main criteria used when selecting the communities were that they should be situated adjacent to the Leroghi Forest Reserve with access to both gazetted forest and communal forest within the group ranch; and that they should differ in distance and ease of access to Maralal and its markets. Once a number of suitable villages had been identified the two main villages were finally selected following consultation with elders and local leaders from the areas involved, officers from the local Forest Department and my research assistant who was from the area and had eight years working experience in many of the villages on the Lerroki Plateau with a non-governmental organisation.

Socio-economic and resource use surveys were carried out in these villages and ecological surveys were carried out in adjacent areas within the Leroghi Forest Reserve.

In addition to the two main study sites, a brief survey was also carried out in two sub-villages on the outskirts of Maralal Town itself (Tamiyoi and Loikas) in September 1994. This section gives a brief qualitative description of the study villages. A detailed description of the economic status and production systems found in all three study areas is given in the chapter 5.

**Figure 2-8 Map showing location of the main study sites in relation to the Leroghi Forest Reserve**



#### *2.3.1.1 Ngorika Village, Angata Nanyukie Group Ranch.*

Ngorika is located 30 km, by road, north of Maralal town, on the northern edge of the Leroghi Forest Reserve. Access by road is poor, the last 10 km being on rough dirt road off the main Maralal-Baragoi road (still without tarmac). The community is thus fairly isolated from commercial activities.

The community is almost exclusively Samburu. In the centre of Ngorika village there is a primary school up to standard 6 and a Catholic church. The church is part of a Catholic mission three kilometres to the north west at Morijo which also has a clinic. The mission also helped build a large water tank in Ngorika which is used heavily during the wet season, but which quickly dries up in the dry season. During the dry season, people are entirely dependent on collecting water from unprotected water holes along dry river bottoms which are shared with the livestock.

The community describes itself as pastoralist with livestock the principal pre-occupation. However, the number of livestock has reportedly fallen drastically in the last 30 years, and there is a strong reliance on agriculture, almost all households having a small enclosed plot which is cultivated. The main crops are maize and kale, which are grown almost entirely for subsistence. The centre of the village, with the school and church and a number of settlements including the house belonging to the head of the Group ranch committee, is located on top of and around a small grassy rise. Two other satellite groups of settlements within 2.5km of the school ("Lkojita" and "Poro") are closely associated with Ngorika and were included in the study. The elders at Ngorika were always present and it was apparent that they commanded much respect and took an active management role in the community.

Ngorika village is close to an area of closed canopy forest within the Forest Reserve called "Saanata", and known locally as "*Supuko*" (meaning impenetrable bush in the local vernacular[14]), which covers an area of approximately 4,400ha. In addition there

[14] *Supuko* is often used to described highland dry season grazing areas in the literature on the Maasai (e.g. Potkanski, 1993). Supuko can also mean 'highland' in Maa (Oba, 1994), but on Lerroki it tended to be used to refer to the closed canopy forest area (hence Heine *et al.* (1988: 24) translate '*lkeek loo supuko*' as 'forest/highland trees'.

are considerable tracts of forest along river valleys both within the group ranch and inside the boundaries of the gazetted forest reserve. While the gazetted forest is officially managed by the Forest Department, the forest guard post at Angata Nanyukie is rarely manned and much control of forest resource use in the reserve appears to be enforced through group elders.

#### *2.3.1.2* ***Upper Lpartuk, Lpartuk Group Ranch***

Upper Lpartuk is situated 9 km north of Maralal on the main Maralal-Baragoi road. The area is therefore highly accessible for trading both within and outside the District.

The population is again, almost entirely Samburu, although a number of the men have married non-Samburu women. There is a primary school in Lower Lpartuk, but otherwise infrastructure is minimal. The nearest clinic is the hospital at Maralal and there is no protected water supply.

As with Ngorika, the number of livestock is reported to have dropped drastically in the last 30 years and nearly all households have enclosed a small plot of land for cultivation of crops such as maize, beans, kale and potatoes.

Lpartuk is located along the top of a ridge, to the east of which lies the Forest Reserve and to the west of which lies a seasonal river, forested, that defines the boundary with the next group ranch. The forest here is fragmented and much of the gazetted forest has apparently been destroyed by fire leaving wooded grassland. What remain are strips of forest along the seasonal river valleys with some larger clumps found in the group ranch, particularly to the north and along the river valley to the west.

With its close proximity to Maralal, people are often away from the village, and there was not a clear sense of community in the way that was evident at Ngorika. Throughout the study, the principal elders were frequently absent and appeared to take a less active management role in the community. The sight of the elders gathered to meet in the shade of an Acacia tree close to the school was common on arrival at Ngorika and it was easy to meet with these elders to discuss the activities of the study. At Lpartuk, in contrast, meetings were frequently rescheduled when we arrived at a pre-arranged time and found the main elders of the community had left to go to Maralal for the day.

The main road running through the middle of Upper Lpartuk creates high demand for posts both for local construction and by traders coming from outside the District despite a ban on the export of cedar posts from the District. This demand took the form of lorries which would pass through Lpartuk at least once a week and buy cedar posts from anyone who could supply them. Live tree felling, an offence in all forests, is evident, particularly in the community forest. Most people claimed that they would only cut dead trees: live trees would only be cut by honey hunters. However, as one elder told us, these days men would not bother to climb a tree for honey as they knew if they cut it down they would be able to sell the wood for a good price.

#### *2.3.1.3 Tamiyoi and Loikas, Maralal Town*

These two villages are sandwiched between Maralal Town itself and the Forest Reserve, within 2km of the centre of Maralal Town. The population density is higher in these villages than in both Ngorika and Lpartuk.

The communities are an ethnic mix of mainly Samburu and Turkana. The Turkana are essentially economic refugees who have come to Maralal in search of security and opportunities following repeated droughts and fighting in their home lands to the north. These Turkana have no rights to grazing or land and many of those we spoke to initially claimed that this was why few if any Turkana households kept livestock. The lack of integration between the two communities was highlighted in the course of defining the sample frame for the questionnaires when the Samburu elders from Loikas told us to go directly to the Turkana to find details of their households. At Tamiyoi, many of the Samburu elders were not happy that we wanted to include the Turkana in the survey at all, since they were considered guests on Samburu land and therefore should not be considered an official part of the community[15].

Since few Turkana own livestock, most depend on other sources of livelihood including sale of beer and charcoal or carving for their livelihood, although these activities are not exclusive to the Turkana community. Many are also dependent on

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[15] It is possible that Turkana were under-represented in the sample frame at Tamiyoi since the Samburu gave the list of Turkana households within the village and may have deliberately excluded less well established Turkana families.

irregular unskilled odd-jobs, such as loading and unloading transport lorries in Maralal. Even among the Samburu 60% of households visited in one such village owned no cattle at all.

As with the other villages, nearly all households , Samburu and Turkana alike, have a small plot of cultivated land.

It was not possible to assess the balance of power between the elders and administrative leaders and between the two ethnic communities in the two villages near Maralal, given the short term nature of the surveys there. However, we met with the Assistant Chief at the local court where he was actively involved in resolving local disputes. The Samburu elders that we met with at Tamiyoi and Loikas clearly distinguished the Turkana and Samburu populations and implied that while Turkana activities were limited by Samburu regulations (such as the ban on grazing of Turkana livestock in the forest), the day to day business within the Turkana communities were kept quite separate from that of the Samburu community.

Forest resources here come almost entirely from the Reserve. In the last 30 years the forest outside the reserve has almost entirely disappeared (Lerroki Forest Officer L. Lenkaak, *pers comm.*; W. Thesiger, *pers comm.;* Chenevix Trench 1964; this study).

### 2.3.2 The Forests

Vegetation surveys were intended to establish the impact of cattle grazing on the forest ecology. It was important, therefore, to identify areas of forest where other human activities would not influence the findings.

Pilot surveys recorded any evidence of human disturbance along two transects of 500m, in the communal forests around Lpartuk, and 2 transects, 1,000m long, in Saanata, near Ngorika. Levels of human disturbance were relatively high in the communal forests around Lpartuk, and within the forest reserve at Lpartuk, the forest was highly fragmented and degraded due to severe fires in the area in the 1980s. As a result, further vegetation surveys were not carried out at Lpartuk. Levels of human disturbance were in comparison very low along one of the transects running from the edge into the forest (known locally as "Lorubai", an area reportedly subject to heavy cattle grazing) and non-existent along the second transect located deeper in the forest in an area reportedly rarely used by cattle except in the severest drought called "Sordon". The results of these human disturbance surveys are summarised in Table 2.8.

**Table 2.8** Summary of all signs of human disturbance found within a 10m strip along the length of the transects

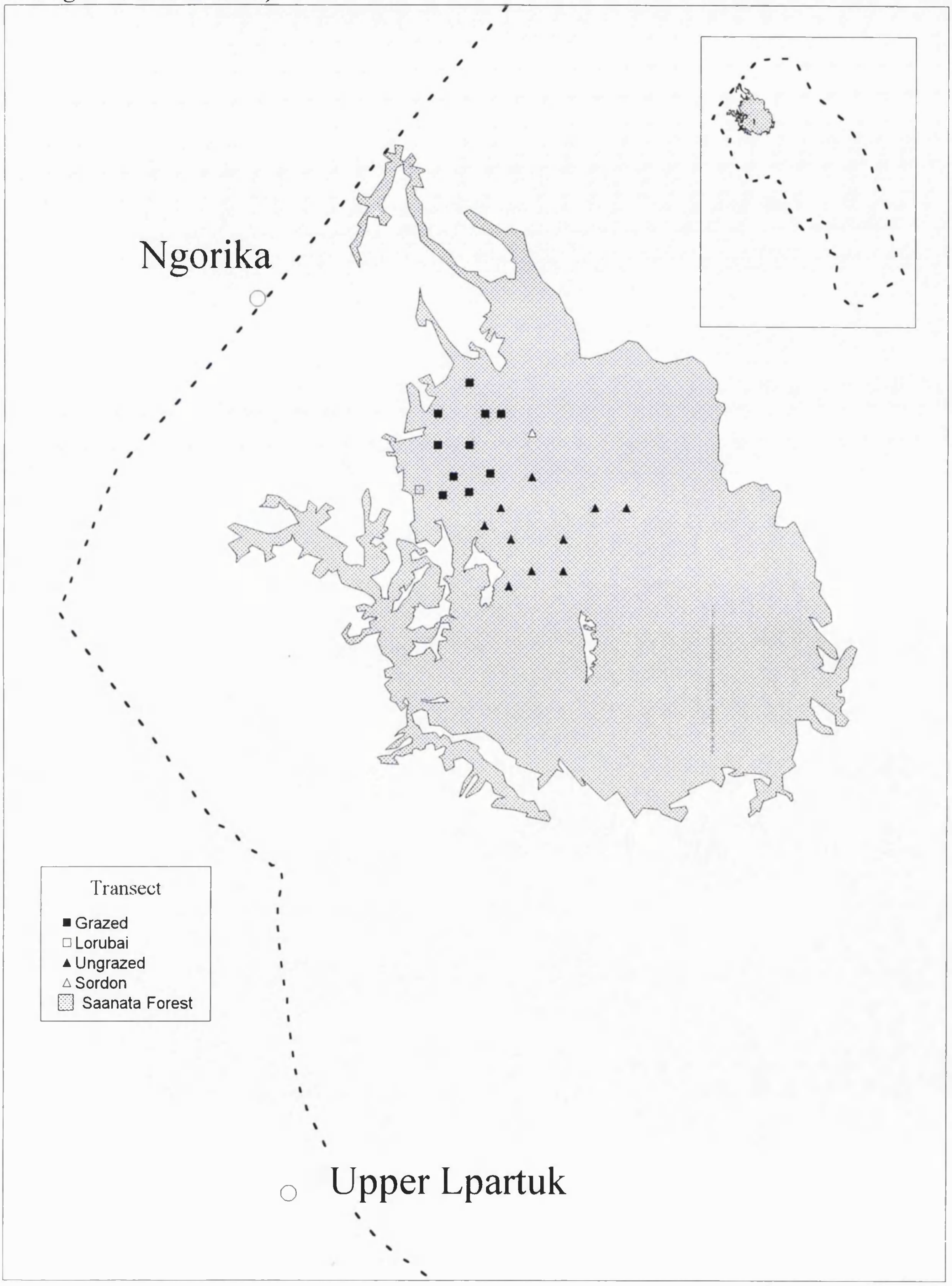
| **Type of Disturbance** | | **Number (per ha) and locality** | | |
|---|---|---|---|---|
| | **Species** | **Lorubai** | **Sordon** | **Lpartuk** |
| Dead stumps | *Juniperus procera* | 1 | 0 | 4 |
| | *Olea europeana* | 2 | 0 | 5 |
| | *Maytenus heterophylla* | 0 | 0 | 13 |
| | *Elaeodendron buchananii* | 1 | 0 | 0 |
| | Unknown sp. | 1 | 0 | 1 |
| | **Total** | **5** | **0** | **23** |
| Live stumps (coppicing) | *Juniperus procera* | 0 | 0 | 1 |
| | *Olea europeana* | 1 | 0 | 2 |
| | *Maytenus heterophylla* | 3 | 0 | 11 |
| | *Olea capensis* | 1 | 0 | 0 |
| | *Nuxia congesta* | 1 | 0 | 0 |
| | *Teclea nobilis* | 1 | 0 | 1 |
| | **Total** | **6** | **0** | **15** |
| Charcoal pits | | 0 | 0 | 2 |
| Debarking | *Juniperus procera* | 3 | 0 | 7 |
| | *Maytenus heterophylla* | 2 | 0 | 0 |
| | *Olea europeana* | 1 | 0 | 0 |
| Logs | *Juniperus procera* | 0 | 0 | 2 |
| | Unknown | 0 | 0 | 3 |

Of the 6 dead stumps at Lorubai, 5 were of diameter less than 15cm, 4 less than 10 cm, the one remaining stump was 40cm. 86% of the live stumps at Lorubai were less than 10cm in diameter. At Lpartuk, 44% of the dead stumps were of diameter greater than 40 cm, and 83% of the live stumps were between 16 and 35cm in diameter.

Saanata was therefore chosen as the main site for the vegetation surveys. Exclosure plots, investigating the effects of cattle grazing on herbaceous cover and seedling growth and survival, were built along the transects at Lorubai and Sordon. Further surveys along a series of transects located throughout the northern part of Saanata investigated the effects of cattle on tree density and population structure. These transects were located with the help of village elders and aerial photographs of the forest enlarged to a scale of 1:10,000[16]. Using the photographs it was possible to identify and locate areas where cattle were regularly taken during the dry season and areas where cattle were rarely taken. The two categories tended to correlate with distance into the forest. This could potentially result in pseudo-replication and will be taken into account when considering the results (Crawley, 1993). To avoid problems of biasing the data due to an edge effect, all transects were located at least 500m from the edge of the forest. The location of Saanata and all the transects used in the course of the study are shown in Figure 2-9.

[16] The elders had little difficulty 'reading' the aerial photographs once a few key recognisable places had been pointed out such as glades and the local school (Fox (1986) using aerial photographs to describe forest use similarly found men had little difficulty understanding the photographs).

**Figure 2-9 Map showing location of transect sites at Saanata (inset shows location of Saanata within the boundaries of the Leroghi Forest Reserve)**



## 2.4 Study Methodology

### 2.4.1 Approach

This study uses a variety of socio-economic and ecological survey techniques to establish patterns in natural resource use, natural resource availability and trends in availability over the last 30 years and natural resource users on the Lerroki Plateau.

There are four main methodological components to the study:

1. Analysis of aerial photographs from 1963 and 1993 quantified changes in vegetation cover in and around the Leroghi Forest Reserve;
2. Socio-economic and wild resource use surveys described both wild resource use and the wild resource users;
3. Ecological surveys and informal, semi-structured interviews defined current and historical use of the forests by herders and their cattle; and
4. Vegetation surveys compared closed canopy forest structure and species diversity in areas of forest under different pressures from cattle grazing and browsing.

The final part of this chapter introduces the methodologies used. Details of methodological techniques, limitations and data analysis are given within each data chapter.

Field work for the study took place from September 1994 to January 1995.

### 2.4.2 Changes in area of woody vegetation in and around the Leroghi Forest Reserve.

Comparative sequences of aerial photographs of the Forest Reserve were available in Kenya from 1963 and 1993. These were analysed using direct stereoscopic aerial photo interpretation, with the assistance of a qualified interpreter who defined the boundaries of a number of clearly defined vegetation types. The results were mapped using a computer mapping programme (MAPINFO) onto existing 1:50,000 topographic maps.

Direct comparison of the two maps quantified overall change in vegetation cover in and around the Leroghi Forest Reserve. The area within a five kilometre radius of the main study sites were examined in more detail. The results provided both a comparison of vegetation change over a thirty year period around the main study sites and a baseline of current availability of different vegetation types which could be used to analyse habitat preferences in wild resource use.

Further photographs from 1954 and 1976, together with photographs from 1993 were used to compare settlement patterns within a 5km radius of the main study sites.

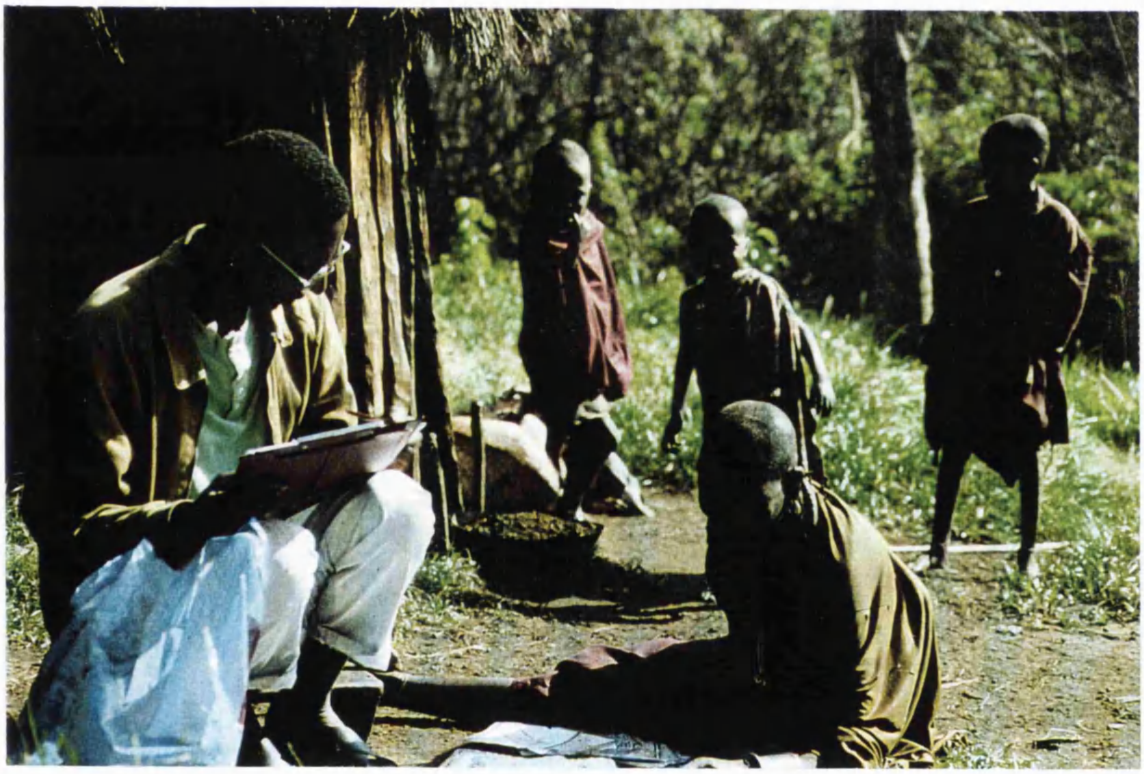
### 2.4.3 Wild resource use and users.

Baseline surveys were carried out in the three main study sites. The surveys covered basic socio-economic parameters such as wealth, i.e. land and livestock holdings; ethnicity; main sources of livelihood and overall use of forest resources.

Repeated forest use surveys were carried out at Lpartuk and Ngorika in March 1994, May/June 1994, July/August 1994, October 1994 and January 1995. Fifteen households from each village were selected on the basis of wealth rank from those interviewed in the baseline surveys and visited each day for a week on each of the periods shown above. Each day a person from the household (nearly always the woman of the household) was shown a number of picture cards depicting different categories of wild resource use, e.g. grazing of cattle or smallstock, collection of firewood or poles for construction, hunting and wild honey gathering, and asked which activities they or any other member of the household had done since the visit the previous day. For each activity they were asked which species was used, whether the resource was for home use or for sale, where the resource had come from - the vegetation type (forest/bush/shrub/grassland) and whether the land was communal or gazetted - and which member of the household had gone for the resource. These surveys provided data on the frequency with which different resource use categories occurred throughout the year, the diversity of species actually used, seasonal variation in use and the main sources of wild resources in terms of habitat type.

The use of pictures made the interviews more interesting for the respondents, but more importantly reduced bias associated with long lists, made the interview quicker and assisted the respondent in recalling his/her activities (Figure 2-10).

(a) Aerial photographs blown up to a scale of 1:10,000 were used to identify areas of different grazing pressure within Saanata forest; and



(b) Pictures displaying different wild resource activities were used to during the multi-round surveys.

**Figure 2-10** Photographs showing the use of photographs and pictures in the course of the study.

### 2.4.4 Cattle as forest users

In the course of the baseline survey, households were asked to rank the importance of closed canopy forest for each of the resource categories carried out by that household. Resource categories included cattle and smallstock grazing and browsing, collection of fodder for livestock and water for livestock. (for details see page 224) This showed the importance of the forest as a source of livestock fodder and water in relation to other activities.

A livestock census around Saanata was carried out at the height of the dry season in January 1994 to quantify the number of cattle currently using the forest as a dry season refuge. The number of cattle using each water hole in the area was observed and recorded for two consecutive days. The herders were asked whether they had taken their cattle for water the previous day (thereby avoiding double counting), where the cattle were from and whether they were currently taking their cattle into the forest for grazing.

Systematic observation of livestock feeding behaviour was carried out for herds of cattle in Saanata in January and April 1994 to establish habitat selection and feeding preferences within the forest by cattle. A focal animal was selected for observation and followed throughout the day from the moment it entered the forest until it left in the evening. At intervals of 3 minutes, the animal's activity was recorded as walking, standing or eating. If the animal was eating, the species being eaten was recorded where possible. Otherwise, the plant type was recorded, categorised as: grass; herb; shrub; or tree. Immediately afterwards the activity of the nearest animal was also monitored in the same way. Habitat use in terms of overall vegetation type was recorded every 20 minutes as: closed forest; open forest; closed scrub; open scrub; forest glade; forest edge.

Faecal counts were carried out along the two transects at Lorubai and Sordon in Saanata in September 1993, January 1994, April 1994, and January 1995 to compare relative densities of cattle and other herbivore in areas under different levels of use by cattle. Total faecal counts provided a measure of changing frequencies throughout the year and the effects of livestock presence on the distribution of wildlife populations.

Finally, elders from different age groups were interviewed on livestock management and forest grazing during their moranhood. These interviews spanned a period from around 1915 (the elder was a member of the *Lmaricho* age group, circumcised between 1912 and 1923) to the present day. Regulations with respect to forest grazing were described and the distance travelled into the forest during the different periods mapped using enlarged aerial photographs of the forest.

### 2.4.5 The impact of cattle

A number of vegetation parameters were identified to establish the long term effect of the presence of cattle in the forest on forest ecology. These were: the population structure, density and biodiversity of the tree population; tree seedling growth and survival; and herbaceous cover. The study used a comparative approach, comparing these parameters from areas subject to high cattle pressure and areas subject to negligible cattle pressure over the past 60 years. With any impact assessment using comparative methods of this nature, it is difficult to categorically define causal linkages. It is also difficult to quantify grazing pressure, particularly in the past. However, given the time limits and the complex nature of multi-species forests, a comparative approach was considered most appropriate for this study.

Broad areas where livestock had and had not been taken within Saanata over the last 60 years were identified from the informal interviews with elders and with the help of an informant who knew the forest well using aerial photographs of the area, enlarged to a scale of approximately 1:10,000 (Figure 2-10).

#### *2.4.5.1 Impact on plant population structure and diversity*

Plant population structure and diversity was measured using the point-centred quarter method. Ten transects were surveyed in areas of low and moderate cattle use and three further transects were surveyed at the forest edge where cattle pressure is highest. At 20 points along each transect the distance to the nearest tree species with a basal girth of greater than 7cm was measured for four defined quarters, and the species, basal girth and evidence of damage or coppicing for all four trees recorded. These data can be used to compare population structure (measured in terms of density of diameter size classes per unit area), species dominance and density for each area, and species diversity.

#### *2.4.5.2 Impact on seedling growth and survival and herbaceous cover*

14 exclosure plots of 5m x 5m were built along the transects at Sordon and Lorubai in Saanata- 8 plots in the area of moderate cattle pressure, and 6 in the area never used by cattle. An open plot of 4m x 4m was marked out approximately 3m from each exclosure for comparison. All tree seedlings of less than 2.5m height were identified, measured and mapped for future identification (they were later numbered with plastic tabs). In the case of the exclosures, seedlings within 0.5m of the edge were not counted.

Measurements were taken in September 1993, April 1994, August 1994, October 1994 and January 1995. Some initial measurements from September 1993, however, have been discarded due to repeated damage to the plots by wild animals. Under 'normal' circumstances, the cattle use the forest during the dry period from December to March/April. During my study period, however, the cattle had entered the forest by August 1993 due to a prolonged drought, left the forest around April 1994 and had not returned by January 1995 due to exceptionally good rainfall in 1994. It was therefore difficult to draw any conclusions with respect to cattle impacts on seedling growth and survival on the basis of data from April 1994 to January 1995.

Finally, herbaceous cover was measured using the line intercept technique in both the enclosed and the open plots. Cover type (bare, litter, grass, herb or seedling), and cover height was recorded at 20cm intervals along a tape measure laid across the plots twice. In this way, forty measurements were recorded for each plot on each of the five occasions.

### 2.4.6 Field Assistants

Throughout the study I relied on a number of Samburu men and women from the area to assist me with translation, carrying out questionnaires and surveys and identifying plants. The use of local assistants, largely untrained in survey techniques has a number of advantages and disadvantages.

The advantages of working with people local to the area of study are many: employing local people is an excellent way of building co-operation in the first stages of a study; interviewers from the area are more likely to gain the trust of their respondents, to be able to identify when people are not giving accurate information and to find out the reasons why (ILCA 1983); and they provide an endless source of local knowledge of the people, their customs and their history - of particular relevance both in household survey work and when looking at availability of natural resources.

There are also many disadvantages of working with local assistants: it can result in a biased data set if, for example, the study objectives are not sufficiently clear, or if they have a political or other motivation to influence the outcome of the study; interviewers may be pressured into recording inaccurate information, for example on livestock holding size, particularly if they have a close affiliation with the respondent; and they may have very little experience of the survey techniques being used. Finally, with any research assistant, supervision of data collection is essential to avoid bias and mistakes made through carelessness. Taking care in selecting assistants, time in training and care in designing the questionnaire are important steps to avoid many of these problems (ILCA 1983).

In all of the surveys, consistency was of greatest importance and I was fortunate to be able to work with the same team throughout the study.

### 2.4.7 Language

All the vegetation and wild resource use surveys used vernacular Samburu names when identifying plants. During an investigative pilot study in September 1993, a botanist from the National Museums of Kenya worked with Samburu elders in the area to create a list of forest species with their vernacular names (Appendix 2). Samburu ethnobotany is fairly well documented for the more arid parts of the District (Heine *et al.*, 1988; Bronner 1992, Morgan 1982, IPAL, 1979). Less work has been done in the upland forested areas although Heine *et al.* (1988) worked close to the Ndoto mountain range to the north of Lerroki and their compendium includes the plant species found in this area. Heine *et al* (1988) also comment on the fact that different names are given to the same plant in upland and lowland areas.

Heine *et al.* (1988) give a thorough description of the logic and method behind Samburu ethnobotany. In summary, Samburu recognise two main plant forms, 'Tree' and 'Grass', the former representing the majority of plants including shrubs, vines and many epiphytes, the latter including, with few exceptions, all Gramineae species known to the Samburu. Samburu generic classification in general has been found to correspond closely with the species level of Linnean taxonomic classification, based on appearance (e.g. most species of Acacia have different Samburu names). This is not always the case, however, with some species having the same Samburu name according to their function. In the course of the September surveys, for example, "segeet" was given as the name for *Justicia extensa, J. striata, J. exigua, Hypoestis verticillaris, Dicliptera laxata, Achyranthes aspera* and an *Oldenlandia sp.* and generally describes a group of herbaceous plants eaten by cattle. The vegetation surveys in this study focused on tree species. Out of the 46 tree species identified in the course of the study, the same vernacular name was given to two or more tree species in six cases.

Using vernacular names is likely, therefore, to have resulted in an underestimation of species diversity in both the vegetation surveys and the resource use surveys. However, it saved much time and therefore allowed a greater diversity of surveys to be carried out than would otherwise have been possible. The same elder from Ngorika, Mr Lenaardo Lelesiit, was employed as plant identifier throughout the study from September 1993 to January 1995. He was in his fifties, had lived on the edge of the forest as a child and had the reputation of knowing the forest and plant names and uses as well as anyone in that part of the Plateau. No experienced botanist would claim to be able accurately to identify every plant species on every occasion and I have no doubt there will be some errors in these surveys. However, having worked with Mr Lelesiit for over a year, I was confident of his consistency and knowledge of the natural resources of the area. On two occasions during the main study, I took a number of samples to be identified by the botanists at the East African Herbarium in Nairobi. The samples included species that had been identified by the botanists during the initial pilot study and the results were consistent with these field classifications.

# 3. Cattle and forests

## 3.1 Introduction

This thesis makes the assumption that closed canopy forest is a vital dry season refuge for cattle. This chapter tests this assumption using evidence from historical sources and from data collected in the course of this study.

Historical evidence for the importance of forest to cattle is presented in the following section. Data for this section come from archival material, the results of contemporary studies, and interviews with members of the local community carried out during the study. These sources provide circumstantial evidence of cattle use of forested areas. A variety of methods were employed to investigate the extent of cattle use within the forest at Saanata during the course of the study. These included semi-structured interviews, cattle counts, cattle follows and faecal pellet surveys within Saanata and the methods and results for each are described in this chapter.

The results of this chapter are used: to test the hypothesis that the closed canopy forest is an important source of water and forage for cattle in the context of the Lerroki Plateau; and to identify areas within which the impacts of cattle on closed canopy forest could be tested using vegetation surveys and the results of aerial photo interpretation (chapters four and seven).

## 3.2 Cattle and forests - evidence from the literature

Evidence of the importance of the forests in Samburu and neighbouring Marsabit Districts dates back to the Colonial reports from the area. The Kenya Native Affairs Report of 1936 comments that "the Samburu who live on Mt. Nyiro are most strict in their protection of the forests on that mountain and also exercise grazing control". The following year, the same report again comments on the "system of strict grazing control in the Mt. Nyiro forest glades". Sobania (1979) referring to archival records, quotes a report of 1925 stating that cattle on Marsabit were so numerous "as to cause serious and constant harm to the Marsabit Forest".

More recently, literature on the area often refers to the importance of forests for livestock grazing, but there is rarely any data on the actual number of cattle in question. Fratkin (1991) notes that "most Ariaal communities are located near or in the mountains, using highland forests to graze their cattle and rivers to water their human and animal populations", Synott (1979) refers to the importance of the forested mountain ranges throughout Samburu and Marsabit Districts for dry-season grazing at that time and Bronner (1992) reports high levels of grazing by both goats and cattle within the forests on the Matthew's Range to the east of Lerroki. On a more general scale, Spencer (1973) stresses the importance of the highest and forested areas in Samburu District as dry season sources of water, since, apart from the Uaso Nyiro river in the very south and Lake Turkana in the north, all water in the district comes from rainfall falling within its boundaries.

Reference to grazing in the forests on Lerroki itself are less abundant and tend to be indirect. For example, Sobania states that no cattle were allowed into the forest reserve at Lerroki from June 1935 when the area was being gazetted (Sobania 1979: 208) and Fumagalli (1977) refers to the admission of 6,000 cattle to the forest for free grazing and water following independence in 1963. Perlov (1987) refers to the reliance on forest grazing on a regular basis in the dry season in an area south of Maralal, and comments on the practice of cutting *Olea europeana* ssp. *africana* in severe drought periods only.

Further afield, the importance of forest to other East African pastoralist groups has also been commented on for the Maasai (Emerton, 1996; Potkanski, 1993; Struhsaker *et* al., 1989; Homewood & Rodgers, 1987) and other communities (Shepherd, 1992; Le Houérou, 1980; Bayer, 1984). During a reconnaissance flight over the Northern Highlands Forest Reserve in Tanzania, "20 herds of cattle..were seen in the forest" (Struhsaker *et al.*, 1989:2). The importance of forest as a dry season resource has been proposed as a major incentive in the development of local mechanisms of control of forest resources (Emerton, 1995) as were quoted for Mt. Nyiro in the 1930's above.

The importance of forest grazing is not restricted to purely pastoral communities. In high potential agricultural areas where grazing resources are severely limited due to very high human population densities, protected areas such as gazetted forest reserves may provide an important source of dry season grazing. For example, livestock entry counts around the Kakamega Forest Reserve in western Kenya (average human population density greater than 200 people/km$^2$) during the short dry season found a minimum of 1,300 cattle entering the forest daily (Emerton, 1991). In 1993, 90% of District Forest Officers in Kenya reported incidences of cattle grazing in forest reserves (KIFCON, 1994) and during the course of this study, cattle were followed to a distance of more than 2km inside closed canopy forest in both the Leroghi and the South Nandi Forest Reserves.

Further afield still, the importance of forest grazing in Indian forests is well documented (e.g. Maikhuri and Ramakrishnan, 1991). A recent estimate suggests more than 90 million cattle use India's forests (Rodgers 1990 quoting from Lal, 1989). The literature on forest grazing in the United States, where forest grazing is seen as an important management tool, is also very extensive.

Cattle are preferential grazers (Pratt *et al.*, 1986; Mitchell and Rodgers, 1985). However, there is considerable evidence that cattle can and do rely on woody browse to support their diet particularly when vegetal and climatic conditions reduce graze quality and/or quantity (Mitchell & Rodgers, 1985; Holechek *et al.*, 1982, Dicko-Touré, 1980, for a general review see Le Houérou 1980). For example, Rees (1972) found 34% of energy intake in cattle kept in paddocks in Zambia came from browse species, and Homewood & Hurst (1986) reported 25%-40% of feeding time by Tugen cattle was spent browsing, even in the peak wet season, when pasture (which was generally scarce) was briefly widely available. Fulani cattle in a grazing reserve in Nigeria spent more than 10% annual feeding time on browse, with values reaching 30% during the dry season (Bayer, 1990) while cattle in Zimbabwe spent up to 60% of their feeding time on browse in the dry season (Scoones, 1989). As well as food, forests provide a source of shelter and shade, which improves productivity in hot climates, since hot temperatures can reduce grazing time and intake (Pratt *et al.*, 1986; Mitchell and Rodgers, 1985).

Despite this evidence, cattle and grazing in the context of closed canopy forests has not been considered in depth in range management literature. For example Walker (1980), in his discussion of browse and its role in livestock production in Southern Africa excludes forests entirely from his discussion "since they are insignificant from the point of view of browsing ungulates" (Walker, 1980: 7). Moreover, woody species are often considered by range managers as weeds which "encroach" on to the more preferable grasslands (e.g. Pratt & Gwynne 1977; Daubenmire 1968).

### *3.3 Cattle and forests - evidence from the ground*

A range of methods were used during this study to establish the current importance of closed canopy forest for livestock in and around the Leroghi Forest Reserve. The objectives of these surveys were:

1. to establish the relative importance of forests for livestock browsing and watering;
2. to quantify the number of cattle using forest as a source of dry season grazing;
3. to establish the extent to which cattle feeding within closed canopy forest fed on woody species, particularly tree species;

4. to determine the relative densities of cattle and other wild herbivores in forest areas of known high and low cattle use intensity; and
5. to determine how forest use has changed over the last 80 years.

### 3.3.1 Methods

#### *3.3.1.1 Ranking forest use*

In the course of the baseline surveys at Lpartuk and Ngorika, described in the previous chapter, respondents were asked to pick from a series of picture cards the activities which they carried out within the forest. They were then asked to rank each activity according to the importance of the forest as a source by placing the cards in order. Using the picture cards had the great advantage of allowing the respondent to see all the activities together when thinking where to rank each card and to change his or her mind in the course of the exercise.

In total, nineteen activities were ranked by the households. However, no household claimed to do all the activities, every household ranking a different number of activities. The maximum number of activities ranked by any one household was 16. The mean rank was weighted by frequency for analysis. This reduced the risk of rare activities (such as timber collection), ranked highly by the few households involved appearing of equal or even greater importance to the community than the very common activities such as firewood collection. At the time of the interview, the cards were ranked with the most important activity taking the value 1. Weighting the mean by frequency reduces the value, therefore the ranks were reversed for the analysis, the most important taking the value of 16. The mean ranks for the two villages followed a normal distribution and were compared by regressing the weighted mean ranks for each village against each other.

#### *3.3.1.2 Current use of forest by cattle*

A livestock census and cattle follows were carried out in order to:

1. estimate current density of cattle in the forest throughout the year;
2. provide data on differential use of vegetation types by cattle; and
3. establish the distance travelled in to the forest by cattle.

A livestock census was carried out in January 1994 to establish the number of livestock using the forest for grazing at the height of the dry season. One person was posted by each of the main water holes in and around Saanata for two consecutive days. Seventeen waterholes were identified during discussion with elders and the moran: 14 within the boundaries of the forest reserve and three outside. The size of each livestock herd visiting each water hole was recorded together with information on where the cattle were coming from, whether the herd had been taken for water the previous day and whether the herd was regularly grazing in Saanata. Before undertaking the census, it had been established that cattle were watered at least every other day at the time. The total number of cattle using the forest was, therefore, calculated by taking the total for the two days and subtracting the number of cattle on the second survey day that had also taken water the previous day.

A similar count was tried during April, however, the heavy rains meant that many people were not taking their cattle to water holes, preferring the temporary surface water that appeared throughout the grazing lands. These counts were therefore discarded.

Systematic observation of livestock feeding behaviour (Rollinson *et al.*, 1956; Altmann, 1974; Homewood & Rodgers, 1991) were carried out for herds of cattle in Saanata in January and April 1994. Three follows took place in January and two in April.

On each occasion, a focal animal was selected for observation and followed throughout the day from the time of leaving the homestead at around 9am to the time of returning at around 5pm. Unfortunately, the follows in April were interrupted at around 2.30. Only records taken before 2.30 could therefore be used when comparing the diets across the two periods.

Every 3 minutes, the animal's activity was recorded. If the animal was eating, the species was recorded where possible. Otherwise, the plant type was recorded, categorised as: grass; herbaceous plant; shrubs; or trees. Immediately afterwards, the activity of the nearest animal was also recorded in the same way. Given the proximity of the animals the two records would not be entirely independent. The five pairs of animals were therefore considered in pairs, taking the mean for each. The overall vegetation type where the cattle were located was recorded every 20 minutes, categorised as: closed forest; forest/bush; open bush/forest; shrub/grass; and forest edge/glade.

Point sampling techniques gives a useful measure of frequency of behaviour patterns (Martin & Bateson, 1993). It depends on the observation made being instantaneous, and one potential source of bias is for dominant behaviour occurring just before or after the sample point being over-recorded. In the case of animal point sampling it is also important not to disrupt the behaviour of the animal by the presence of the observer. The relatively open and sparse nature of the vegetation and the fact that the cattle were well habituated to people made it relatively easy to follow the cattle without disrupting their behaviour patterns and to identify the plants they were eating. Where the plant itself could not be seen it was generally possible to identify the plant more closely between sampling points. A morning was spent with the observers testing the practicability of the technique during which the importance of recording the behaviour instantaneously was emphasised to the recorders.

The point sampling method results in proportionate data on each behaviour type for each individual followed. The method is simpler and less time consuming than continuous monitoring and can give a good estimate of frequency (Martin & Bateson, 1993).

The maximum distance travelled into the forest during these surveys, estimated from aerial photographs of the forest was approximately 2km from the forest edge.

#### *3.3.1.3 Current use of forest by cattle and other wild herbivores*

Faecal counts carried out in September 1993 (Mwangi, 1993) along two transects in Saanata, both 1km in length, were repeated in January and April 1994 and January 1995.

Faecal pellet group surveys provide a useful measure of relative abundance. Converting pellet group counts from relative to absolute measures of abundance, however, requires quantitative data on decay rates of pellet groups, which depend on a wide variety of factors such as local rainfall, cover and microfauna (e.g. Barnes & Jensen, 1987; Barnes & Barnes, 1992; Koster & Hart, 1988). These surveys were intended only to establish relative density of livestock and wildlife in the two selected areas, and no attempt has been made to quantify absolute herbivore densities.

The first transect was located near the edge of the forest where livestock grazing during the dry season was reportedly intensive near a river called *Lorubai*. The second transect was located deeper in the forest, near a water hole called *Sordon*, where livestock were reportedly rarely taken except in severe drought. 10m x 10m plots located every 50m along each transect were demarcated and all faeces within the plots were identified with the help of a young elder who had considerable knowledge of the forest and wildlife.

The total number of faeces of each species found along each transect was compared to provide estimates of relative densities of the main species of livestock and wildlife. No attempt was made to determine the age of the faeces. While the plots were located along the same transect, the plots were not cleared at each count and no attempt was made to relocate the plots exactly. The counts were therefore accumulative and equivalent throughout. 1992-1993 was a very dry year (chapter two, figure 2-3). The counts from September 1993 and January and April 1994 are therefore likely to be inflated compared to the counts made in January 1995 which followed a long rainy season. Despite these differences, repeating the surveys made it possible to compare relative densities of cattle and wild herbivores under different climatic conditions.

#### *3.3.1.4 Historical use of the forest for cattle grazing*

Informal interviews with elders from different age groups were carried out to discuss grazing patterns and use of the forest during their moranhood. The age groups interviewed are summarised in Table 3.1. Interviewees were asked questions about the history of grazing controls before and after the colonials came to the area where possible, the main grazing areas throughout the year and use of the forest for grazing and water throughout the year.

**Table 3.1** Age groups interviewed in grazing surveys

| Age group | Years of moranhood | No. of individuals interviewed |
|---|---|---|
| Lkororo | 1976 - 1992 | 6 (group interview) |
| Lkishili | 1960 - 1976 | 5 (group interview) |
| Lkimaniki | 1948 - 1960 | 3 (group interview) |
| Lmekuri | 1936 - 1948 | 2 |
| Lkileko | 1923 - 1936 | 1 |
| Lmaricho | 1912 - 1923 | 1 |

### 3.3.2 Results

#### *3.3.2.1 Ranking forest use*

The results of the ranking exercise are summarised in Table 3.2.

**Table 3.2** Mean weighted rank data ranked from 1 (most important) to 19 (least important.

| Activity | Rank (of mean weighted ranks) | | | |
|---|---|---|---|---|
| | Ngorika | Lpartuk | Men | Women |
| Grazing cattle | 1 | 2 | 1 | 1 |
| Grazing shoat | 2 | 1 | 2 | 2 |
| Livestock water | 3 | 4 | 3 | 3 |
| Fodder | 4 | 6 | 6 | 4 |
| Household tools | 5 | 8 | 6 | 7 |
| Thatch/bark | 6 | 4 | 5 | 5 |
| Firewood | 7 | 3 | 4 | 6 |
| Cultural | 8 | 9 | 9 | 9 |
| Rope | 9 | 13 | 12 | 11 |
| Poles and posts | 10 | 7 | 10 | 8 |
| Medicine | 11 | 10 | 11 | 10 |
| Weapons | 12 | 12 | 8 | 13 |
| Wild foods | 13 | 11 | 13 | 12 |
| Wild honey | 14 | 14 | 15 | 14 |
| Honey hives | 15 | 15 | 14 | 15 |
| Hunting | 16 | 16 | 16 | 16 |
| Timber | 17 | 19 | 18 | 19 |
| Furniture | 18 | 18 | 17 | 18 |
| Charcoal | 19 | 17 | - | 17 |

The results from the two villages are very similar. The mean weighted ranks for each village and for men and women were correlated against each other using Spearman's coefficient of rank correlation ($r_s$) (Siegel & Castellen, 1984). In both cases, the two groups were significantly similar in the way they ranked the various categories of wild resource use (between villages, $r_s$=0.96, P<0.001; between men and women, $r_s$ = 0.94, P<0.001). Looking at the data it is clear that livestock use of forest, both for cattle and smallstock, ranks very highly. It is important to note, however, that at the time of the baseline surveys, the local population knew that the study was interested in livestock use of the forest. It is possible that this may have resulted in an overestimate of the importance of the forest to livestock.

### *3.3.2.2 Current use of forest by cattle*

**Livestock census**

The results of the livestock census from January 1994 are shown in Table 3.3 below.

Given that the cattle were taken for water every day or every other day, the data covers two complete days. The final total for the number of cattle using the water holes could then be calculated by adding the total number of cattle which took water on the first day with the number of cattle which *only* took water on the second day.

**Table 3.3** Results of the livestock census carried out at 14 water holes in and around the Leroghi Forest Reserve at Ngorika in January, 1994. The water holes weree watched from 8.30am until 6pm.

| | **Cattle from Angata Nanyukie[a]** | **Cattle from elsewhere[a]** | **Total cattle** | **Shoat** |
|---|---|---|---|---|
| **Total count of livestock on day 1 'A'** | 2868 | 1483 | 4351 | 2304 |
| **Total count of livestock on day 2 'B'** | 2758 | 1818 | 4576 | 1814 |
| **Number of livestock on day 1 which had taken water the day before [a] 'C'** | 1366 | 694 | 2060 | |
| **Number of livestock on day 2 which had also taken water on day 1 [a] (D)** | 1376 | 698 | 2074 | 351 |
| **Total number of livestock (A+ (B - D) )** | 4250 | 2603 | 6853 | 3767 |
| **Total number of livestock using forest for grazing** | 3708 | 2275 | 5983 | 1984 |
| **% livestock using forest** | 87 | 87 | 87 | 53 |

[a] Data from interviews with the herders responsible for each herd at the water point.

The census suggests there were approximately 6,900 cattle and 3,800 smallstock using the 17 water holes under observation at the time. Of these, 38% of the cattle came from outside Angata Nanyukie Group Ranch whereas none of the small stock counted were from elsewhere.

A much greater proportion of cattle were reported to be regularly grazing in the forest than small stock: 87% of cattle, compared to 53% of smallstock. It was not specified whether this "forest" was inside or outside the forest reserve. However, only 19% of the small stock counted (717) were counted inside the reserve, the remainder all being counted at the three waterholes outside the reserve. Of the smallstock counted inside the reserve, they were only seen at 6 of the 14 waterholes, all of which were very close to the edge. In comparison, 71% of the cattle (4,871) were counted at 14 waterholes inside the boundaries of the forest reserve. This corresponds well with my observations that small stock were using forest and bush areas, but almost entirely outside the reserve compared to cattle which were present in large numbers well within the boundaries of the reserve.

**Livestock follows**

The results of the livestock follows are summarised in Table 3.4, Table 3.5 & Table 3.6.

Table 3.4 and Table 3.5 shows diet composition data from the livestock follows..

**Table 3.4** Observed dietary intake of cattle

| | | Total | Grass | Herb | Shrub/tree | Total |
|---|---|---|---|---|---|---|
| **Month** | **cattle id.** | **no of obs** | **%** | **%** | **%** | **%** |
| **January up to 2.30 pm** | 1 | 53 | 36 | 51 | 13 | 100 |
| | 2 | 56 | 46 | 41 | 13 | 100 |
| | 3 | 59 | 53 | 41 | 7 | 100 |
| | 4 | 60 | 45 | 47 | 8 | 100 |
| | 5 | 91 | 22 | 54 | 24 | 100 |
| | 6 | 90 | 22 | 56 | 22 | 100 |
| **January up to 2.30 pm average** | | **68.17** | **37%** | **48%** | **15%** | **100%** |
| **April up to 2.30 pm** | 7 | 47 | 60 | 11 | 30 | 100 |
| | 8 | 62 | 61 | 10 | 29 | 100 |
| | 9 | 69 | 78 | 7 | 14 | 100 |
| | 10 | 68 | 76 | 6 | 18 | 100 |
| **April up to 2.30 pm average** | | **62** | **69%** | **9%** | **23%** | **100%** |
| **January after 2.30 pm** | 1 | 43 | 84 | 5 | 12 | 100 |
| | 2 | 47 | 89 | 4 | 6 | 100 |
| | 3 | 48 | 79 | 6 | 15 | 100 |
| | 4 | 47 | 77 | 6 | 17 | 100 |
| | 5 | 26 | 38 | 23 | 38 | 100 |
| | 6 | 30 | 47 | 33 | 20 | 100 |
| **January after 2.30 pm average** | | **40** | **69%** | **13%** | **18%** | **89%** |
| **Grand Total** | | **896** | **55%** | **28%** | **18%** | **100%** |

There were considerable differences between the individual animals followed and in the case of the animals followed in January, between the diet composition during the morning and during the afternoon. With such small sample sizes it would be difficult to carry out any meaningful statistical tests. However, there are still clear trends in the data.

Comparing the data up to 2.30pm, the proportion of herb species in the diet was consistently higher in January than in April, whereas the opposite was true of grass species. This is as would be expected given the greater availability of fresh grass in April following the first rains of the season. There is no such clear pattern when comparing the proportion of woody species in the diet. Individual animals varied considerably in the proportion of woody species in the diet, intake ranging from 7% to 30%, and there is considerable overlap in the data from the two months. The overall average proportion of browse species in the diet was 18%.

The proportion of grass in the diet increased considerably after 2.30. One of the reasons given as to why the cattle only used the forest in the dry season was that too much "segeet" (the vernacular name given to a range of herbaceous species eaten by cattle) was not good for the cattle. The habitat selection data suggests that cattle are herded out of the forest in the afternoon to increase roughage intake in the form of dry grass.

Of all observations of browsing, 76 were of tree species and 82 were of shrub species. Seven tree species were seen being browsed and 12 shrub species. The number of observations for each species is shown in Table 3.5 below.

**Table 3.5** Tree and shrub species browsed during follows with number of observations

| Tree species | Total no. of observations | Shrub species[a] | Total no. of observations |
|---|---|---|---|
| *Maytenus undata* | 32 | *Flacourtia sp.* (S) | 13 |
| *Olea europeana* | 26 | *Lippia spp.*(S) | 11 |
| *Cassipourea malosana* | 9 | *Myrsine africana* (S) | 11 |
| *Nuxia congesta* | 5 | *Rhamnus staddo* (L) | 10 |
| *Oxyanthus speciosus / Schrebela alata* | 2 | *Dodonaea augustifolia* (L) | 9 |
| *Euclea divinorum* | 1 | *Abutilon/Hibiscus spp.*(S) | 8 |
| *Olea capensis* | 1 | *Maytenus heterophylla* (L) | 6 |
| | | *Dovyalis abyssinica* (L) | 5 |
| | | *Rhus natalensis* (L) | 4 |
| | | *Grewia villosa* (L) | 2 |
| | | *Rhamnus prunoides* (L) | 2 |
| | | *"Ingoriyo" (unknown)* | 1 |
| **Total** | 76 | **Total** | 82 |

[a] S = small shrub species, smaller than 1m in height, L = large shrub species, greater than 1 m in height

Table 3.6 below shows habitat selection over the five follows. Comparison of the data up to 2.30 only shows considerable difference between the two periods. The proportion of time spent in closed forest, woodland and open bush/woodland was much greater during January than in April. Forest edge and glade were used more in April than in January. In April, more time was spent in forest edge and glade than in any other habitat type. It is interesting to note that habitat selection in the afternoon in January differed considerably from the morning, with less use made of closed forest and more made of forest edge and glade areas. This accounts for the higher proportion of grass in the diet seen in Table 3.4. All of these results should be interpreted with caution given the very low sample size.

Almost six thousand cattle were regularly taken to the forest at Saanata for grazing or water. Saanata itself covers an area of roughly 4,460ha and it is clear that cattle do not go into the interior of the forest block. If the cattle use between 50% and 75% of the forest area (this is probably an overestimate), and spend 50% of their day in the forest every other day, there was a density of between 0.45 and 0.7 cattle per ha per day using the forest at the peak of the dry season in 1994.

**Table 3.6** Summary of habitat selection data from cattle follows

| **Month** | **Follow no** | **Total no of obs** | **Closed forest** | **Forest edge/ glade** | **Forest/ bush** | **Shrub / grass** | **Open bush /woodland** |
|---|---|---|---|---|---|---|---|
| | | | % | % | % | % | % |
| **January up to 2.30 pm** | 1 | 15 | 20% | 0% | 20% | 13% | 47% |
| | 2 | 17 | 41% | 6% | 29% | 0% | 24% |
| | 3 | 17 | 65% | 18% | 0% | 0% | 18% |
| **January up to 2.30 average** | | **(49)** | **42%** | **8%** | **16%** | **4%** | **29%** |
| April | 4 | 7 | 14% | 57% | 29% | 0% | 0% |
| | 5 | 9 | 11% | 67% | 22% | 0% | 0% |
| **April average** | | **(16)** | **13%** | **62%** | **25%** | **0%** | **0%** |
| January after 2.30 | 1 | 6 | 0% | 17% | 33% | 33% | 17% |
| | 2 | 7 | 0% | 29% | 0% | 0% | 71% |
| | 3 | 4 | 25% | 50% | 25% | 0% | 0% |
| **January after 2.30 average** | | **(17)** | **6%** | **29%** | **18%** | **12%** | **35%** |
| **Overall total** | | **82** | **29%** | **23%** | **18%** | **5%** | **24%** |

#### *3.3.2.3 Current use of forest by cattle and other wild herbivores*

The overall results from the faecal counts are shown in Figure 3-1 & Figure 3-2.

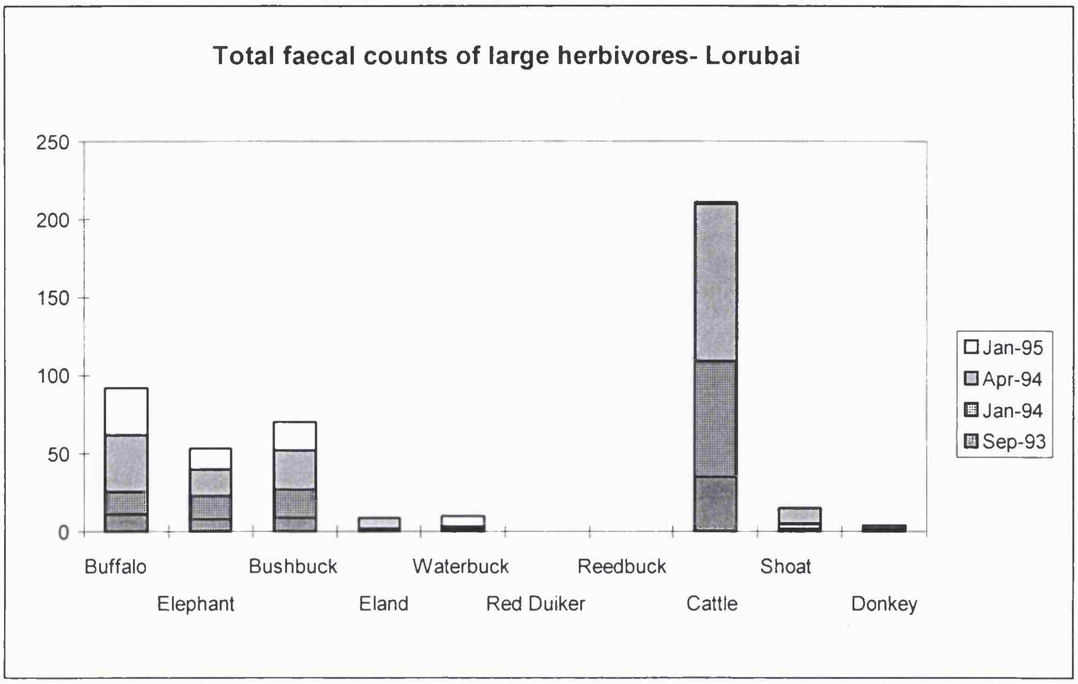



**Figure 3-1** Total number of faecal piles counted along the transect at Lorubai by species and date of survey

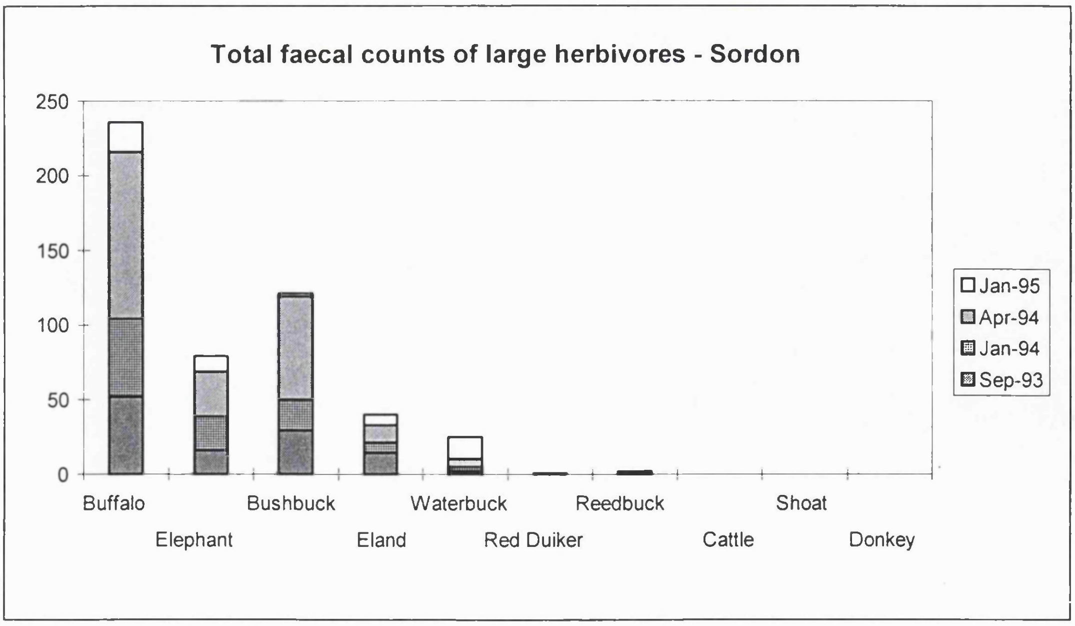



**Figure 3-2** Total number of faecal piles counted along the transect at Sordon by species and date of survey

The graphs show the accumulative number of dung piles found over the four survey periods. The results show:

1. Other herbivores present in the forest were mainly buffalo, elephant, bushbuck, waterbuck and eland. Evidence of red duiker and reedbuck was also found as were sign of baboon, warthog, bush pig, tree hyrax, hyena, leopard and lion.
2. Cattle did not use the area around Sordon during the dry period from 1993 - 1994, while cattle presence around Lorubai was comparatively high. This confirms the assertion made by the informants that cattle rarely if ever use the area around Sordon.
3. Use of the forest by smallstock is low, the few pellets that were seen being limited to the first plot, located at the very edge of the forest.
4. The presence of cattle appears to suppress the density of other wildlife, particularly buffalo.
5. Use of forest by cattle is highly seasonal, with very little evidence of cattle using the forest in January 1995 compared to January 1994. The rains from March/April 1994 had been very good and rangeland quality around the Lerroki Plateau was still relatively good in January 1995 (Drought Monitoring Programme Report, 1994 and *pers obs.*).

#### *3.3.2.4 Historical use of the forest for cattle grazing*

The results of the informal interviews with elders of different age groups are summarised in Table 3.7.

**Table 3.7** Results of informal interviews with elders showing historical trends in forest use

| **Year**<br>**Age group** | **1912**<br>**Lmaricho** | **1936**<br>**Lmekuri** | **1948**<br>**Lkimaniki** | **1960**<br>**Lkishili** | **1976**<br>**Lkororo** |
|---|---|---|---|---|---|
| **No of cattle** | "people were few but they had many cows" | There used to be more cows than now | There used to be more cattle. | There used to be more cattle. | There used to be more cattle |
| **Grazing in forest** | Used the forest for grazing and water in the dry season | "Used forest in dry season for grazing"<br>"There were no parts of the forest where the cattle would not go because there were more cattle and the bush was thinner" | Dry seasons were shorter but cattle would still use the forest every year. | Use of the forest depends on the rain - if there was enough rain they did not use the forest. | Forest was used in the dry season and there was a regular dry season every year |
| **State of forest** | "Inside Supuko is thicker now because there are fewer cattle grazing inside" | "the bush was thinner"<br>"the forest has become thicker" | | "The forest is becoming thicker -more trees and segeet[a]" | |
| **Rule makers and enforcers** | Elders<br>Elders would say when cattle could enter the forest<br>Would leave the forest during the wet season because the grass outside was better for the cattle and there was plenty of water. | Elders<br>"when the time came, the elders would meet from around and go to the forest to pray for rain. At that time the cattle could go to the forest. After the rains everyone would come out. They would hold a meeting to make sure that no-one was still inside"<br>There was never a forest guard. If a moran loses a cow inside [the forest] when the elders have not permitted them to enter he will be punished | | Elders and government<br>1960 - 1966 they would need to get permission from the elders to use the forest.<br>1966 - 1984 it was illegal to enter the forest. Few people admitted to using the forest so no-one knew how many were inside" "People would sneak in every year"<br>"when it was illegal to enter the forest, no-one had authority to allow grazing so no-one would ask"<br>Rules were enforced by government guards & people were chosen to live close to the forest to control forest use. | Elders and government<br>These days when there is no grass the elders must meet with the government to decide to open the forest.<br>The elders gave permission<br>If a moran was repeatedly caught in a part where he was not permitted to go he would be first threatened, then fined, then cursed by the elders.<br>Once inside the forest, its up to the morans to decide where they go. |
| **Reasons for rules** | To ensure enough grass to last the dry season & because there were a lot of wildlife at that time when the forest was wet | Movement in forest was controlled to provide enough grass. | | | Cattle do not like the forest when the grass and segeet is too wet. |

[a]Segeet is the vernacular name for a group of grasses and herbaceous plants edible by cattle - see appendix

### 3.4 Discussion

Extensive review of the literature found many references to the importance of dry season grazing for pastoral and other communities in East Africa and northern Kenya in particular. However, most evidence of dry season grazing tends to be circumstantial, with little hard data quantifying the number of cattle actually using forest resources at any one time (e.g. Struhsaker *et al.*, 1989, Bronner, 1990).

The results presented in this chapter aimed: to establish the importance of forest for livestock relative to other activities; to quantify current use of the forest by cattle, both in terms of the numbers using the forest and the proportion of browse, and specifically tree species in the diet of cattle; to compare the relative abundance of other wild herbivores in areas of known cattle grazing intensity; and finally to establish how use of the forest for cattle grazing and watering has changed over the last 70 years.

In summary, the forest was perceived as being of great importance for both cattle and smallstock, both for fodder and for water. Census data of cattle using the forest during the height of the dry season supported this perception, with 87% of cattle regularly grazing inside closed canopy forest, representing around 6,000 animals. The forest was not used exclusively by members of the forest adjacent community: thirty eight percent of the cattle counted came from outside the group ranch. All, however, came from locations on the Lerroki Plateau. While 53% of smallstock also used closed canopy forest for browsing and watering, the vast majority of these were using forested areas outside the forest reserve. Smallstock are strictly prohibited from entering the Forest Reserve and my observations as well as these data support the fact that this rule is generally well observed. In contrast the majority of cattle were counted at waterholes inside the boundaries of reserve.

The results of the resource use ranking exercise overall shows similarities with a similar exercise carried out with Maasai around Oldonyo Orok Forest in southern Kenya which ranked forest resources based on their comparative economic advantage (Emerton, 1996). Grazing resources and water resources were ranked most highly. Firewood and building materials were next in importance reflecting perhaps less availability of these woody resources outside the forest than seen on Lerroki, followed by medicinal products, honey, hunting, wild foods and utility items - the last being less valued as forest products given their greater availability outside as well as within the forest. Emerton also notes that households living further away from forest valued the forest as highly as households living adjacent to the forest as a source of dry season fodder and water (Emerton, 1996).

The sample size for the livestock follows was small. However, the proportion of diet from woody species averaged 18%, with almost half of that made up of tree species. There was little difference in browse intake between the height of the dry season and the start of the rainy season. These figures correspond well with those quoted at the start of this chapter (e.g. Rees, 1972; Homewood & Hurst, 1986; Bayer, 1990) There was, however, a considerable difference in the proportion of herbaceous plants in the diet, with herbs accounting for 34% of food intake in January, compared to just 9% in April. The proportion of time spent in closed canopy forest, open bush and woodland also declined sharply between January and April, from 71% to 13%, with a corresponding increase in time spent at the forest edge and in forest glades from 8% to 62%. The dry season figures correspond closely with those found in Tugen cattle in an area of poor pasture availability north and west of Lake Baringo, where the cattle spent just 8% of their active day in open grassland and more than 50% of their active day in bush and bushed grassland (Homewood & Hurst, 1986). In the same study, the Il Chamus cattle (to the south west of the lake), kept in an area where high quality pasture was more available, spent most of the active day in open grassland. The figures from this survey are inevitably affected by the herding strategies of the herders, but comparison with data from the Baringo area suggests availability is an important factor in determining cattle habitat use.

The faecal pellet counts suggest the presence of cattle may suppress the population of most other wild herbivores. The number of cattle using the forest was much higher in January 1994 compared to January 1995, when evidence of cattle using the forest was almost non-existent. These data, together with the results of the cattle follows, support the assumption that cattle tend only to use the forest during the dry season when range quality and grass availability outside the forest is poor.

Another factor that might encourage herders to 'drive' the cattle from the forest at the start of the rains is the rapid increase in the potentially disease carrying tick population associated with fresh grass growth (Potkanski, 1993; Norval *et al.*, 1994). The buffalo population found inside the forest almost certainly acts as a carrier for East Coast Fever and the tick load inside the forest and at the forest edge visibly increased at the onset of the rains (*pers obs.* of the number of ticks on my socks at the end of each day). The occurrence of biting flies in the forest also increased considerably towards the end of the rainy season and a number of dead bush buck and one dead buffalo were seen in the forest[1].

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[1] Unfortunately the disease was not identified, although the most likely is trypanosomiasis (District Wildlife Officer, *Pers comm.*).

Finally, systematic interviews with men of different age-groups seem to suggest that the number of cattle using the forest in the past was much higher than today.

### 3.5 Conclusions

The results presented in this chapter clearly demonstrate the importance of access to the closed canopy forest at Saanata during the dry season. Closed canopy forest provides both fodder and water and browse species can be an important dietary constituent of cattle in spite of their being preferential grazers. Certain tree and shrub species were selected over others. The next chapter investigates the impact that cattle have had on the closed canopy forest canopy in terms of species composition and plant population structure as a result of this use.

# 4. The Effect Of Cattle On Closed Canopy Forest Structure And Diversity

## *4.1 Introduction*

This chapter investigates the effects of cattle grazing on closed canopy forest. The importance of closed canopy forest as a source of dry season fodder and water for cattle was established in the previous chapter. Despite the growing evidence for the importance of browse as a dry season food source for cattle, the effects of this use on forest vegetation in Africa has never been rigorously tested (Le Houerou,1980; Scoones, 1990). This lack of evidence, however, has not prevented resource managers and researchers portraying cattle grazing as a major cause of forest degradation in dry zone forests (e.g. Bronner, 1990; Struhsaker *et al.*, 1989; Synnott, 1979, Rocheleau, 1993).

The current study does not attempt to unravel the precise mechanisms by which cattle grazing affects forest biodiversity. Given the complexity of any indigenous forest ecosystem this would be almost impossible. Instead, the study uses a comparative approach to establish the effects of cattle on overall plant population structure and species diversity, on the basis that these parameters ultimately reflect past opportunities for individual plant recruitment and the mortality risk to which each recruit has been exposed.

In the next section a literature review examines the ways in which cattle (and other large herbivores) are known to affect woody vegetation and species diversity. Much of the literature on cattle impacts on woody vegetation in Africa relates to open savanna woodland and bush, particularly with reference to plant-herbivore-fire interactions. The review describes this data and, where possible, relates it to the closed canopy forest habitat. The use of plant population structure to assess historical events and the future potential of forest is discussed and the power function model, used in this study to compare forest populations, is introduced. This review is used to develop a number of hypotheses on the potential impacts of cattle on closed canopy forest. The methods used to measure specific vegetation parameters are then described. The data collected were analysed using a variety of statistical techniques which are introduced before presenting the results and analysis. In the final discussion, the hypotheses proposed at the start of the chapter are assessed in the light of the results and the implications for forest management are outlined briefly.

### *4.2 The impacts of cattle on vegetation - a review*

A forest is a mosaic of patches, constantly changing as individuals compete for limited resources to grow, reach sexual maturity and reproduce (Whitmore, 1990). The forest ecosystem is inherently dynamic, maintained through the processes of recruitment, growth and mortality (Shugart & Urban, 1989). When a canopy tree falls a gap is created with a radically different micro-climate. Shade tolerant trees, which have remained suppressed in the understorey, compete with light demanding seedlings from a new wave of germination to reach the highest canopy. The new canopy species may have different properties from the original creating different soil and light conditions in the understorey which will affect species recruitment for the next cycle. Tree recruitment, growth and mortality are highly variable, even within individual species stands, depending on a vast array of biotic and abiotic conditions. In a complex, multi-species system, tree species must compete with each other for limited resources and this competitiveness may differ radically in response to herbivory.

Cattle may have direct and indirect impacts on this system. Direct effects include mechanical damage to young trees through trampling and browsing and the impact of cattle trampling, urinating and defecating on soil properties. Indirect effects include altering the competitive advantage of young tree seedlings through selective browsing and grazing and the reduction of the herbaceous layer, and changing the potential severity of forest fires caused by the accumulation of dry matter in the herbaceous layer.

This section reviews the evidence in the literature for the direct and indirect effects of forest grazing by cattle. This evidence is used to develop hypotheses and predictions which are tested using the results of the vegetation surveys in the rest of this chapter.

### 4.2.1 Mechanical impacts of cattle

There is considerable evidence that cattle can damage seedlings and reduce their growth rate through browsing and trampling (Adams, 1975; Belsky, 1985; Putman, 1986). The severity of browsing and trampling damage depends on timing and intensity (Taylor *et al.*, 1993). The effects of trampling and browsing also depends on the individual tree species being affected and its tolerance to damage. For example, Eissenstat *et al.* (1982) found that Douglas fir (*Psedotsuga menziesii*) seedlings were much more susceptible to slight exposure of cambium caused by cattle trampling than were those of slash pine (*Pinus elliotii*).

Slow growth and delayed recruitment from seedling or sapling to mature stage caused by browsing or trampling damage may also result in increased mortality rates, but this again depends on the species. Osunkoya *et al.* (1993), looking at the effects of grazing on six tree species in New Queensland, Australia, found that caged seedlings suffered much lower levels of mortality than uncaged seedlings. However, despite heavy losses of uncaged seedlings to vertebrate seed and seedling predators, those that survived grew just as well as those that were protected; grazing did not alter the recruitment rate of the surviving seedlings. Similarly, Pellew (1983) found that *Acacia tortilis* browsed by giraffe took 2.8 times longer to reach a height which exceeds the maximum browse height of a giraffe and 2.6 times longer to exceed the minimum height at which a tree is not vulnerable to fire. However, once seedlings were protected or browsing pressure reduced, the browsed individuals were often able to recover rapidly (Pellew, 1983a).

Trampling by cattle may alter soil properties in a number of negative ways: reducing soil pore spaces and causing poor aeration, low infiltration rates, low water retaining ability, and frequently low micro-faunal densities. Coppock (1993) reviews several of studies attributing soil erosion to high cattle densities, the severity of erosion increasing in areas with steep slopes and high rainfall. There is some evidence that such effects are really only serious in areas of very high cattle densities such as along tracks and around watering points (e.g. Murai, in Adams, 1975). Adams (1975) suggests that cattle reduce organic matter and increase acidity in soils.

Cattle browsing and trampling may also directly effect tree seedling regeneration and survival in a positive way. Dung piles often provide the conditions necessary for germination whether or not the seed has passed through the gut of the herbivore (Harper, 1977). Peinetti *et al.* (1993) found the dominant Calden (*Prosopsis caldenia*) of the semi-arid pampa of Argentina had extended its range in the last century largely due to cattle, which feed on the pods, grazing in the forest areas. High grazing intensity can also result in the concentration of nutrients, recycled from dung and urine, which can stimulate growth, particularly in areas where soil nutrients may otherwise be low (Reid & Ellis, 1995; Sinclair, 1995; McNaughton, 1979; Homewood, 1992). For example, Reid and Ellis (1995) found higher germination and survival of *Acacia* species in abandoned night cattle enclosures in Turkana District, Kenya.

Thus, the direct mechanical effects of cattle may work both for and against individual tree species. However, forests are complex ecosystems. The next section reviews the ways in which cattle grazing and browsing can affect the ecosystem as a whole.

### 4.2.2 Cattle, fire and forests

Cattle can and do browse on tree seedlings (reviewed in chapter three). However, preferential grazing on herbaceous and grass species overall tends to reduce the competitive advantage of grasses and herbs over woody species (Shackleton, 1993). Reduced competition from the herbaceous layer was thought to account for very high tree seedling densities found in areas of high cattle grazing intensity in miombo forest in Malawi (Abbot & Lowore, in prep).

The reduction of biomass in the herbaceous layer due to cattle (or other wild herbivores) also reduces the volume of dry inflammable biomass, which in turn reduces the frequency and the severity of wild fire. The positive effect on seedling survival due to the reduction in the severity of fires and competition has been found to outweigh the losses caused by trampling and browsing by herbivores. For example, Norton Griffiths (1979) found that the extent of fires in the Serengeti National Park had decreased significantly over a ten year period in correlation with an increase in buffalo and wildebeest populations, in spite of severe losses of *Acacia* seedlings in the

Serengeti from trampling following the annual wildebeest migration (Dublin *et al.*, 1991). Fire was found to account for 44% of variation in woody vegetation percentage cover in the drier parts of the park. Norton Griffiths goes on to suggest that burning could itself have been partly responsible for the increase in herbivores as it promoted the growth of more palatable grass species. Interestingly, in the wetter areas elephants were responsible for most of the changes (elephants 26% and fire 13%). In a similar case, cattle outside the Maasai Mara Game Reserve have reduced grass biomass since 1982 to the extent that fire is infrequent and woody plants are re-establishing (Dublin, 1991).

Perlov (1987) commented on the encroachment of certain tree species into the rangelands to the south of Maralal including *Croton dichogamus*, *Acacia nilotica*, *A. gerardii* and *Euclea divinorum* despite dry season forest grazing on a regular basis. And in West Africa, farmers actively "establish improved bush fallows from savanna through intensive cattle grazing strategies to reduce fuel fire" (Fairhead & Leach, 1994: 41).

The effect of fire on woody vegetation is highly dependent on fire frequency and intensity (Ahlgren & Ahlgren, 1960; Walker, 1980; Huntley & Walker, 1982 for reviews). The intensity of fire depends on the amount of dry biomass that accumulates and correlates positively with the amount of rainfall and subsequent biomass production (Dublin, 1991). If there is limited dry biomass, e.g. due to high grazing pressures, there will be fewer and less intense fires and the balance will tip in favour of woody species resulting in bush encroachment (McNaughton, 1979; Lamprey, 1985). The early dry season burn is commonly used in pastoral areas to create a green flush which is then heavily grazed. The green flush is a product of root reserves and early dry season burns often weaken the vigour of the grass sward leading ultimately to encroachment by woody species that have greater root reserves. Late dry season burns, however, when dry matter has been left to accumulate in the grass layer, may cause minimal damage to grasses which are dormant at this stage, and severe damage to shrubs and trees, particularly where they have already flushed (Walker, 1980; Edroma, 1984; Turner, 1967). The ample evidence for the inverse relationship between grazing impact and fire is reviewed in Norton-Griffiths (1979), Lamprey (1985) and Huston (1994).

Most research into the integrated effects of herbivory (by large mammalian herbivores) and fire on woody vegetation has focused on tree/grass ratios in typical "savanna" (which includes wooded grassland, bushland or shrubland *sensu* White, 1983). Derived savanna is maintained by a combination of herbivory and fire, dependent on an alternating wet and dry soil phase (Walker and Noy-Meir, 1982; Longman & Jenik, 1992) and, to a large extent, on soil nutrients (Belsky, 1990; Bell, 1982; Hopkins, 1992). Grasses are able to dominate water supplies in the upper soil layer owing to the nature of their root system during the wet phase; these upper layers dry out first, while the lower layers remain wet enough to support the deeper rooted woody species. Thus, within a savanna ecosystem, therefore, herbivory plays a vital role in maintaining the trees:grass ratio through its impact on competition for soil moisture and nutrients and the accumulation of dry biomass (McNaughton, 1979).

However, there are three fundamental differences between forest and savanna (Buechner and Dawkins, 1961; Huntley, 1982) which make studies of cattle/habitat interactions in rangeland of limited value within a forest environment:

- water content of the soil in forest tends to be more constant;
- the micro-climate is generally too moist for fire to reach deep inside forest; and
- light intensity is too low to allow grass growth.

Where the herbaceous cover is low, herbivory is most likely to influence vegetation dynamics through browsing and trampling of seedlings and altering soil properties through trampling and defecating discussed above. However, within forest glades, at the forest edge, and where canopy cover has been thinned due to natural or man induced causes, increased light incidence will promote the build up of the herbaceous layer. Such glades and open patches are frequent within dry montane forest, although it is often impossible to determine their cause (Hopkins, 1992). A greater accumulation of herbaceous matter in the wet season and increased desiccation in the dry season in such areas increases the risk of fire penetrating the forest and causing considerable damage. Where light penetration is higher, therefore, the role of herbivory in preventing fires by reducing the build up of the herbaceous layer increases in importance.

The risk of fire encroaching on forest is particularly acute when trees around the edge of the forest die, increasing light intensity and desiccating the micro-climate. Buechner and Dawkins (1961) found that ring-barking and destruction of trees around the edge of closed canopy forest in the Murchison Falls National Park in Uganda due to the combined effects of elephant and fire damage allowed sufficient light penetration to permit the spread of grasses into the forest in quantities that enabled fire from the surrounding grasslands ever deeper into the forests. Elephant damage without fire was rarely sufficient to kill trees, but where fire occurred before fire-resistant cork layers were formed, freshly debarked trees were particularly susceptible. Tree felling by people would have a similar effect. However, where shrubs are clumped they may be resistant to fire (Trollope, 1982), and the trampling of understorey trees and shrubs by elephants was also necessary to allow the spread of grasses into the forest at Murchison Falls.

Repeated severe burning can ultimately lead to reduced plant cover and compacting of soil (Walker, 1980; Turner, 1967). The long term effects of changes in soil structure and properties are difficult to establish in a complex forest ecosystem. However, any change in soil properties is likely to alter the recruitment potential of different individual species (Longman & Jenik, 1992).

Adams (1975) refers to three papers that discuss the importance of cattle grazing in reducing fire hazard. In Louisiana heavy grazing was found to reduce dry grass or fuel weight per hectare to a quarter of that found in ungrazed forest. In subsequent fire outbreaks, survival of pine seedlings in the grazed forest areas was improved. Two studies in New Zealand and Australia found grazing in *Pinus radiata* plantations reduces fire hazards.

Once forest degradation and desiccation has occurred, the impact of herbivory and fire on plant succession in derived savanna relates to the ability of forests to recover. Menaut and Cesar (1982), looking at the savanna-forest mosaic zone bordering the west African rainforest have found that forest tree species tend not to establish in grass patches, but require the invasion of shrub species and a reduction in the herbaceous layer first. Similarly, White (1983), referring to work in the Mt. Kulal region of Samburu District, suggested that regeneration of tree species was concentrated within relatively non flammable evergreen bushland which correlates with my own observations on Lerroki where young *Juniperus procera* occurred mainly in clumps of *Maytenus heterophylla*, *Rhus natalensis*, *Euclea divinorum* and *Carissa edulis*. The build up of woody vegetation depends on the frequency and severity of fire which, once again, invokes the intensity of herbivory as a function of the accumulation of dry matter in the herbaceous layer.

### 4.2.3 Forests and plant population structure

Plant population structure within forest is an important measure of forest health and history (Hall & Bawa, 1992). The frequency distribution of age or size classes found within a population at any given moment in time is taken to represent the progression of an even age cohort through its entire life span (Hett & Loucks, 1976; Veblem *et al.*, 1980). This frequency distribution reflects past opportunities for individual plant recruitment; the mortality risk to which each recruit has been exposed (Shugart & Urban, 1989); and the future potential of a forest through recruitment from younger/smaller individuals (Harper, 1977).

The use of plant population structure to interpret historical events is reviewed in Hall & Bawa (1992). Peterken and Tubbs (1965) found only three major age-classes were present in the New Forest in England, which corresponded to the periods when the numbers of grazing animals in the forest were reduced (Putman, 1986). In at least one of these periods, grazing was not the only influencing factor: once regeneration had started, a protective canopy formed, allowing further regeneration to continue after herbivore numbers had increased. The wave of regeneration eventually stopped because the canopy itself prevented further regeneration. This did not occur where fire, used in heath management, destroyed the young shrubs.

Mortality in most tree species is naturally higher in the smaller/younger size classes due to the large number of recruits in relation to limited levels of resources such as minerals, soil moisture and light and habitat heterogeneity (Hutchings, 1986). Where there is perfect accordance (correspondence of young species in the understorey with mature trees in the canopy) the size class distribution curve for the species is a characteristic reverse J shape as shown below in Figure 4-1.

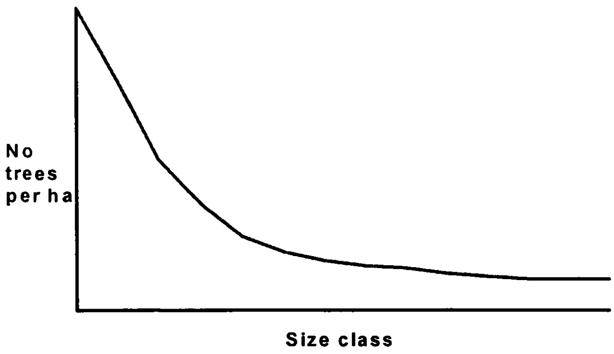


**Figure 4-1** Mortality among tree cohorts would naturally decrease with size resulting in high numbers of small/young trees and fewer large/old trees (Harper, 1977; Hett & Loucks, 1976)

For a forest to maintain a steady state there should be enough seedlings of the dominant species to maintain the current population of mature trees. "Light" or "moderate" levels of cattle grazing intensity may reduce recruitment, but not to any greater extent than might be found in a "control" area with no cattle (e.g. Pearson *et al.*, 1981; Nakata *et al.*, and Shibata, both in Adams, 1975). This study asks whether the reduction in growth and recruitment of individual tree species caused by cattle trampling and browsing results in forest senescence in the longer term or alters species diversity through differential effects on recruitment of preferred species.

The steady state ideal shown above has been modelled quantitatively using both the negative exponential distribution and the power function model (Hett & Loucks, 1976).

The negative exponential model states that the probability of death is constant throughout the life time of the species being studied. A regression using this model is generally significant in describing the depletion of herb and seedling populations over a relatively short span of years. However, in long lived species, the negative exponential distribution tends to underestimate the numbers in the youngest age-groups and overestimate the numbers in the mid portion of the age-distribution.

The power function model states that the probability of mortality decreases with age and was found a better description for a steady state population of shade tolerant species in which the population is continuously regenerating (Hett & Loucks, 1976; Veblem *et al.* 1980). The power function model is defined in Box 4-1.

**Box 4-1 The power function model has the equation:**

$$y = y_0 x^{-b}$$

which can again be transformed to provide the linear equation:

$$\log_e y = \log_e y_0 - b \log_e x$$

where: y is the number of stems in any diameter class x;

$y_0$ is the initial input into the population at time zero;

and b is the mortality rate per unit time.

Where regenerating species are different to those found in the mature classes the forest is probably in a seral state. Where the number of juvenile trees of all species combined is low, the forest may be in a state of senescence. Evidence reviewed above suggests that cattle grazing is likely to reduce seedling growth and survival through browsing and trampling (Adams, 1975; Belsky, 1985). This could have the effect of reducing levels of recruitment to the upper canopy, the equivalent of senescence. However, there is also evidence that cattle may reduce competition from herbaceous undergrowth and fire, hence increasing survival of small tree seedlings and saplings. Selective browsing of palatable tree species is likely to result in under-representation of palatable species in the middle and upper canopy layers.

Modelling the population structure using generalised linear modelling techniques allows powerful parametric statistical analysis to be used to test the degree of departure of size class distributions from the steady state ideal in different forest environments. In this case, it allowed forest structure to be compared in areas under different grazing pressure.

This study collected size data to reflect stand structure. It cannot be assumed that size can be correlated with age: single aged stands have been found to assume rapidly the characteristic reverse J- size distribution curve, and conversely, "saplings", small individuals of canopy species within the understorey have been found to be up to 60 years of age (Harper, 1977). Harper discusses the problems associated with accurately ageing individual trees, including the complete absence of age rings in many tropical species, false rings in tundra species, and the difficulty of getting an accurate age without destroying the tree. However, given that the purpose of stand structure analysis is to provide a measure of the forest's future potential through recruitment of individuals to a stage of full reproductive capacity, then the size structure may actually be a better parameter than age structure since reproductive capacity is frequently associated with size and not age (Harper, 1977). Hett & Loucks (1976) argue that the theory of decreasing mortality rate with age is consistent with the gradual emergence of individuals into the canopy layer and their establishments as dominants. The same argument could equally be applied to a decrease in mortality with size.

### 4.2.4 Cattle grazing and species diversity

Whatever the mechanism by which cattle influence forest vegetation, it is likely to have an indirect effect on forest species diversity. Different plant species show different levels of tolerance to grazing, trampling and fire (Crawley, 1983; Eissenstat *et al.*, 1982). Miombo woodlands of southern Africa are typified by fire tolerant species (Abbot, 1996). Similarly, selective grazing of a dominant species can allow less dominant species to flourish while non-selective grazing will suppress grazing intolerant species and give grazing tolerant species the competitive edge (Huston, 1994). In the Serengeti, herbivory was found to increase biodiversity in areas of high usage through an increased high fibre nutritional value across soil types (McNaughton & Banyikwa, 1995).

Tolerance, whether to browsing, trampling or fire, may be related to temporal variables (such as the occurrence of grazing relative to seeding or establishment of energy reserves), or morphological and physiological responses of the plant to defoliation levels (e.g. Coley *et al.* 1985, Fitzgerald *et al.*, 1986). Initial changes in species composition due to such herbivore-plant interactions can have a knock-on effect on plant species competitiveness due to changing plant-plant interactions.

Crawley (1983: 293) states that "there is no general relationship between grazing intensity and plant species diversity". Grazing can decrease species diversity when less abundant, grazing intolerant species are selected, allowing a few grazing tolerant species to dominate. It can also increase species diversity, when the population of a dominant species is reduced, allowing the spread of less abundant, more grazing tolerant species (McNaughton, 1979).

As a final note, it should be remembered that a natural forest complex contains many wild herbivores as well as cattle. The forest under study contains a rich array of large herbivores: elephants, buffalo, waterbuck, bushbuck and eland were all sighted in the forest during the course of the study. These other herbivores will also affect the vegetation through the various mechanisms described in this section and the impacts of cattle must be differentiated from the impacts of other herbivores before management decisions on cattle grazing in forests are made (cf. Homewood and Rodgers, 1991 in Ngorongoro Crater Conservation Area). In a Cypress Pine forest in Queensland sheep were initially blamed for a total absence of regeneration, however removing sheep from the area made no difference to levels of regeneration - all the seedlings were being destroyed by rabbits (Johnston in Adams 1975).

### *4.3 Generating hypotheses*

On the Lerroki Plateau, altitude strongly influences climate and, by association, the vegetation (see chapter 2 for discussion on agro-climatic zones). Higher rainfall and lower evapo-transpiration rates at higher altitudes to the north and east of the plateau supports the closed canopy forest. Lower rainfall and higher temperatures at lower altitudes to the west and south support a savanna type ecosystem characterised and possibly maintained by frequent dry season fires. From the previous discussion, cattle grazing is likely to influence forest cover on the Lerroki plateau directly, by trampling, defecating and browsing, and indirectly by reducing the build up of a herbaceous layer in glades within the forest and at the forest edge. The direct effects are likely to be negative, reducing seedling regeneration and recruitment (although nutrient recycling through defecating may have a positive effect). The indirect effects are more likely to be positive, reducing the frequency and severity of fires and reducing competition for nutrients and moisture, both of which will enhance seedling regeneration and recruitment. Both types of effect will be felt differently by different species at different stages in their life-cycle by altering the relative competitive advantage of individuals, thereby affecting overall species composition in the long term (Crawley 1983; Westoby, 1979).

The preceding discussion suggests a number of hypotheses and predictions, some of which will be counter to each other, which are tested in the course of this chapter:

**Hypothesis 1**. Cattle trampling and browsing reduces seedling regeneration and survival above and beyond the effects of wild herbivore browsing and trampling.

**Prediction 1**. Density of the youngest individuals will be lowest in areas of highest cattle grazing intensity and density will fall rapidly with increasing size.

**Hypothesis 2**. The reduction in seedling regeneration and survival caused by cattle grazing (hypothesis one) leads to long term forest senescence.

**Prediction 2**. Seedling densities may be reduced in areas of high cattle grazing intensity. Density of the youngest individuals will be lowest in areas of highest cattle grazing intensity and density will fall rapidly with increasing size. Given the evidence for long term cattle grazing in the area (chapter three), densities of individuals in the higher size classes should be reduced in areas subject to high cattle grazing and browsing intensities.

**Hypothesis 3**. Cattle grazing facilitates seedling growth and survival by reducing the herbaceous layer beyond the levels caused by wild herbivores, thereby reducing competition for light and soil nutrients and moisture.

**Prediction 3**. The herbaceous layer will be lower in areas grazed by cattle than in areas grazed only by other wild herbivores. Seedling and sapling densities will be highest in areas of high cattle grazing and lowest in areas of no cattle grazing. The herbaceous layer in protected plots will be greater than that in open plots.

**Hypothesis 4**. The direct and indirect effects of cattle in forest will differentially affect species diversity.

**Prediction 4**. Species diversity will be different in areas of high cattle grazing intensity and areas of low cattle grazing intensity.

## 4.4 Methods

Plotless techniques were used to measure stand structure, species abundance and dominance and species diversity. Exclosure plots were established to monitor herbaceous cover and seedling growth and survival. These methods are described in turn in this section.

Species lists, including vernacular and botanical names, were initially established during the course of the pilot study with the help of botanists from the National Museums of Kenya. These lists were augmented throughout the course of the study.

### 4.4.1 Methods - Tree density, stand structure and species composition

The point-centred quarter technique, PCQ, (Mueller-Dombois & Ellenberg, 1974, Greig-Smith 1982, Heyting 1968, Cottam & Curtis, 1956) was used to establish species diversity and density, species importance values (the sum of relative frequency, relative density and dominance value), and stand structure using diameter class frequency, under three different grazing regimes: heavily grazed forest edge, moderately grazed inner forest and ungrazed inner forest. In addition, small 2m x 2m quadrats were used to establish seedling density and evidence of browsing along the same transects used for the PCQ method.

#### *4.4.1.1 The point-centred quarter method*

The point-centred quarter method, devised by Cottam and Curtis (1956), is one of a number of plotless techniques developed to provide an efficient means of determining stand structure in forests (Mueller-Dombois & Ellenberg, 1974, Greig-Smith, 1982). It has been used extensively in studies determining the impacts of various herbivores on woody vegetation (e.g. Croze, 1974; Pellew, 1983; Dix, 1961; Ruess & Halter, 1990). Plotless distance methods provide a measure of four major quantitative parameters: basal diameter, frequency, species diversity, and density. From these parameters it is possible to establish a measure of dominance and species abundance. The advantages and disadvantages of the PCQ method over other distance and plot methods are discussed fully in Mueller-Dombois & Ellenberg (1974).

In summary, the advantages of the PCQ method are:

- the relatively high intensity of sampling (four trees per point) compared to the other plotless techniques such as nearest neighbour, or the wandering quarter methods;
- the random placement of the sampling point; and
- the efficiency compared with laying out plots which can be very time consuming in forested areas.

The major limitation to the technique is that it is only applicable to random distributions. In mixed-species stands, a non-random distribution of individual species is the norm (Mueller-Dombois & Ellenberg, 1974) and the technique can therefore only be applied when considering all species in the stand. Where the stand itself is clumped, the point to plant distances will tend to be overestimated because of the probability that the point will fall between clumps, while in regularly distributed populations, the density is likely to be overestimated. Diameter and frequency measures are independent of the correct mean distance, but cannot be said to be entirely independent of each other, since species are often aggregated and size class will depend on each individual's neighbours.

Following this method, points were located every 25m along a transect, measured with a 30m tape measure. At each point, a stick was laid at right angles across the tape measure to mark out the four quarters. The nearest tree (basal girth > 7cm) was located in each quarter and the following data were recorded: tree species, distance to the tree trunk, basal girth, evidence of damage and cause where known, and whether the tree was coppiced/multi-stemmed. The distance from the point to the centre of the nearest tree could easily be calculated as the sum of the distance to the tree trunk and girth/2$\pi$. The basal area was measured (as opposed to the more commonly measured diameter at breast height) to ensure broken and coppiced stems were included in the survey, damage being potentially related to livestock and wildlife pressures.

Evidence of damage was recorded, classified as described in Table 4.1. In many cases it was possible to identify elephant damage, however, where it was uncertain, no distinction was made. The same is true of damage due to human activity where a knife/panga had been used. No attempt was made to measure only the current year's damage or to define the age of the damage; damage on larger trees may have accumulated over several years.

**Table 4.1** Types of damage recorded during PCQ surveys

| | | |
|---|---|---|
| 1. No damage | 5. Debarked | 9. Coppiced |
| 2. Cut branch - human | 6. Trampled | 10. Browsed |
| 3. Coppiced - human | 7. Elephant damage | 11. Fallen |
| 4. Debarked - human | 8. Debarked - elephant | 12. Branch damage |

In addition, small plots, 2m x 2m, were marked out at every PCQ point along each transect and the height of all seedlings within the plots and evidence of browsing was recorded (Mueller-Dombois & Ellenberg, 1974).

#### *4.4.1.2 Locating the PCQ Transects*

The aim of these vegetation surveys was to distinguish the effects of cattle on the above vegetation parameters. It was therefore important to minimise any confounding variables, particularly the effects of other human activities. Saanata was chosen as the most appropriate site for these surveys on the basis of discussion with the local communities and the results of human disturbance surveys (Chapter two). The results of the faecal count surveys had also shown that parts of Saanata were extensively used by cattle during the dry season, but cattle use did not extend over the entire Saanata area (Chapter three).

The transects were located in a stratified random manner. Three strata were identified, based on cattle grazing indices: 'moderately grazed', 'ungrazed'[1] and 'forest edge' (intensively grazed). Two informants, both of whom had extensive knowledge of the forest and local plants and plant use, used large scale aerial photographs to establish areas of Saanata forest where livestock had and had not been taken for grazing. The older of the two informants was roughly 55 years of age so it

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[1] areas not grazed by cattle will be referred to here as ungrazed, although of course the area will be subject to grazing by wildlife

was possible to be sure that the 'ungrazed' areas had not been used by cattle at least in the last 40 years.

Once the overall 'grazed' and 'ungrazed' areas had been identified on the photographs, a 5km x 5km grid was drawn onto a map of the area. Ten squares from both the grazed and ungrazed areas were selected at random, and each square was then located with the help of the aerial photographs and the informants and surveyed using the plotless techniques described above. The highest grazing intensities were located close to the forest edge, but there were no comparable forest edge areas where cattle had not grazed at all. Three transects were surveyed within 200m of the forest edge. However, direct comparison between these transects and the moderately grazed and ungrazed transects is difficult given the very different micro-climate found at the forest edge.

Unfortunately it was not possible to quantify grazing pressure in the areas chosen. A pellet count along each transect would not have been practical given that the surveys took place at the end of the rainy season, when cattle use of the forest was practically non-existent and would anyway apply only to current levels of use and not to historical levels.

The location of the transects are mapped and shown in chapter two (Figure 2-8). The distribution of the moderately grazed transects and the ungrazed transects tended to co-vary with distance from the forest edge, due to accessibility by the herds and the greater risk from wild animals. By spreading the transects over as great an area as possible and ensuring none of the moderately grazed transects were less than 500m from the forest edge, it was hoped that this problem would be minimised. It would be difficult to rule out this distributional effect, however, if a significant difference was found between the two sets of transects.

Variation is inherent in a forest ecosystem, particularly in an area such as this with steep slopes, ridges and river courses. Different altitude, aspect and slope gradient adds to the list of common variables cited, such as soil structure, water and nutrient availability and light intensity. As far as possible, the transects were kept homogenous by avoiding ridges, steep slopes, valley bottoms and large glades within each grid square, by choosing area of roughly the same altitude, and by selecting for areas of forest which looked similar in terms of overall structure (Greig-Smith, 1982). It may be argued that the selection of areas which look similar would bias the results towards showing no difference between grazed and ungrazed sites. However, if the long term presence of cattle in the area is having an effect, it should be evident from the data. Altitude was recorded for each transect and used in multivariate analysis of the data.

The transects were each 500m in length which ensured a total of 20 points along each transect, the number recommended for the PCQ method in forest vegetation (Mueller-Dombois & Ellenberg, 1974). For each transect, therefore, measurements were taken for 80 trees except for once, where this would have meant recording the same tree twice (i.e. from the previous point). Given the varied topography of the area, the transects were laid out in a zigzag pattern: 150m south, 50m west, 150m north, 50m west and 100m south (Figure 4-2). Straight transects, would have made it impossible to avoid the transect following ridges or valley bottoms or crossing glades, which would have increased the variance within each transect considerably.

The transect layout is shown below in Figure 4-2.

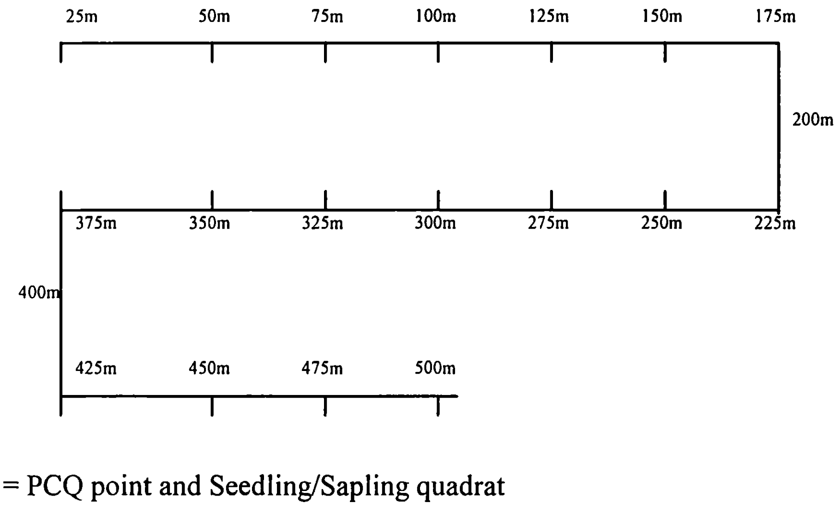



**Figure 4-2** Transect layout for PCQ and seedling plot surveys

### *4.4.1.3 The sample*

As a rule, the greater the size of the sample, the better the representation of the population as a whole (Goldsmith *et al.* 1986). A total of 23 transects were sampled, ten in areas of moderate cattle grazing, 10 in areas of no cattle grazing and three close to the forest edge where cattle pressure is highest. A total of 800 trees were counted for the ungrazed transects; 799 in the moderately grazed transects; and 240 trees in the heavily grazed forest edge transects. The area covered by the transects totalled 4.26ha, 2.25 in ungrazed areas and 2.01 in the grazed areas. World Bank (1991) recommends sampling of a forest area to cover at least 0.5% of the total area as an ideal. The areas described above represent approximately 1% of the total area of Saanata.

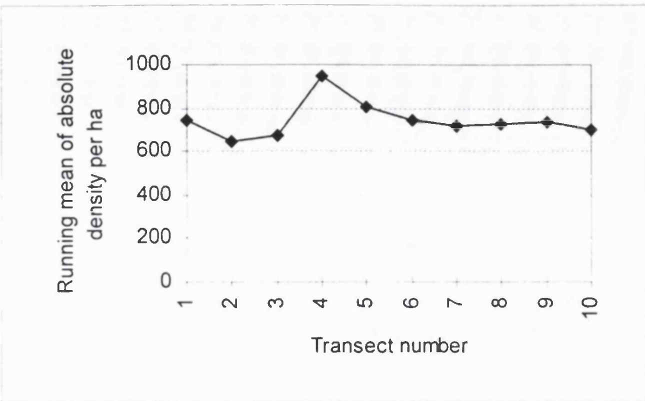
However, the final sample size should also depend on the variability between samples. The parameters under study included species diversity and plant density. The running means for the absolute density by transect were plotted for each set of transects representing the three different grazing indices shown in Figure 4-3 to test the adequacy of the sample size (Goldsmith *et al.*, 1986). In the moderately grazed and ungrazed transects the oscillations in density are considerably reduced after 10 transects suggesting that the ten transects within each grazing strata were sufficient. The three transects at the forest edge show little variation, although a sample size of three is very low. Given the great differences in micro-climate at the forest edge, it would not be possible to attribute any differences in vegetation to grazing pressures. These transects, therefore, were surveyed to give an impression of the vegetation at the forest edge where grazing pressures were highest. Given the limited conclusions relating to forest grazing that could be drawn from these data, it was decided to limit the time and resources spent surveying the area.

Only 18 tree 'species' were recorded in the local vernacular in the course of the PCQ surveys (reflecting the low species diversity associated with dry montane forests (Langdale-Brown *et al.*, 1974). The species were identified using their vernacular names which may have resulted in an underestimate of species diversity. On five occasions, two botanical species were given the same name in the vernacular, and the 18 local 'species' could relate to 23 botanical species. The species encountered are given in Table 4.2.

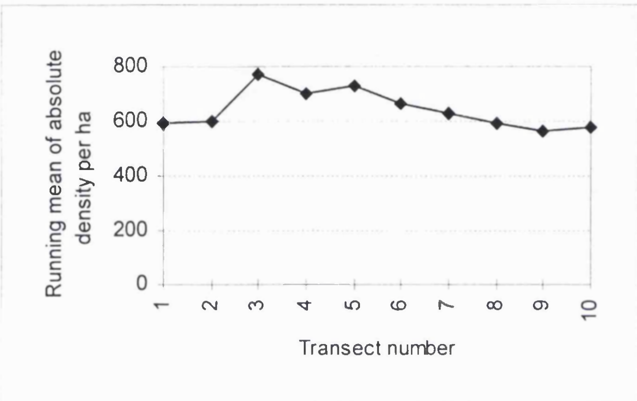
**Table 4.2** Species recorded in PCQ surveys[a]

| **Species - vernacular** | **Species - botanical** | **Species - vernacular** | **Species - botanical** |
|---|---|---|---|
| Misigiyoi | *Rhus natalensis* | Lpiripirinti | *Podocarpus gracilior* |
| Sagomai | *Maytenus heterophylla* | Lgilai | *Teclea nobilis* |
| Lngeriyoi | *Olea europeana ssp africana* | Ltarakwai | *Juniperus procera* |
| Moror | *Dovyalis abyssinica* | Mashakudu | *Cassipourea malosana* |
| Saramonai | *Maytenus undata* | Sanaguri | *Scutia myrtina* |
| Musungash | *Nuxia congesta,* ***or*** *Buddleia polystachya* | Songoroi | *Ekbergia capensis* ***or*** *Lepidotrichilia volkensii* |
| Kinyil | *Rhamnus prunoides* | Lgumi | *Canthium lactescens* ***or*** *Vangueria infausta* |
| Matassia | *Clausena anisata* | Loliontoi | *Olea capensis* ***or*** *Chionanthus mildenraedii* |
| Nkinatei | *Schefflera volkensii* ***or*** *Schefflera abyssinica* | Lkukut | *Xymalos monospora* |

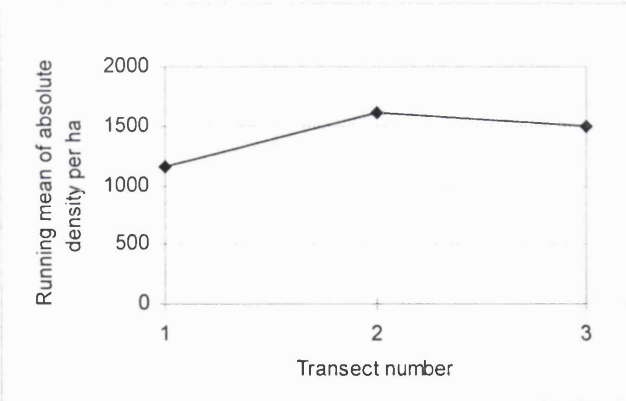
[a] two or more species are given where one vernacular name was applied to two or more botanical species.




Moderately grazed transects




Un-grazed transects




Forest edge transects

**Figure 4-3** Graphs showing running mean of absolute density per hectare for each graze strata.

### 4.4.2 Methods - Seedling growth and survival and herbaceous cover

Two transects at Saanata (described in chapter 2 and chapter 5) were used to site a series of exclosure plots and paired open plots to establish the effects of large herbivores on herbaceous cover and tree seedling growth and survival[2]. The transects (Lorubai and Sordon) were situated within areas of forest subject to moderate and negligible cattle grazing respectively. The faecal count surveys (described in chapter 5) confirmed the difference in grazing pressure.

Exclosures are not ideal: patterns of growth of ungrazed vegetation may be different from that of grazed vegetation; and (when considering production only) damage and death may be disproportionately higher outside the plot due to trampling by the researchers themselves.

The exclosure plots, 5m x 5m, were built in September 1993 at a distance of 25m perpendicular to the transects to avoid the effects of our trampling along the transects themselves. Eight plots were built at Lorubai and 6 at Sordon made from cedar posts and three layers of barbed wire. Next to each plot, a minimum of 3m away to allow for avoidance behaviour caused by the presence of the plots, another 4m x 4m open plot was marked out using small wooden posts.

Unfortunately, as the drought became more severe at the end of 1993 the plots were repeatedly broken into by wild animals. Buffalo and elephant were usually the problem (although on one occasion, eland and lion hair was found in the barbed wire, suggesting the plots had been damaged during high speed pursuit). In April 1994, the plots were rebuilt and reinforced with stronger posts, another layer of barbed wire and rafters (small sticks and cedar splinters threaded through the wire). From that date only one exclosure plot was found to be broken. All damage and any evidence of

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[2] Exclosure plots were also built in the forest at Lpartuk, where small stock were observed in the forest outside the reserve. Unfortunately, these plots had to be abandoned after hunters repeatedly stole the barbed wire to make snares. Despite discussions with the chief and elders, the plots were continually tampered with and eventually it was decided to dismantle the plots to avoid an unnecessary increase in poaching. This was not seen as a major loss: since the results of the pilot surveys showed considerable levels of human disturbance in all the Lpartuk transects, the conclusions that could have been drawn regarding the causes of any differences inside and outside the plots would have been severely limited.

animals entering the plots were recorded by a local assistant who visited all the plots each week throughout the course of the study.

The plots were surveyed at the initial establishment in September 1993, and then in April 1994, August 1994, October 1994, and January 1995. The initial measurements taken, however, had to be discarded due to the repeated damaging described above.

All tree seedlings inside the plots, more than 0.5m from the edge in the case of the exclosures and less than 2.5m in height, were identified, mapped and measured, taking their height from the ground to the apical meristem (later they were numbered with plastic tags). Seedlings were identified by their local names. It is not possible to establish the error associated with correctly identifying individual species, but it has been assumed such error would be equivalent for both sets of transects.. From April 1994 ground cover in the herbaceous layer was estimated using a simple point sampling method: Cover (herb, grass, seedling or litter) was recorded at a point every 20cm along a tape measure laid across the plots twice in the same orientation roughly two metres apart. The height of the cover at each point was measured to the nearest 5cm using a gradated stick. A 0.5m. strip within the fence of the exclosures was excluded from the surveys to avoid any edge effects (Goldsmith *et al.*, 1986).

The seedlings in the exclosure plots were initially mapped with the intention of re-identifying individual seedlings without any bias associated with using tags (such as avoidance behaviour by animals). It proved difficult, however to accurately re-identify seedlings, particularly where the herb layer was relatively thick and many more seedlings were identified in the last survey following the rainy season. This was probably due to leaves on the seedlings making them easier to see and to identify. These problems made it very difficult to make viable comparisons of seedling growth and survival.

The plots were established to determine whether there were any differences in seedling growth and survival in an area of high cattle grazing intensity and an area of low cattle but high wildlife grazing intensity. Depending on variations in rainfall, the cattle "usually" enter the forest for fodder and water at the height of the dry season, from December, and remain using the forest until the beginning of the rains in March or April. During the period of this study, the cattle entered the forest unusually early in August 1993 due to a prolonged drought, left at the beginning of April 1994 and had not returned by the end of January 1995 due to exceptionally good rainfall in 1994. The absence of cattle grazing inside the forest throughout the entire period the plots were monitored would make it impossible to infer any conclusions on the impacts of cattle grazing from the exclosure plots.

For this reason, together with the problems described in re-identifying the seedlings, the seedling growth data have been discarded. The seedlings were tagged in January 1995 for future monitoring.

Data on vegetation cover in the herbaceous layer, however, would give an idea as to the build up of biomass with no cattle grazing and are therefore analysed below.

## 4.5 Data analysis

### 4.5.1 Tree Density

The distance measurements were used to establish absolute density of all species combined and the density of individual plant species (Mueller-Dombois & Ellenberg, 1974). Distance from the point to the plant centre was initially calculated as the sum of the radius (calculated from the girth measurement) and the distance to the trunk.

The absolute density for all species, *D*, may be calculated from these distance measures as described in Box 4-2 (Mueller-Dombois & Ellenberg, 1974 pp113-114).

> **Box 4-2 Calculating density from distance measures**
>
> Mean distance ($\bar{d}$) for each transect = $\frac{\sum d}{n}$
>
> where $d$ = distance to the centre of an individual tree,
>
> $n$= number of trees of all species
>
> Absolute density, ($D$) = $\frac{Area}{\bar{d}^2}$
>
> E.g. where distance measures are in metres, absolute density/ha = $\frac{10000}{\bar{d}^2}$
>
> The density ($D_a$) for an individual tree species "a" can also be calculated:
>
> $$D_a = \frac{\text{Number of species"a"}}{n} \times \text{Absolute density}$$

These estimates of density are useful for description, but cannot readily be statistically compared (Greig-Smith, 1982) in the absence of any measure of variance. For statistical comparison between transects within the same strata, the distance data were used. For comparison between strata, mean values for the transects were used to avoid pseudo replication which tends to increase the likelihood of rejecting a null hypothesis incorrectly by over-inflating the sample size (Crawley, 1993).

The density data for individual species were used in direct ordination to establish patterns of species density across the 23 transects.

### 4.5.2 Seedling density

Seedling density was calculated per hectare for each transect (by multiplying the number counted within each plot by 125 (10,000/(4x20)) and the averages for all transects compared across the three blocks, for all species combined and individually, using a simple analysis of variance (using SPSS 6.1, Norusis, 1994) and multivariate ordination techniques.

### 4.5.3 Stand structure

For the analysis of the stand structure, the number of individuals within defined basal diameter size classes (each class had a width of 5cm) was calculated per hectare for each transect using equation 5 shown above. These calculations were made for individual species and for all species combined.

The efficiency of the power function model (Box 4-1 above), to describe the relationship between density (the independent variable) and the mean of each size class linearly was tested by regressing log density against the log of the mean of each size class. Linear relationships within different populations can be compared using analysis of covariance. Given a linear relationship, it was possible to compare the stand structure within the three grazing strata statistically by analysis of covariance using GLIM4 (Crawley, 1993, see appendix four).

### 4.5.4 Species diversity

#### *4.5.4.1 Diversity indices*

The above measures all describe the physical attributes of the forest in the different strata without taking differences in species diversity into account.

A number of indices have been developed which encapsulate species diversity data in one parameter. These are by definition simplistic but can provide a rapid means of comparison (Magurran, 1988). The three indices used in this study are the Sorensen coefficient of similarity, the Shannon-Wiener index and Pielous's J.

**The Sorensen coefficient of similarity ($S_s$)** is used to determine the degree to which the species composition of the transects is alike. This looks only at the presence/absence of species and gives no weight to relative density or dominance. Species diversity was probably underestimated since a number of vernacular names included more than one species. The formula for the Sorensen coefficient of similarity ($S_s$) is shown in Box 4-3.

**Box 4-3 Calculating the Sorensen coefficient of similarity ($S_s$)**

$$S_s = \frac{2a}{(b+c)} \times 100$$

where $a$ = number of species common to both samples

$b$ = number of species in sample 1

$c$ = number of species in sample 2

The greater the similarity the closer $S_s$ is to 100

When $S_s = 0$ there is zero similarity.

A direct count of species provides a simple and objective measure of species richness, however it is highly dependent on the sample size (Peet, 1974) and does not take heterogeneity into account. **The Shannon-Wiener index** is used to express the diversity of a transect in a single parameter, combining species richness (the number of species) with relative abundance or equitability (Magurran, 1988; Kent & Coker, 1993; Greig-Smith, 1983; Peet, 1974). The index measures the "average degree of uncertainty of predicting the species of a given individual picked at random from a community" (Hair, 1980). There are other indices of diversity, however, the Shannon-Wiener index is most sensitive to differences in the rarest species and therefore considered most suitable for this study (Peet, 1974).

Equitability defines the evenness with which individuals are divided among the species present (Hair 1980). This may be measured from the Shannon diversity index using **Pielous's J**. The formula for the Shannon diversity index and Pielou's J is shown in Box 4-4.

**Box 4-4 Calculating the Shannon diversity index (H′) and Pielou's J**

$$\text{Diversity } H' = -\sum_{i-1}^{s} p_i \ln p_i$$

where s = the number of species

$p_i$ = the proportion of the total number of individuals consisting of the ith species from the sampled population

ln = log $\text{base}_e$

$$\text{Pielou's } J = \frac{H'}{H\max} = \frac{-\sum_{i-1}^{s} p_i \ln p_i}{\ln s}$$

Where J = 1, i.e. where H' = ln s, the individuals in each sample are evenly spread between the species.

Bias is introduced in the estimation of $p_i$ , if all the species in the community are not included in the sample. In an ecological situation, this is impossible to avoid but this error will be small (Peet 1974) and a larger sample size helps insure the discrepancy is negligible.

#### *4.5.4.2 Multi-variate analysis of diversity*

Multivariate ordination techniques allow a more complex analysis of diversity. Ordination techniques can identify patterns of variation in vegetation parameters between sites or transects. The ordination techniques used for this analysis were: TWINSPAN, two-way indicator species analysis (Hill, 1979), a divisive polythetic ordination; and Redundancy analysis (RDA), a direct linear ordination. The strength of both techniques lies in their ability to analyse data on all species collectively (ter Braak & Looman, 1995). TWINSPAN is an exploratory technique which creates hierarchical groups of species and sites based on similarities or dissimilarities in the vegetation parameter under study. RDA is a direct ordination technique which uses environmental data to arrange the vegetation data (Kent & Coker, 1992). The efficacy of the environmental variables in defining pattern in the vegetation data can be tested statistically using Monte Carlo Permutation testing. TWINSPAN is a computer programme in itself. RDA and Monte Carlo Permutation tests were carried out using the computer programme CANOCO (ter Braak, 1995). Both types of analysis are described briefly below.

The two environmental variables used in the study were the mean altitude of the transects and a dummy variable for grazing or no grazing. Transects were identified as ungrazed, moderately grazed and forest edge. In the TWINSPAN analysis the site classification dendrograms were interpreted on the basis of whether the groups of sites identified by TWINSPAN in any way matched this classification of sites by grazing. In the RDA analysis, Monte Carlo permutation testing was used to identify whether altitude and/or grazing significantly reduced the observed variation in the different vegetation parameters.

The vegetation parameters analysed using these techniques were: density of species and density of seedlings (calculated as described above in equation 5 and Section 4.5.2) and species importance values. These importance values combine relative basal area, density and frequency for each species into one measure (Mueller-Dombois & Ellenberg, 1974) and are described in more detail below, followed by a brief description of the ordination techniques.

**Importance Values**

Relative basal area, density and frequency within each transect can be combined for each species to produce an "importance value", I.V. (Mueller-Dombois & Ellenberg, 1974) defined as the sum of the relative density, relative frequency and relative dominance. Since relative parameters are used, this I.V. gives no indication of plant biomass or cover. However, the combination of the three parameters emphasises slight differences between stands of otherwise similar species composition (Mueller & Dombois, 1974: 118). Calculation of the relative density, frequency and basal area and of the importance value itself is described in Box 4-5.

**Box 4-5 Calculating the Importance values (I.V.) for species "*a*"**

Importance Value $(I.V.)_a$ = Relative $density_a$ + relative $dominance_a$ + relative $frequency_a$

Where:

$$\text{Relative density of species } a = \frac{\text{Number of individuals of species } a}{\text{total no of individuals}} \times 100;$$

$$\text{Relative dominance of species } a = \frac{\text{Dominance of species } a}{\text{Dominance of all species}} \times 100;$$

$$(\text{Dominance of species } a = \text{mean basal area of } a \times \text{absolute density of } a);$$

and

$$\text{Relative frequency of species } a = \frac{\text{frequency of species } a}{\text{sum frequency of all species}} \times 100$$

$$(\text{frequency of species } a = \frac{\text{no of points with species } a}{\text{total no of points}} \times 100)$$

**TWINSPAN**

**TWINSPAN** was used to provide an initial classification of transects and species based on both the importance value data and species density data, (the latter for both seedlings and trees).

TWINSPAN is a divisive polythetic method which uses species data to produce a two way classification: a site classification where groups are defined on the basis of similar species composition; and a species classification where species which are found together are put into the same class. The vegetation data is redefined as pseudospecies, which are presence-absence variables based on subjectively predefined levels of the vegetation parameter under study (ter Braak & Looman 1995). TWINSPAN divides the transects and species into groups according to the presence or absence of these pseudospecies. Pseudospecies are non-exclusive and cumulative. For example, in this study the cut levels for the species density data were set at 0, 15, 32, 69 and 110. In a transect where *Podocarpus gracilior* had a density of 300 individuals per hectare, all five pseudospecies would be present; in a transect where the density was 62 individuals per hectare, only the first three pseudospecies would be present.

The values at which the cut levels are set depends on the distribution of the data. Given the different types of data to be analysed by TWINSPAN, for this study (seedling density, tree density and species importance values), percentiles were used to divide the data into five equally weighted pseudospecies, with an equal proportion of data points within each pseudo species (20%). Detailed descriptions of the process are provided in Hill (1979) and Kent and Coker (1992).

The output of a TWINSPAN analysis is a two-way table which sorts transects and species into groups based on presence or absence of pseudospecies. This can be presented as two dendrograms showing the hierarchical division of the transects and species into groups:

1. Sites that are similar in terms of species diversity and abundance will be grouped together. At each division, the similarity between the groups become greater, but the significance of the division becomes less. Thus, the first division is the most significant in terms of transect similarity. The indicator pseudo-species that form(s) the basis for a particular split is given in the output for the TWINSPAN analysis. In deciding on the number of divisions that are valid, the data in the table can be examined subjectively to see whether a split is justified on the basis of the indicator species given, or seems to produce a spurious sub-group.

   If browsing by cattle was having a significant effect on species diversity and abundance, the TWINSPAN analysis should sort the transects into groups of similar grazing intensity.

2. Species that occur together at similar levels of abundance can also be grouped hierarchically from the TWINSPAN table. Again, if browsing was having a considerable effect on species diversity and abundance, the TWINSPAN

dendrogram might sort the species according to whether a species tended to be browsed or not.

Comparing a TWINSPAN analysis of tree data and seedling data may also show whether cattle grazing is having a differential impact on species recruitment, although different life strategies of species will also affect recruitment of particular species to the mature phase.

**Redundancy analysis**

Redundancy analysis (RDA) is a type of *ordination,* "the collective term for multivariate techniques that arrange sites along axes on the basis of data on species composition" and *vice versa* (ter Braak, 1995 p.91). RDA is a direct ordination technique, whereby species data are arranged along a series of axes according to variation in abundance across different sites. The axes of a direct ordination are "the linear combination of environmental variables that gives the smallest total residual sum of squares" (ter Braak, 1995 p.144). The degree to which the species axes correlate with each environmental variable defines the importance of each environmental variable along that axis.

The advantage of a direct ordination is that the results can be tested statistically using a Monte Carlo Permutation test. This technique determines the probability of finding the same relationship between species and environmental data as found during the RDA in a fixed number of random permutations of the data set. If a better relationship can be described with a random permutation of the data, the relationship described by the RDA is not significant.

This study uses partial RDA to test for relationships which are independent of co-variables. The two environmental variables examined are grazing index and altitude. Partial RDA can test the importance of grazing on species diversity, taking the effects of altitude into account and *vice versa.*

### 4.5.5 Evidence of browsing of seedlings and other damage

Tree species browsed by cattle were monitored during the cattle follows described in the previous chapter. Any evidence of browse or other damage to seedlings or trees were recorded in the course of the PCQ and seedling surveys. Frequency of browse or other damage by species was compared across the three grazing strata.

### 4.5.6 Herbaceous cover

The proportion and height of herbaceous cover was compared across the three strata, inside and outside the plots for the different survey months.

## *4.6 Results: Tree density, stand structure and species composition*

### 4.6.1 Tree Density

Absolute density and relative density of the different tree species were calculated as described above and the results are summarised for the three grazing indices in Table 4.3 below.

Analysis of variance of the distance measures between transects within each of the grazing strata showed significant differences in all three cases (grazed: $\chi^2$= 93, d.f. = 9, P<0.05; ungrazed: $\chi^2$= 71, d.f. = 9, P<0.05; forest edge: $\chi^2$= 6.7, d.f. = 2, P = 0.03; all values corrected for ties) suggesting considerable variation within each forest "type".

Analysis of covariance was used to establish the importance of grazing index and altitude in determining tree density. The original plant to point distance measures were used for this analysis. Given the variation across transects and to avoid pseudo replication, the analysis was carried out on the mean distances for the 23 transects. This also had the advantage that the means were normally distributed, allowing the use of more powerful parametric tests.

A positive correlation was found between plant to point distance and altitude ($F_{1,19}$ = 12.45, P<0.01, $r^2$ = 0.35). However, taking this correlation into account, mean distance in the forest edge transects were still significantly smaller than mean distance for either the moderately grazed or the forest edge (heavily grazed) transects (t = 2.39 and 2.517 respectively, df = 11, P<0.05 in both cases). There was no significant difference between the moderately grazed and ungrazed transects (t = 0.304, 18 d.f.).

**Table 4.3** Summary of results of PCQ distance data

| | Number of cases | Mean Distance(m) | s.e. across transects | Mean density ($ha^{-1}$) |
|---|---|---|---|---|
| **Moderately grazed** | 10 | 4.13 | 0.910 | 703 |
| **Ungrazed** | 10 | 4.43 | 1.02 | 576 |
| **Forest edge** | 3 | 2.65 | 0.39 | 1500 |

### 4.6.2 Tree damage

Incidences of damage were recorded for each tree. Where there was a clear cut from a panga or axe, the damage could be attributed to humans. In cases where a branch had been broken or in cases of debarking it was often impossible to tell the cause, although sometimes it was clear that elephants had caused the damage.

The percent incidence of damage is summarised for each grazing strata in Table 4.4.

**Table 4.4** Mean percent incidence of damage by grazing strata

| Graze index/ Damage type | Ungrazed | Moderately grazed | Forest edge | Overall average |
|---|---|---|---|---|
| **No damage** | 40.48% | 40.68% | 47.08% | 41.43% |
| **Human** | 0.00% | 2.13% | 3.75% | 1.42% |
| **Branch damage** | 23.06% | 27.28% | 28.33% | 25.59% |
| **Trampled** | 2.76% | 2.88% | 0.42% | 2.50% |
| **Browsed** | 5.26% | 4.01% | 2.92% | 4.41% |
| **Debarked** | 18.67% | 17.40% | 10.83% | 17.09% |
| **Coppiced** | 4.01% | 3.63% | 3.33% | 3.76% |
| **No known cause** | 5.76% | 1.88% | 3.34% | 3.75% |
| **Fire** | 0.00% | 0.13% | 0.00% | 0.05% |
| **Grand Total** | 100.00% | 100.00% | 100.00% | 100.00% |

### 4.6.3 Seedling density

The results of the seedling surveys carried out along the same transects used for the PCQ surveys are summarised in Table 4.5 below. The mean seedling density was slightly higher in the ungrazed transects than in the moderately grazed transects. However, the variance in both cases was very high and the difference was not significant. The very high seedling density in the forest edge transects was, perhaps not surprising, given the favourable micro-climate. Seedling density at the forest edge was significantly higher than in the other two grazing strata (L.S.D. test, $F_{2,20} = 4.68$, $P<0.05$).

**Table 4.5** Results of the seedling surveys for the ungrazed and moderately grazed transects

| Graze index | Number of cases | Mean | s.e |
|---|---|---|---|
| **Ungrazed** | 10 | 4,138 | 2,947 |
| **Moderately grazed** | 10 | 3,650 | 3,836 |
| **Forest edge** | 3 | 10,250 | 2,939 |

### 4.6.4 Seedling damage

Sixty five percent of seedlings counted were completely undamaged, 31% were browsed and less than 3% were trampled or damaged in any other way. Table 4.6 below summarises density and browse damage for each species by grazing strata. Evidence of browsing was found for eleven out of the sixteen 'species'.

The overall proportion of seedlings grazed was higher in the moderately grazed and the forest edge transects (both 41%) than in the ungrazed transects (25%)

**Table 4.6** Seedling density by species and grazing strata showing per cent incidences of browsing.

| Graze strata | Ungrazed | | Mod grazed | | Edge | |
|---|---|---|---|---|---|---|
| **Species** | **Mean Density ($ha^{-1}$)** | **% grazed** | **Mean Density ($ha^{-1}$)** | **% grazed** | **Mean Density ($ha^{-1}$)** | **% grazed** |
| ***Rhus natalensis*** | 0 | | 250 | 50% | 813 | 24% |
| ***Maytenus heterophylla*** | 0 | | 500 | 61% | 3084 | 69% |
| ***Olea europeana* ssp *africana*** | 500 | 0% | 175 | 50% | 563 | 58% |
| ***Dovyalis abyssinica*** | 188 | 100% | 125 | 33% | 250 | 50% |
| ***Maytenus undata*** | 250 | 19% | 281 | 73% | 125 | 0% |
| ***Nuxia congesta, or Buddleia polystachya*** | 1805 | 54% | 1844 | 71% | 2291 | 63% |
| ***Rhamnus prunoides*** | 500 | 4% | 219 | 25% | 291 | 47% |
| ***Clausena anisata*** | 1312 | 2% | 598 | 6% | 1000 | 2% |
| ***Podocarpus gracilior*** | 204 | 0% | 550 | 0% | 1125 | 0% |
| ***Teclea nobilis*** | 396 | 0% | 400 | 0% | 750 | 9% |
| ***Juniperus procera*** | 0 | | 125 | 0% | 188 | 0% |
| ***Cassipourea malosana*** | 563 | 9% | 396 | 15% | 375 | 0% |
| ***Ekbergia capensis*** | 125 | 0% | 0 | | 0 | |
| ***Canthium lactescens or Vangueria infausta*** | 0 | | 125 | 100% | 0 | |
| ***Olea capensis*** | 334 | 75% | 334 | 42% | 375 | 33% |
| ***Xymalos monospora*** | 0 | | 125 | 0% | 0 | |
| **Total seedlings (all species)** | 6177 | 25% | 6047 | 41% | 11230 | 41% |

### 4.6.5 Stand Structure

The density of trees within 5cm diameter size classes were calculated for each transect by multiplying the proportion of trees found within each size class by the absolute density for each transect (shown in section 4.5.1 above). The mean density data for the ten transects within each of the ungrazed and the moderately grazed areas and the three edge transects are plotted against size class in Figure 4-4.

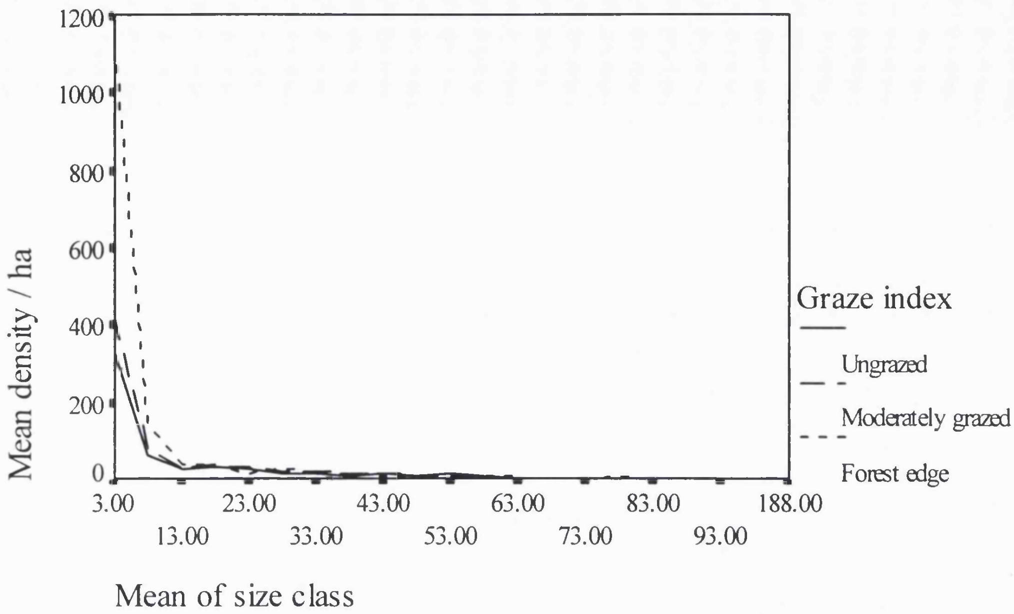


**Figure 4-4** Graph showing mean population structure for the three grazing strata

The results of the linear regression for the power function model using the mean density by size class data from each transect within the three different grazing areas and overall are shown below in Table 4.7 (all regressions were significant $P<0.001$).

**Table 4.7** Linear regression analysis on PCQ species data.

| Transects | power function | N | $r^2$ |
|---|---|---|---|
| **Moderate grazing** | $\log_e$ size = 6.46 - 1.03 $\log_e$ density | 112 | 0.64 |
| **No grazing** | $\log_e$ size = 6.10 - 0.97 $\log_e$ density | 130 | 0.63 |
| **Forest edge** | $\log_e$ size = 7.54 - 1.22 $\log_e$ density | 34 | 0.73 |
| **Combined (all transects)** | $\log_e$ size = 6.48 - 1.04 $\log_e$ density | 266 | 0.64 |

Using log transformed data tends to reduce the error variance, which can increase the likelihood of rejecting a null hypothesis incorrectly. Having established the goodness of fit of the power function model, the data were analysed in GLIM4 using the logarithmic link function which takes the log values of the y variable (in this case density) when calculating the linear equation without losing the original error structure, thereby allowing the assumption of additive errors to be met (Crawley 1993).

The results of the GLIM4 analysis are summarised in Table 4.8 and Table 4.9[3]. Analysis of covariance for density found a significant relationship with $\log_e$(size) ($\chi2 = 4404$, 1df, P<0.001, % explained variance = 82%) and grazing intensity ($\chi2 = 185.8$, 2df, P<0.001, % explained variance = 3.4%). There was also a significant interaction effect between the two ($\log_e$(size) and grazing intensity) ($\chi2 = 61.58$, 2df, P<0.001, % explained variance =1.1%). Finally, transect ID also significantly improved the fit of the model reflecting the considerable variation between transects of the same grazing strata ($\chi2 = 263$, df=20, P<0.001, % explained variance = 5%).

In summary, there was no significant difference in the slope of $\log_e$(density) against $\log_e$(size) in the moderately grazed areas and in the ungrazed area, but there was a significant difference in intercept, with the density of small trees in the moderately grazed transects significantly higher than that in the ungrazed transects (P<0.05). The slope of $\log_e$(density) against $\log_e$(size) in the forest edge transects was significantly steeper than those for the ungrazed transects (P<0.01) and for the moderately grazed transects (P<0.01), The intercept was also significantly greater in both cases (edge & ungrazed: P<0.01; edge and moderately grazed: P<0.01).

**Table 4.8** Results of GLIM4 analysis showing power function equations and intercept values in areas of different grazing intensity (where the intercept represents the hypothetical population of tree seedlings with basal diameter of zero cm)

| Graze index | Power function | Untransformed intercept |
|---|---|---|
| **Ungrazed** | $\log_e$ density = 7.25 - 1.37 $\log_e$ size | 1408 |
| **Moderately grazed** | $\log_e$ density = 7.62 - 1.46 $\log_e$ size | 2039 |
| **Forest edge** | $\log_e$ density = 9.18 - 1.95 $\log_e$ size | 9701 |

[3] The data showed some overdispersion (where variance is greater than the number of degrees of freedom) so the variance was scaled to avoid rejecting the null hypotheses incorrectly (Crawley, 1993).

**Table 4.9** Results of GLIM4 analysis showing significant differences in mortality and the hypothetical population of tree seedlings with basal diameter of zero cm between transects in areas of different grazing intensity

| | **Mortality rate** | | | **Hypothetical population of tree seedlings with basal diameter of zero cm** | | |
|---|---|---|---|---|---|---|
| **Graze index** | **Ungrazed** | **Mod grazed** | **Edge** | **Ungrazed** | **Mod. grazed** | **Edge** |
| **Ungrazed** | - | n.s. | t = 10.17<br>df = 11<br>P<0.01 | - | t = 2.25<br>df = 18<br>P<0.05 | t = 5.58<br>df = 11<br>P<0.01 |
| **Moderately grazed** | - | - | t = 8.58<br>df = 11<br>P<0.01 | - | - | t = 4.79<br>df = 11<br>P<0.01 |
| **Forest Edge** | - | - | - | - | - | - |

These results clearly show a higher density of tree seedlings in areas of higher cattle grazing intensity. It is interesting to note that the intercept values for all three grazing strata from the regression are lower than the seedling densities estimated from the 2m x 2m plots from each of the grazing strata shown in Table 4.5. However, in all cases the intercept values from the regression fall within the 95% confidence limits of the plot estimates. It is not possible to tell from these results whether there is a difference in density of mature trees.

The mean density within three broad size classes were calculated for each transect and compared between the different strata by analysis of variance using a Poisson link function in GLIM4. The size classes were chosen to reflect three stages in the population curve shown in Figure 4-4: young, small trees (0 - 10cm basal diameter) subject to high mortality (defined by the steep slope at the start of the curve); trees entering the recruitment phase (10 - 30cm basal diameter), subject to lower mortality rates (where the rate of change starts to decline at the bend of the curve); and mature trees (>30cm basal diameter) with lower and more stable mortality rates (where the curve flattens). The results are summarised below in Table 4.10.

**Table 4.10** Mean density per hectare for broad size classes in the three grazing strata

| Density per hectare | Diameter size class | | |
|---|---|---|---|
| **Grazing strata** | **0-10cm** | **10-30cm** | **30-100cm** |
| **Ungrazed** | 194.0 | 25.6 | 5.7 |
| **Moderately grazed** | 250.4 | 29.3 | 5.7 |
| **Forest edge** | 653.8 | 29.5 | 5.0 |

Density in the largest size classes is slightly lower in the forest edge transects and almost identical in the ungrazed and moderately grazed transects. However, there is no significant difference between the three ($\chi 2$ = 0.259, 2df). Likewise, there is no significant difference between the three transects in the 10cm-30cm diameter size classes, although the grazed transects did have slightly higher densities than the ungrazed transects. There was, however a significant difference in density of the smallest size classes across the three strata ($\chi 2$ = 9.362, 2df, $P<0.01$). In this smallest size class: there was no significant difference between the ungrazed and the moderately grazed transects; the forest edge transects had significantly higher densities than both the moderately grazed transects ($t = 2.633$, 11df, $P<0.05$) and the ungrazed transects ($t = 3.14$, 11df, $P<0.01$)

The overall densities may be divided into browsed and unbrowsed species using the results of the seedling transects shown in Table 4.6. The results are summarised for the three grazing strata below in Figure 4-5, Figure 4-6 and Figure 4-7.

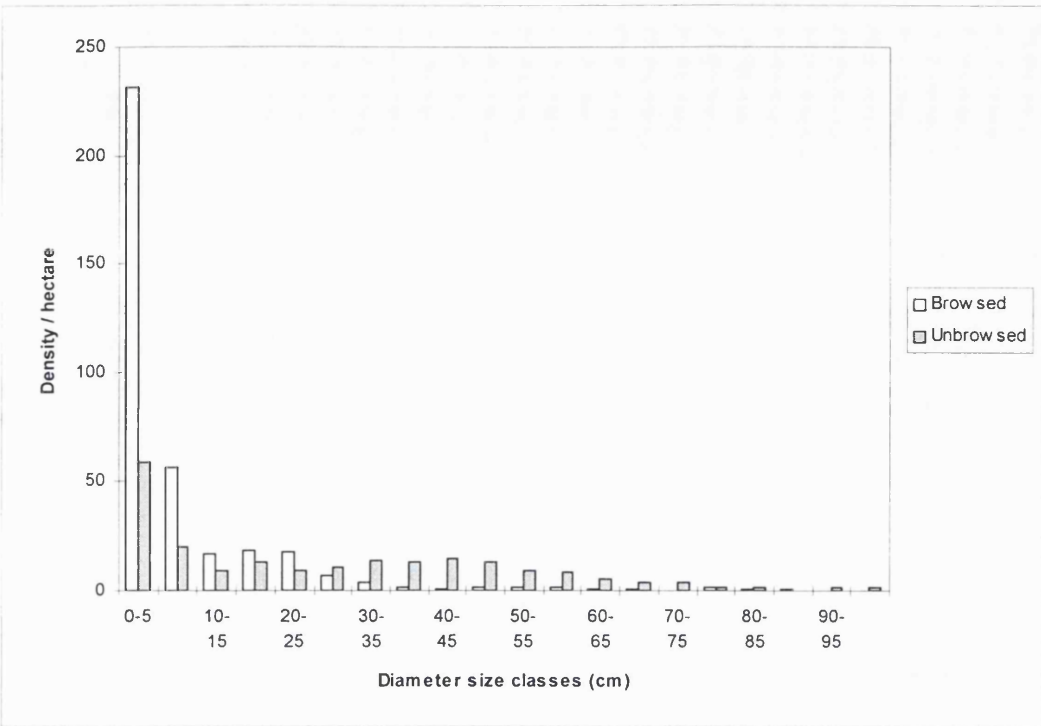


**Figure 4-5** Density by diameter size classes for browsed and unbrowsed species - ungrazed transects

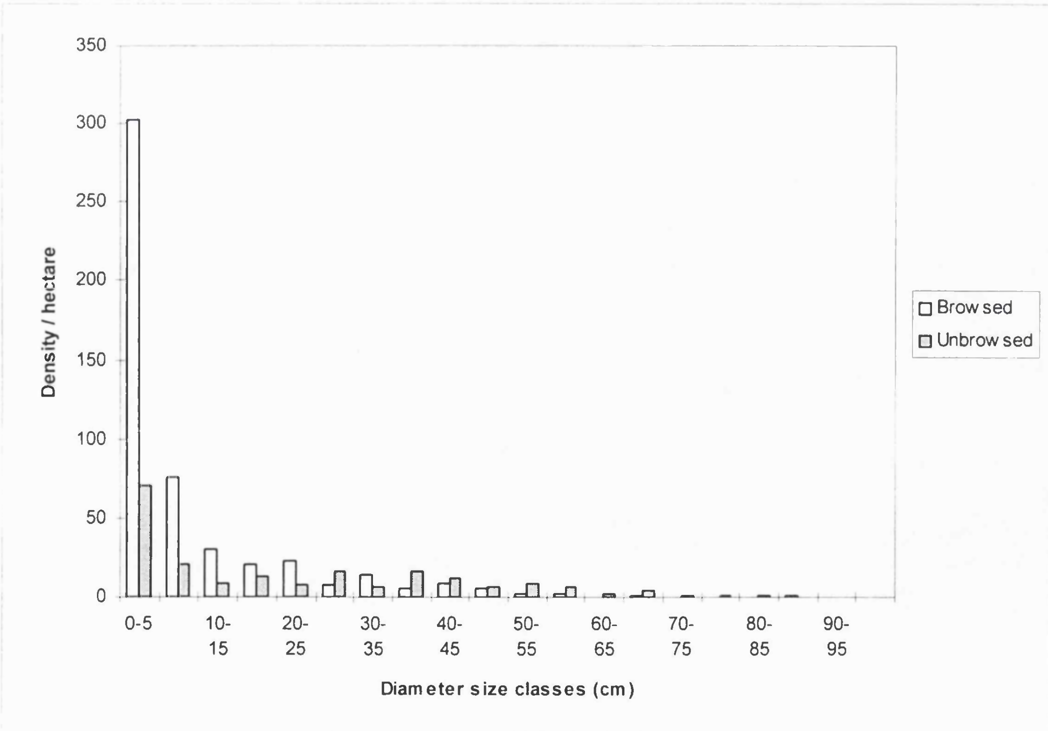


**Figure 4-6** Density by diameter size classes for browsed and unbrowsed species - moderately grazed transects

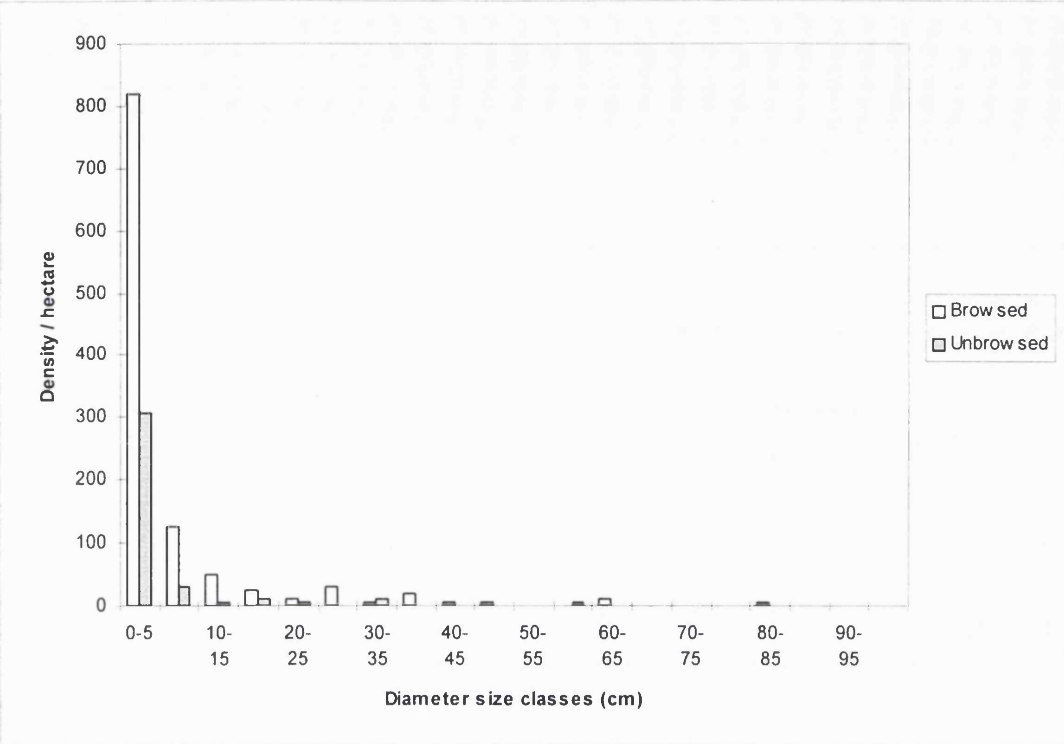


**Figure 4-7** Density by diameter size classes for browsed and unbrowsed species - Forest edge transects

These figures suggest that browsed species are present with a greater density in the smaller size classes in all three grazing strata. In both the moderately grazed and the ungrazed transects, the frequency of browsed species becomes lower than that of the unbrowsed species as the size classes increase. The impacts of grazing on species diversity is analysed statistically using multivariate statistics in the following section.

In summary, the data from the PCQ transects show no evidence that cattle grazing is associated with forest senescence for the full data set with all species combined. Seedling densities are higher in areas of highest cattle grazing, although for the forest edge data this could be explained by edge effect, comprising many other factors (light intensity, fire, microclimate, etc.) as opposed to cattle impacts alone. Comparison of the population structure overall supports these results with much higher densities of smaller trees at the forest edge and to a lesser extent in areas of moderate grazing pressure. (An association of higher grazing intensity with higher seedling densities can equally be explained in terms of the cattle actively selecting such areas, although, again, the absence of difference between moderately and ungrazed transects reduces this possibility). It is harder to interpret the results of the regression analyses on the larger size classes. However, a comparison of the density of larger individuals show no evidence of reduced recruitment of mature trees in the grazed areas.

Finally, there is no evidence that browsing affects the density of young saplings, since the density of browsed species is higher in the smaller size classes than that of unbrowsed species. This was true of all three grazing strata. The effects of cattle grazing on species diversity by limiting the recruitment of browsed species to larger size classes is investigated in the next section.

### 4.6.6 Species Diversity

#### *4.6.6.1 Diversity indices*

The Sorensen coefficient of similarity ($S_s$) was calculated as described in Box 4-3 to compare species richness across the three transects and the results are shown in Table 4.11 below.

**Table 4.11** Sorensen coefficient of similarity for the three grazing strata

| Combination of transects | Sorensen's coefficient |
|---|---|
| Moderately grazed and ungrazed | 0.91 |
| Forest edge and ungrazed | 0.91 |
| Forest Edge and moderately grazed | 0.91 |
| All three combined | 0.80 |

All pairwise comparisons are very close to unity suggesting great similarity in overall species richness.

The Shannon-Wiener diversity indices and Pielou's J values were calculated for each transect, and combined for the three grazing types to give three mean values of species diversity and evenness of diversity which could be compared by analysis of variance. The results are summarised in Table 4.12 and Table 4.13 below.

**Table 4.12** Shannon Index

| Graze type | Number of transects | Mean | Standard Deviation |
|---|---|---|---|
| **Ungrazed** | 10 | 1.85 | 0.21 |
| **Moderately grazed** | 10 | 2.05 | 0.18 |
| **Forest Edge** | 3 | 1.83 | 0.09 |
| **Combined** | 23 | 1.94 | 0.21 |

**Table 4.13** Pielou's J

| Graze type | Number of transects | Mean | Standard Deviation |
|---|---|---|---|
| **Ungrazed** | 10 | 0.83 | 0.05 |
| **Moderately grazed** | 10 | 0.84 | 0.04 |
| **Forest Edge** | 3 | 0.78 | 0.05 |
| **Combined** | 23 | 0.83 | 0.05 |

Analysis of variance showed no significant difference in the Pielou's J values ($F = 2.57$, $P = 0.101$, 2 df.), but a significant difference for the Shannon-Wiener Indices ($F = 3.58$, $P = 0.047$, 2 df.).

The moderately grazed transects had a significantly higher species diversity than the ungrazed and the forest edge transects, but there was a relatively even distribution of species among transects within each grazing strata.

#### *4.6.6.2 Multivariate measures of diversity*

**Results of the TWINSPAN analysis**

The results of TWINSPAN analysis of the tree density and I.V. data and the seedling density data are presented as dendrograms in figures 4-9 to 4-14 at the end of this chapter. These dendrograms show how the sites and species were split by TWINSPAN and the final grouping of the species and sites into classes and groups respectively.

The objective of the TWINSPAN analysis was to determine whether species diversity and abundance related to grazing intensity. The transects were identified according to grazing intensity such that any grouping of transects by grazing intensity by the TWINSPAN analysis would be clear.

The forest edge transects were grouped together at the first division for all three parameters. The dendrogram for the tree density and importance value data placed the three forest edge transects in a separate group (together with transect 11, the moderately grazed transect located closest to the forest edge) after just two divisions which implies the three transects were very similar in terms of species abundance and significantly different from the transects in all the other groups.

There was considerable mixing of the moderately grazed and ungrazed transects within all three of the TWINSPAN analyses, particularly in the first two divisions. At later divisions, the groups began to split along the lines of grazing intensity, however, this implies grazing intensity was not the main environmental variable defining species diversity and the relationship between species diversity and grazing intensity was weak.

Interestingly, the TWINSPAN analysis of the seedling data seemed to split the transects more closely along the lines of the grazing strata, with all ungrazed and three out of the ten moderately grazed transects on the positive side of the dichotomy and all the forest edge transects and the remaining moderately grazed transects on the negative side of the dichotomy after the second division. Thus, the forest edge transects and the moderately grazed transects were similar in species diversity of tree seedlings, but became progressively less similar in larger age classes. The opposite was true for the moderately grazed and the ungrazed transects.

A comparison of the species classifications shows a total lack of consistency in the classification of the species on the basis of whether a species was browsed or not suggesting palatability does not affect species distribution with respect to cattle grazing intensities alone.

**Results of the partial redundancy analysis**

Partial redundancy analysis with the Monte Carlo Permutation test was used to test the null hypothesis that altitude and grazing have no independent significant impact on the species data. Each variable was tested after partialling out the influence of the alternative co-variable. The difference in species abundance and diversity in the forest edge transects was clearly evident from the results of the TWINSPAN analysis discussed above. Partial redundancy analysis, therefore, was carried out for the transects in the moderately and ungrazed areas alone to test for consistent differences between these two grazing strata. The results of partial RDA on species density data are shown in Table 4.14. The results of partial RDA on species importance data are shown in Table 4.15. In both cases, altitude significantly affected species composition and abundance. Taking this effect into account, grazing intensity was not significantly correlated with species diversity. No significant relationship between seedling density and altitude or seedling density and grazing in the moderately grazed and the ungrazed transects found using RDA. (The results of this last analysis is therefore not presented).

**Table 4.14** Results of unrestricted Monte Carlo Permutation tests from Partial RDA of species density data

| Environmental variable | Partialled out co-variable | Percentage variance explained by single environmental variable | F ratio | P |
|---|---|---|---|---|
| Altitude | Grazing intensity | 26.9% | 6.89 | 0.01 |
| Grazing intensity | Altitude | 5.4% | 1.38 | 0.21 |

**Table 4.15** Results of unrestricted Monte Carlo Permutation tests from Partial RDA of species importance value data

| Environmental variable | Partialled out co-variable | Percentage variance explained by single environmental variable | F ratio | P |
|---|---|---|---|---|
| Altitude | Grazing intensity | 14.0% | 3.12 | 0.02 |
| Grazing intensity | Altitude | 8.0% | 1.79 | 0.12 |

### *4.7 Herbaceous cover*

The overall percent cover was transformed by arc sine transformation (Bishop, 1983) and the mean cover throughout the year inside the exclosure plots was compared with open plots at Lorubai and Sordon, using paired sample t-tests. The data from the two different transects were also compared using independent sample t-tests. The mean cover values are summarised in Table 4.16. Linear regression of the transformed data was used to test for significant changes in cover over the study period.

The overall percent cover at Lorubai was significantly higher in the exclosures (75%) than in the open plots (63%) ($t = 2.90$, $df = 29$, $P<0.01$). Mean cover increased significantly throughout the study period in the exclosures at Lorubai (Closed plots $F_{1,28} = 8.72$, $P<0.01$, $r^2=0.24$). The increase in cover in the open plots at Lorubai was not significant.

At Sordon, there was no significant difference in overall percent cover in the exclosures and the open plots. In both the open plots and the exclosures, mean cover increased significantly throughout the study period (Open plots $F_{1,23} = 5.13$, $P<0.05$, $r^2=0.19$; Exclosures $F_{1,23} = 15.03$, $P<0.001$, $r^2=0.41$).

**Table 4.16** Percent cover (by herb, grass or tree/shrub species) inside and outside exclosure plots for Lorubai (grazed ) and Sordon (ungrazed) transects

| | Month | Lorubai | Sordon | Average |
|---|---|---|---|---|
| **Open plots** | **April** | 39 | 64 | 50 |
| | **August** | 77 | 95 | 84 |
| | **October** | 67 | 93 | 78 |
| | **Jan** | 70 | 88 | 79 |
| **Average of open** | | 63 | 85 | 73 |
| **Exclosures** | **April** | 56 | 75 | 64 |
| | **August** | 83 | 89 | 85 |
| | **October** | 83 | 92 | 87 |
| | **Jan** | 83 | 96 | 89 |
| **Average of closed** | | 76 | 88 | 81 |

Comparison of cover type at each transect (using a t-test on arc sine transformed proportions for each plot) found a significantly greater proportion of grasses in the herbaceous layer at Lorubai than at Sordon (Proportion grass cover: Lorubai, 32%; Sordon 7.5%, $t = 6.79$, 106df, $P<0.001$); and a significantly greater proportion of herbs in the herbaceous layer at Sordon than at Lorubai (Proportion herb cover: Lorubai, 36%; Sordon 78%, $t = 10.79$, 106df, $P<0.001$).

## 4.8 Discussion

In this section, the results presented in this chapter are summarised and used to test the hypotheses and predictions made at the start of this chapter in Section 4.3. The results from this study are then compared with those from other studies. The concluding section discusses the implications of these results for forest management.

### 4.8.1 Summary of key results

#### *4.8.1.1 Tree density and stand structure*

The hypotheses made specific predictions relating to seedling regeneration and regenerant survival and levels of recruitment into the mature stages. These are dealt with in turn below. Overall, very little difference was found between the moderately grazed and ungrazed transects in terms of plant population structure and density with all species combined for the analysis. The forest edge transects had a very different stand structure as might be expected given the very different micro-climate, particularly the greater light intensities and desiccation rates. The very different nature of the forest edge to the rest of the forest makes it impossible to assign differences in the results to the higher grazing intensities experienced at the forest edge.

Evidence of browsing was found in all three grazing strata. Browsed species were present in higher densities than unbrowsed species in the smallest size classes.

The PCQ data showed tree density to be higher for the smallest size classes in the moderately grazed transects and regression analysis of the population structure as a whole from the PCQ data found this difference to be significant. However, seedling density from the seedling plots was slightly higher in the ungrazed areas than in the grazed areas, but not significantly so. Given the conflicting results from the seedling and PCQ surveys it is not possible to conclude definitely that greater regeneration is associated with cattle grazing intensity. There is no evidence that cattle either increase or decrease regeneration and regenerant survival, nor that they select areas with high regenerant densities to graze in. The very high levels of regeneration found at the forest edge where cattle grazing is highest is consistent with the possibility that cattle increase (rather than reduce) regeneration and regenerant survival, although the very different micro-climate found along the forest edge makes it impossible to compare these results directly.

Levels of browsing and trampling of seedlings were higher in the moderately grazed and forest edge transects. However, taking only mature individuals from all species into account, there was no significant difference in densities across all three strata. These results suggest that mortality due to cattle browsing and trampling falls within expected levels of 'natural' mortality.

In the absence of cattle, herbaceous cover in the transect usually frequented by cattle increased both inside and outside exclosure plots. However, the increase was not significant outside the plots suggesting wild herbivores are having an effect on herbaceous cover irrespective of cattle presence. In the area of no cattle pressure, there was no difference in herbaceous cover inside and outside the plots, suggesting that in a year of good rainfall, such as 1994, the density of wildlife within the forest is not sufficient to significantly reduce the herbaceous layer. A prolonged rainy period would result in the gradual build up of biomass in the herbaceous layer in the absence of cattle grazing which could present a serious fire hazard.

#### *4.8.1.2 Species composition*

Cattle browsing and to a lesser extent trampling (given the much lower incidence of trampling damage found) could alter species composition, shifting the competitive advantage in favour of unpalatable or browse tolerant species. Species diversity was compared across the three grazing strata using a number of diversity indices and multivariate analysis.

Simple diversity indices found no difference in species richness or evenness of diversity between the three strata of different grazing intensity. However, the moderately grazed transects had a significantly higher diversity index than both the ungrazed or the forest edge transects[4].

The TWINSPAN analysis grouped both sites and species together on the basis of their density and importance values. If the effects of cattle were different to those of other wild herbivores, this would be reflected in the distribution of the sites and species within the TWINSPAN dendrograms.

The site classifications for the TWINSPAN analysis of tree species density, importance values, and seedling density suggested that primary differences in species diversity were not related to grazing intensity alone. There was no clear dichotomy between the moderately grazed and the ungrazed transects in either tree species density or importance values. The forest edge transects were clearly different from the other transects in tree species density and importance values, but the very different conditions at the forest edge make it impossible to definitely relate this difference to grazing. Interestingly, there was a stronger dichotomy by grazing type in seedling densities, with the forest edge and half of the moderately grazed transects grouped together and all of the ungrazed transects grouped together with just three of the moderately grazed transects at the second division.

Partial redundancy analysis of the results from the ungrazed and moderately grazed transects found a significant relationship between species density and altitude and between importance value and altitude, but no significant relationship between species density and grazing pressure independent of the altitude effect. However, no significant relationship was found between seedling density and either altitude or grazing intensity.

The classification of species similarly found no clear relationship between the TWINSPAN groups in terms of whether or not a species is browsed, particularly at the highest divisions.

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[4] Only 18 tree 'species' were identified in the course of the PCQ surveys (this may reflect up to 24 botanical species given duplication in the vernacular names for some species), which is low compared to forests found in more humid climates

Tree density data take no account of size or basal area and the very high numbers of individuals within the smallest size classes could mask this effect. Analysis of the importance values which takes both frequency and basal area as well as density into account may be more representative of the overall stand structure as well as species diversity *per se*.

In summary, the results of this study suggest that, within the grazing intensities found on the Lerroki Plateau and over the lifespan of the mature population of the forest, cattle have had no effect on species diversity over and above the effect of wild herbivores in the area.

### 4.8.2 The hypotheses tested

The hypotheses and predictions presented at the start of this chapter are repeated here and rejected or accepted on the results of the surveys.

**Hypothesis 1**. Cattle trampling and browsing reduces seedling regeneration and survival above and beyond the effects of wild herbivore browsing and trampling.

**Prediction 1**. Density of the youngest individuals will be lowest in areas of highest cattle grazing intensity and density will fall rapidly with increasing size.

**Summary of results** Seedling densities were highest at the forest edge where grazing intensity is highest and there was no significant difference in seedling density within the moderately grazed and ungrazed transects. Browsed species were present in higher densities than unbrowsed species in the smallest size classes in all three grazing strata.

On the basis of these data, hypothesis one can be rejected.

**Hypothesis 2**. The reduction in seedling regeneration and survival caused by cattle grazing (hypothesis one) leads to long term forest senescence.

**Prediction 2**. Seedling densities may be reduced in areas of high cattle grazing intensity. Density of the youngest individuals will be lowest in areas of highest cattle grazing intensity and density will fall rapidly with increasing size. Given the evidence for long term cattle grazing in the area (chapter three), densities of individuals in the higher size classes should be reduced in areas subject to high cattle grazing and browsing intensities.

**Summary of results** Levels of browsing and trampling of seedlings was greater in the moderately browsed and forest edge (heavily browsed) transects. Unbrowsed species were present in lower densities than browsed species in the smallest size classes and higher densities than browsed species in the higher size classes in both moderately grazed and ungrazed areas. Taking only mature species into account, there was no significant difference in densities across the three strata.

On the basis of these data, therefore, hypothesis two can be rejected.

**Hypothesis 3**. Cattle grazing facilitates seedling growth and survival by reducing the herbaceous layer beyond the levels caused by wild herbivores, thereby reducing competition for light and soil nutrients and moisture.

**Prediction 3**. The herbaceous layer will be lower in areas grazed by cattle than in areas grazed only by other wild herbivores. Seedling and sapling densities will be highest in areas of high cattle grazing and lowest in areas of no cattle grazing. The herbaceous layer in protected plots will be greater than that in open plots.

**Summary of results** The absence of cattle grazing inside the forest during the study period made it impossible to test this hypothesis fully. However, wild herbivores did not prevent a build up of herbaceous biomass in open plots compared to exclosures. Seedling densities were significantly higher at the forest edge than in the other two grazing strata and density of seedling and sapling size classes was higher in the moderately grazed than in the ungrazed transects, although not always significantly so.

These data are consistent with the hypothesis that cattle grazing shifts the competitive advantage in favour of tree and shrub species by reducing the herbaceous layer beyond the levels caused by wild herbivores. However, in the absence of data on the effects of cattle on the herbaceous layer it is not possible to categorically accept or reject hypothesis three. Given the nature of correlations, it is also possible that cattle herders preferentially select areas of high regenerant potential as opposed to cattle creating those conditions.

**Hypothesis 4**. The direct and indirect effects of cattle in forest will differentially affect species diversity.

**Prediction 4**. Species diversity will be different in areas of high cattle grazing intensity and areas of low cattle grazing intensity.

**Summary of results** Species diversity appeared significantly different at the forest edge, but it is not possible to assign this difference to grazing alone given the very different conditions found at the forest edge. No relationship was found between species diversity and cattle grazing intensity between the moderately grazed and ungrazed transects.

Hypothesis 4 can be rejected for levels of grazing intensity found in the moderately grazed areas. It is possible that higher levels of grazing intensity found at the forest edge can influence species diversity, but the different micro-climate at the forest edge is likely to have a greater effect than grazing intensity alone.

### 4.8.3 Comparison with other studies

The results of this study presented in this chapter do not support the theory that cattle grazing (within the intensities experienced at Lerroki) adversely affects forest population structure or diversity beyond the levels caused by naturally occurring indigenous wildlife populations (cf. Struhsaker *et al.*, 1989; Synnott, 1979; Stott, 1986). The very high levels of seedling regeneration at the forest edge where cattle densities are highest (and wildlife densities lowest) appear to support the theory that cattle grazing promotes woody vegetation cover through the reduction of herbaceous cover , thereby reducing the severity of forest fires and competition for light and soil nutrients and water (Norton-Griffiths, 1979; Dublin, 1991; Huston, 1994; Coppock, 1993, Turner, 1967). Moss (1996) similarly found no evidence of cattle grazing reducing regenerant survival and recruitment in *Acacia* woodland in Marsabit district to the north east of Lerroki, despite *Acacia* being a favoured browse species in this area. The ability of cattle to promote woody vegetation is not a new concept - bush encroachment on rangeland caused by 'overgrazing' is a familiar problem for most rangeland managers (Lamprey, 1985; Turner, 1967). While there is clear evidence that cattle can and do browse on woody species and damage seedlings through trampling, on the basis of the results from this study, the effect of these impacts fall within expected levels of natural mortality.

The lack of difference in species diversity between areas grazed and not grazed by cattle may be explained by the presence of a number of wild herbivores, particularly eland, elephant and buffalo that would also be having an impact on forest structure and diversity through similar mechanisms to cattle, i.e. browsing and trampling. The very dense herbaceous layer in the ungrazed transects compared to the grazed transects, however, suggest that the densities of these other herbivores may not be as great as that of cattle using the forest during the dry season.

### *4.9 Conclusions*

The results from this study suggest that cattle grazing does not reduce tree regeneration or recruitment, and there is considerable evidence that regeneration and recruitment are actually increased.

There are a number of reasons why this might be so. Forest grazing will reduce the herbaceous layer and may release nutrients and other resources to seedlings, which would otherwise have been out-competed. Alternatively, the presence of cattle and their herders may discourage other wildlife species (such as elephant and buffalo) that browse or trample on tree seedlings and may cause greater damage. Further analysis of data on wildlife/livestock distribution and herbaceous cover may provide more evidence for these effects.

The population structure of a habitat ultimately reflects past opportunities for recruitment and the mortality risk to which each recruit has been exposed. This study used this principle to establish the long term impact of cattle activities on closed canopy forest biodiversity and cover.

The mechanisms through which cattle are likely to have an impact (positive or negative) on their environment are: grazing and browsing; trampling; and defecating. These activities may affect vegetation directly - e.g. killing a seedling by eating it or trampling on it; or creating a safe site (sensu Harper) for germination within cattle dung - or indirectly, by influencing plant species competitiveness. Cattle activities are likely to produce different effects on different plant species and ultimately vegetation types.

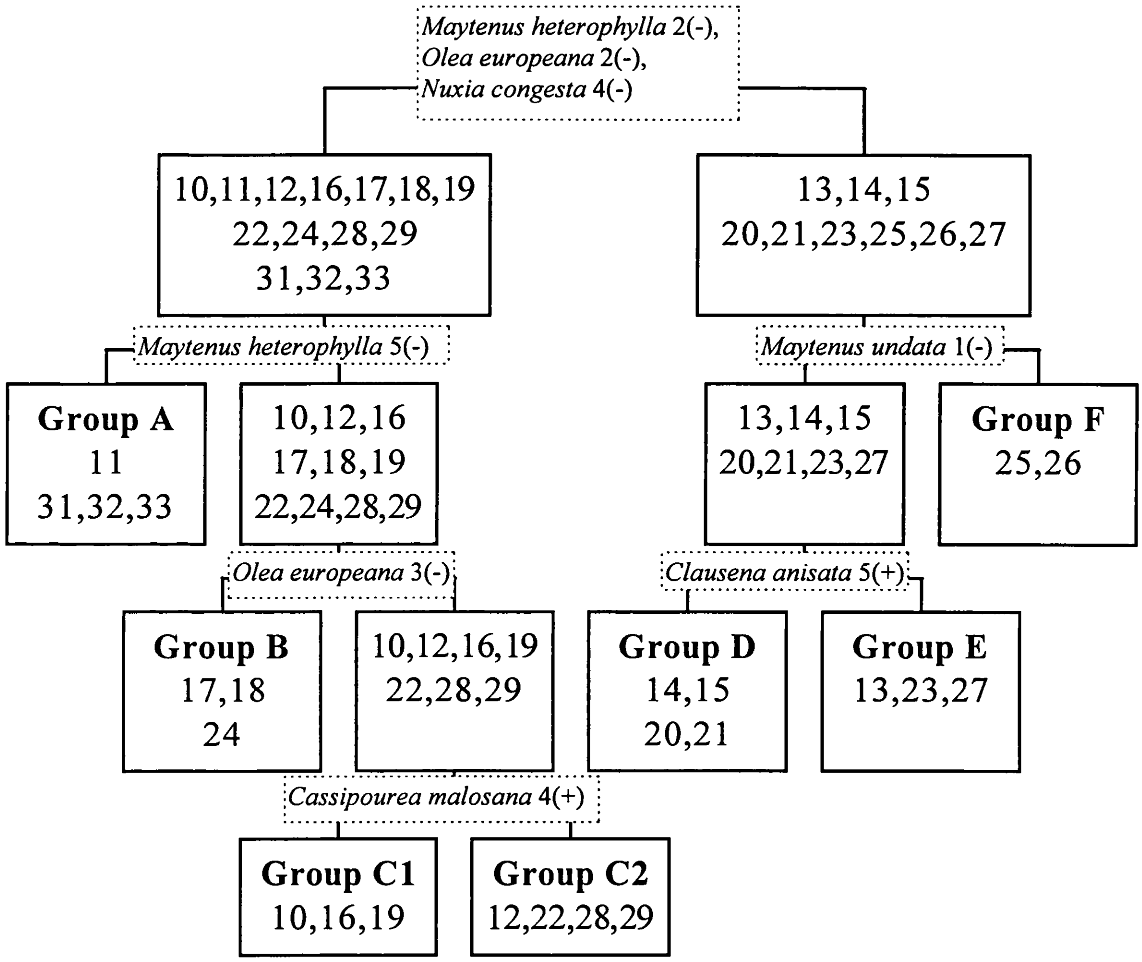
The methods for this study were based on the assumption that if livestock have an impact on tree species recruitment and mortality, this would be reflected in the overall population structure. Of major concern in this study was the long term overall effect of cattle on tree cover - does cattle grazing reduce recruitment of tree species to a level at which overall tree mortality exceeds overall tree recruitment? and on a species level does cattle grazing change the forest biodiversity?

The problems of drawing conclusions on the basis of correlations have been touched on earlier. The problem of identifying the direction of such a causal effect on the basis of a correlation has also been raised in the course of this chapter. Very few environmental variables were measured in this study and the few correlations between vegetation patterns and grazing intensity may not be causal, particularly in the case of the intensely grazed forest edge transects. However, the patterns that emerge from the data are surprisingly consistent.

The fact that cattle may actually assist in maintaining forest cover has important implications for dryland forest management. These will be discussed in the final chapter.

**Figure 4-8** TWINSPAN dendrogram for the site classification by species density, indicating the seven different transect groups and the indicator species for each division

(Cut levels (from percentiles): 0 15 32 69 110)




Transect coding:

10 - 19 Moderate grazing

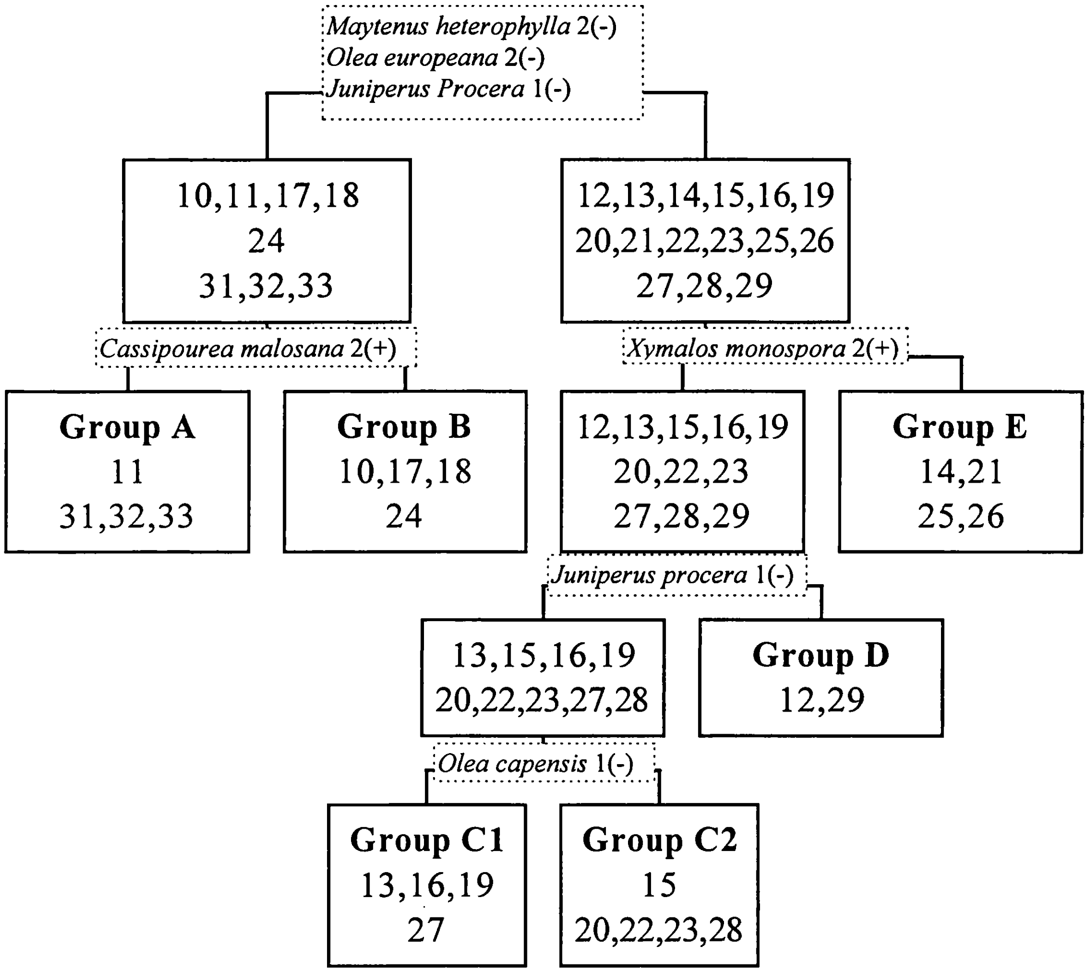
20 - 29 Ungrazed

31 - 33 Forest edge

*Maytenus heterophylla* 5(-) Indicator species (e.g. *Maytenus heterophylla*), showing pseudospecies (5, density greater than 110 individuals/ha) and direction of influence in the dichotomy (in this case negative).

**Figure 4-9** TWINSPAN dendrogram for the site classification by species importance values, indicating the six different transect groups and the indicator species for each division

(Cut levels (from percentiles): 0 6 12 26 50 )




Transect coding:

10 - 19 Moderate grazing

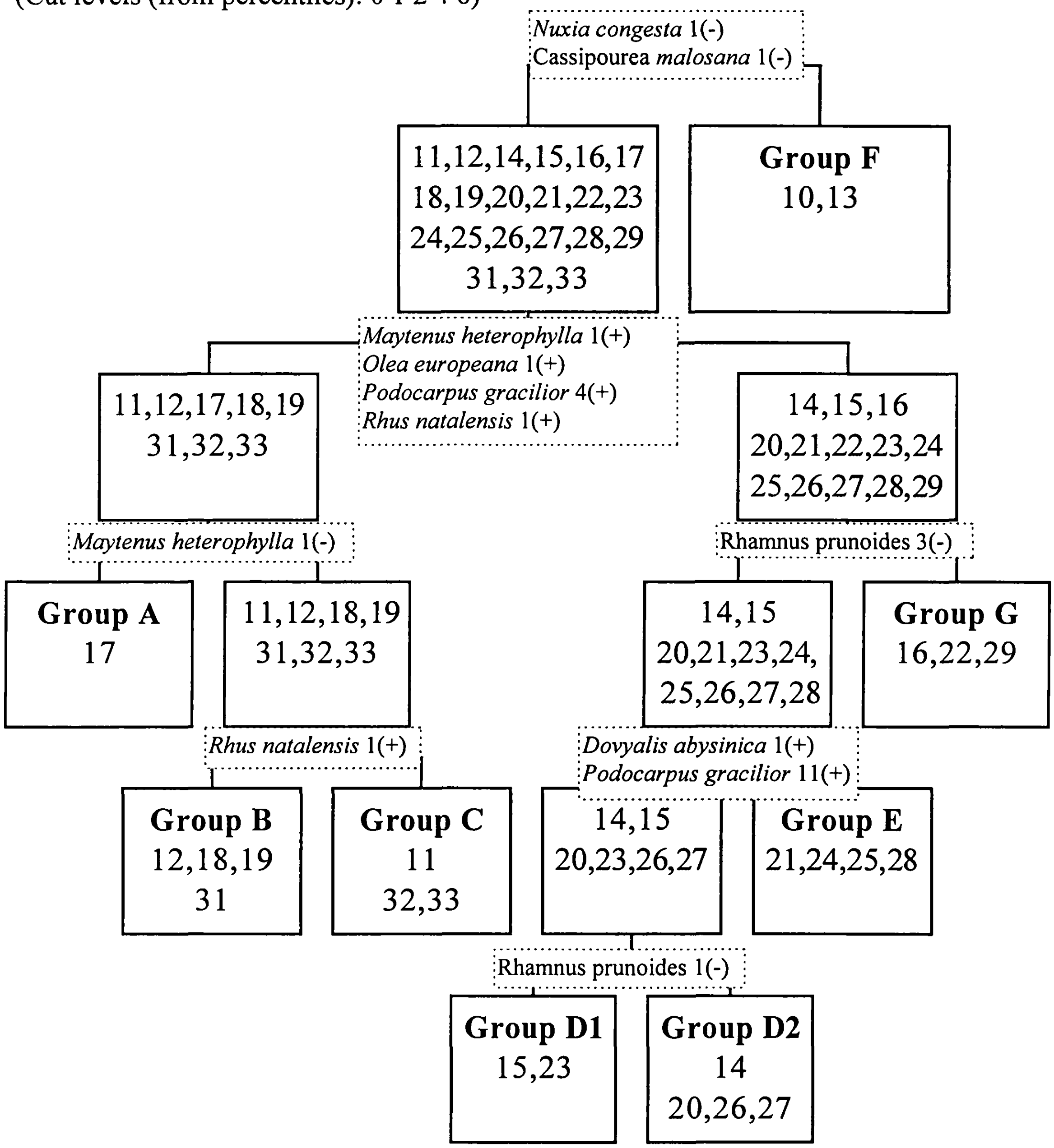
20 - 29 Ungrazed

31 - 33 Forest edge

*Maytenus heterophylla* 5(-) Indicator species (e.g. *Maytenus heterophylla*), showing pseudospecies (5, density greater than 110 individuals/ha) and direction of influence in the dichotomy (in this case negative).

**Figure 4-10** TWINSPAN dendrogram for the site classification by seedling species density, indicating the seven different transect groups and the indicator species for each division

(Cut levels (from percentiles): 0 1 2 4 6)




Transect coding:

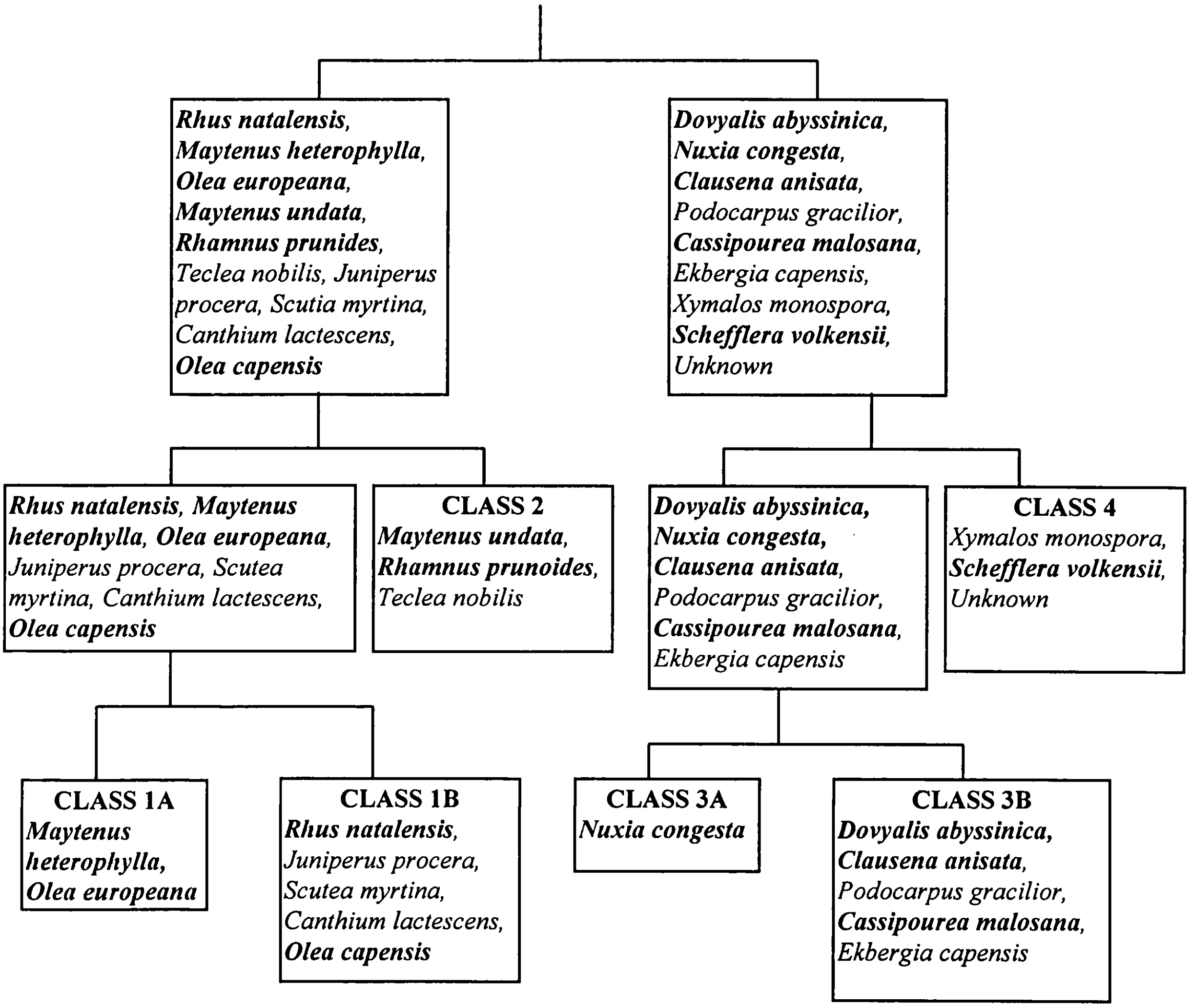
10 - 19 Moderate grazing

20 - 29 Ungrazed

31 - 33 Forest edge

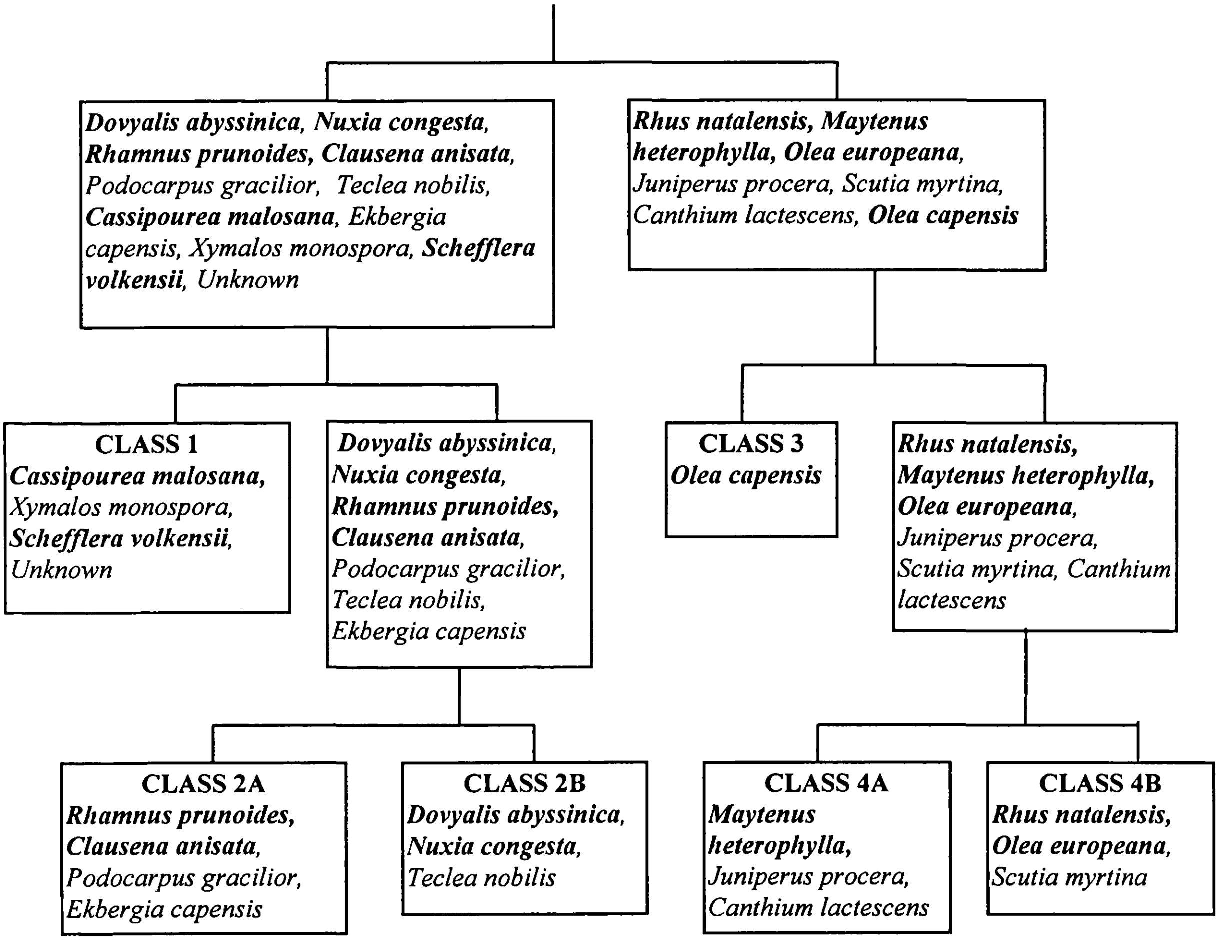
*Maytenus heterophylla* 5(-) Indicator species (e.g. *Maytenus heterophylla*), showing pseudospecies (5, density greater than 110 individuals/ha) and direction of influence in the dichotomy (in this case negative).

**Figure 4-11** TWINSPAN dendrogram for the species classification by species density, indicating the six different classes



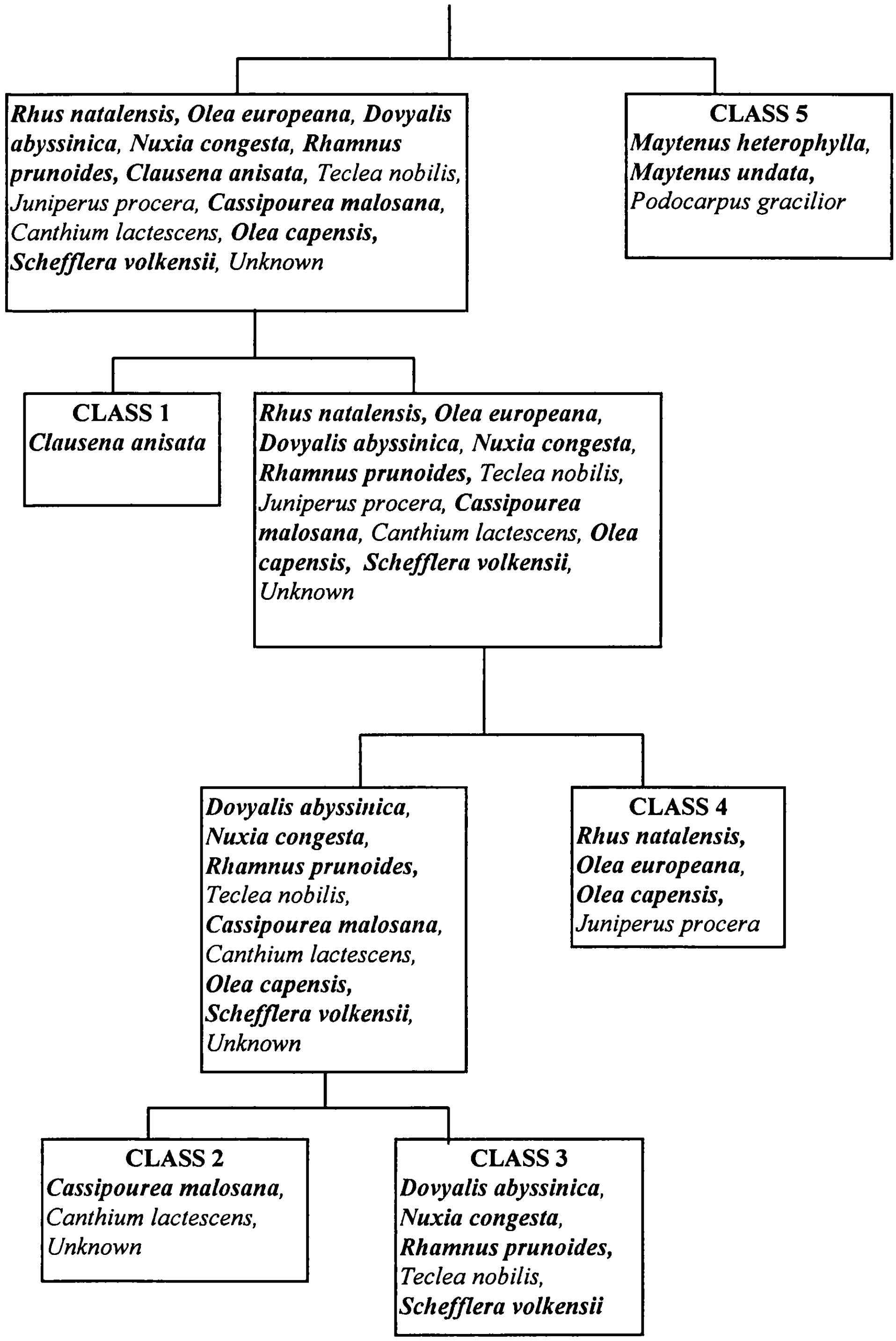

Species in bold are those which are browsed

**Figure 4-12** TWINSPAN dendrogram for the species classification by species importance values, indicating the six different classes




Species in bold are those which are browsed

**Figure 4-13** TWINSPAN dendrogram for the species classification by seedling species density values, indicating the six different classes




Species in bold are those which are browsed

# 5. Villages, households and wealth

## 5.1 Introduction

Chapters three and four have looked at one specified group of forest users - cattle. The next two chapters examine more general forest resource use by forest adjacent communities. This chapter looks at the forest adjacent communities themselves, identifying socio-economic differences and settlement trends over time within and between the study villages that may affect levels of resource use. Chapter six quantifies wild resource use and examines whether levels of resource use vary in relation to market demands and/or the socio-economic differences between sub-households and villages identified in the course of the present chapter.

A brief description of the study villages (Lpartuk, Ngorika, Loikas and Tamiyoi) was given in chapter two. The villages were chosen as cases typifying other forest-adjacent villages in the area with the over-riding difference between them being distance to Maralal and its market (Figure 5-1). This difference was considered to be potentially powerful factor in determining the socio-economic and ethnic composition of the forest users, market opportunities and, therefore, levels of forest resource use (Cunningham, 1993). Thus, Tamiyoi and Loikas were selected as two villages on the edge of Maralal with very easy access to the market; Lpartuk was located 9km to the north of Maralal, but on the main Maralal-Baragoi road, with regular traffic into Maralal and middlemen who would visit the village itself to buy products; and Ngorika was selected as an example of a relatively isolated village, 24km by road to Maralal, the last 4km being on ungraded road with little or no transport.

However, proximity to a market may actively define a population as well as affect it. A village is made up of a complex network of individuals and households stretching beyond the boundary of the village itself, with historical events and trends affecting current land use and population. Urban areas may attract both wealthy pastoralists, in search of better access to trade routes and commerce, and poor pastoralists in search of employment and alternative sources of livelihood (e.g. Sikana *et al.*, 1993; Sperling

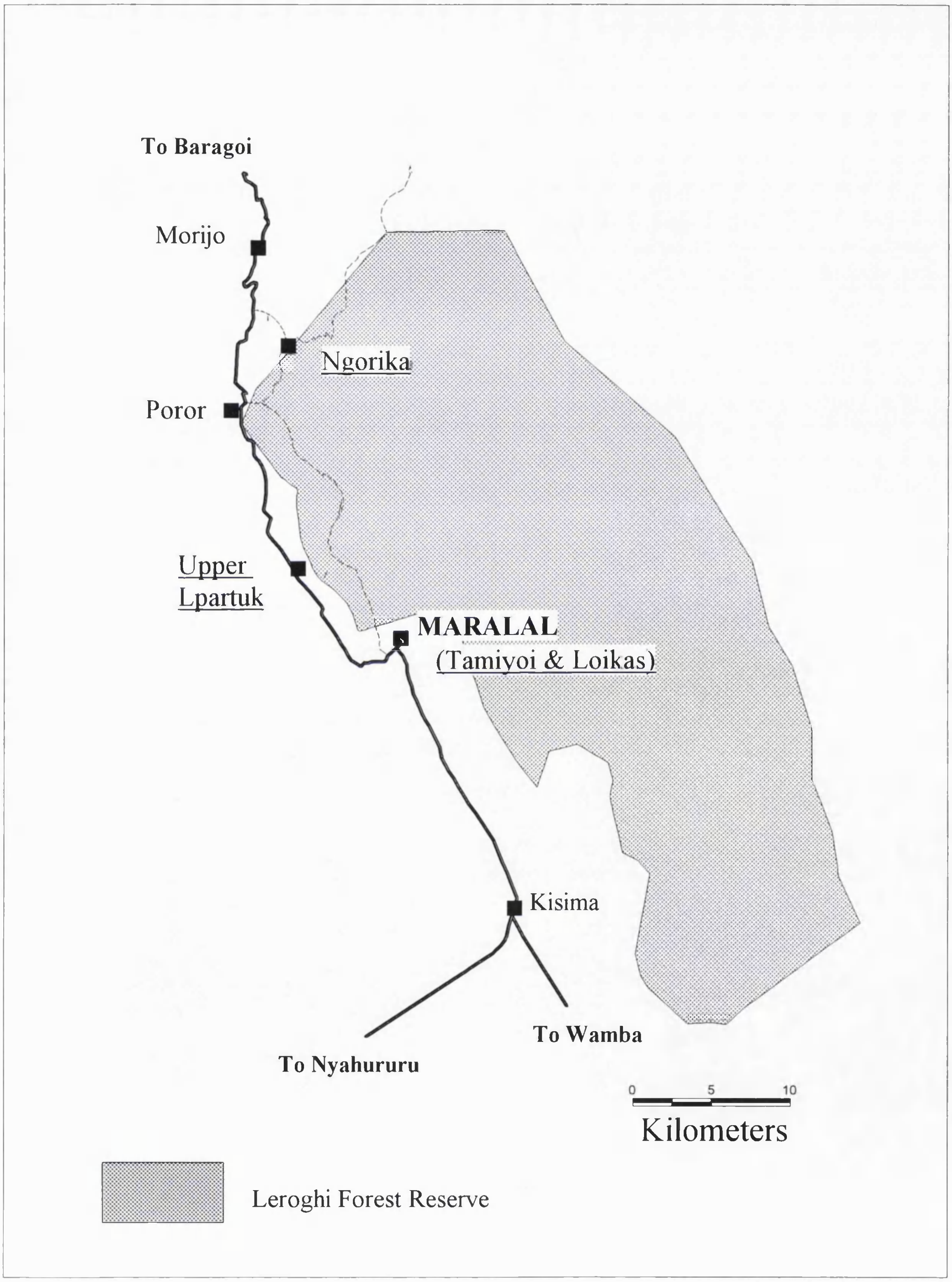
& Galaty, 1990). In the last few decades, missions established around important trading centres have also encouraged many pastoralists to settle (Sobania, 1988).

Baseline surveys were carried out in all four study villages to establish differences in various indicators of household wealth within and between the villages. The surveys measured wealth both directly using quantitative measures of assets such as livestock and land holdings, and indirectly using qualitative indicators such as the importance of alternative sources of livelihood for each sub-household. Problems associated with defining and measuring wealth are discussed during the course of this chapter. Differences in wealth at the sub-household level were analysed in relation to the village the household was located in, the ethnicity and gender of the household head and the gender of the respondent, using multiple regression analysis.

Aerial photographs from 1956 to 1993 provided historical evidence for trends in land use and settlement patterns around each study site, which would have had important implications for long term trends in natural resource use.

The following section describes the importance of wealth and markets in determining wild resource use in the context of the existing literature. The question of wealth within a pastoral community is discussed in some detail. This is followed by a description of the methods used for the baseline survey, beginning with a definition of the analytical units used (village and sub-household), and the design of the questionnaire and sampling strategy. The results of the baseline surveys are presented in two parts: the results of analysis of the quantifiable measures of wealth - livestock and land holdings; and the results of the more qualitative measures on economic activities and sources of livelihood. The methods for the aerial photo interpretation (API) are then outlined, followed by the results. Finally, the results from both the baseline surveys and the API are discussed in the light of the literature review at the start of the chapter. If differences in wealth and market demand can affect levels of resource use, they have implications for forest management. The results of these surveys enable hypotheses regarding the importance of market accessibility and wealth on levels of wild resource use to be tested in the following chapter.

**Figure 5-1 Map showing location of the study villages in relation to the Leroghi Forest Reserve**



## 5.2 Context

### 5.2.1 Markets and wild resource use

The positive correlation between levels of natural resource extraction and the market value of a resource is well documented (Cunningham, 1990; Koppell 1992; Scoones *et al.* 1992; Godoy & Bawa, 1993; Appasamy, 1993; Falconer, 1992; Shepherd, 1992). Short-term cash needs and the lack of resources to help buffer periods of stress often leave households with few alternatives and ready markets for wild resources provide an incentive for their collection and sale. As distance to markets decreases, the opportunity costs of time spent travelling to markets are also lower. The greater the distance to market, the greater the potential for conflicting labour demands (Sikana *et al.*, 1993).

Informal market activities such as beer brewing, and charcoal making are "especially vital to those hovering on the fringe of pastoral settlements and growing savanna towns", i.e. the poorer members of the pastoral community (Sperling & Galaty, 1990; Sikana *et al.*, 1993). The effects of markets on wild resource use are, therefore, closely related to the effects of wealth.

### 5.2.2 Wild resource use and wealth

"Those areas that are characterised by impoverishment, where people may be landless and/or stockless, are likely to experience environmental problems, since short-term cash needs will outweigh conservation investments among the poor." (Little & Brokensha, 1987:195)

The importance of forest to poorer people in general, and in particular to women, for income and subsistence products is reviewed in Koppell (1990, p90) and Scoones *et al.* (1992). Trees and their products are used in a variety of ways to meet contingencies faced by the poor, either directly or as a source of cash (Chambers &

Leach, 1987), and foraging is often viewed among communities as a socially inferior activity[1] (Gura, 1986; Godoy & Bawa, 1993;).

Wily (*pers comm.*) found that forest resource use was highest in the poorest and the wealthiest groups among agricultural communities elsewhere in Kenya and suggested the larger size and therefore demands of many wealthy households could explain this pattern. However, Godoy *et al.* (1995) and Evers (1994) both report a parabolic relationship between forest resource use and wealth: levels of forest resource use were lowest in the poorest and wealthiest households, peaking somewhere in the middle. The low levels among the poorest sub-households were attributed to limited access to labour and equipment, whereas availability of alternatives (such as cheap manufactured substitutes) reduces demand among wealthier households.

Reliance on wild resource use at different times of the year may vary according to wealth. Poorer members of a community have a lower capacity to cope with seasonal stress, since they do not have access to the resources that wealthier households use to buffer seasonal fluctuations in demand (Raikes, 1981; Thomas & Leatherman, 1990). Dei *et al.* (1989) found that the poor showed higher dependence on bush products than the wealthy in the lean pre-harvest period in a community in Ghana: bush products contributed 20% of household food supply in the poor households pre harvest, compared to just 2% in wealthy households.

#### *5.2.2.1 Wealth and pastoral societies*

While pastoral communities are often popularly perceived as egalitarian, a view perhaps perpetuated by the tradition of common access to grazing resources, there is considerable wealth inequality within pastoral communities (Grandin, 1983; Cossins & Upton, 1987; Bekure & Grandin 1991; Sellen 1995) and the Samburu are no exception: Fumagalli (1987) states that, at that time, 50% of the cattle in Samburu District were owned by just three individuals. Even within a household, a married

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[1] The low social status associated with foraging for wild resources has been proposed as a reason for an apparent decline in wild food collection in general and may be important in determining the potential for adoption of development projects that promote extraction of wild resources as an income generating activity (Godoy & Bawa, 1993).

man will share his wealth between his wives and sons and there is often considerable variation in wealth between co-wives, depending on the management of the different herds and the number of cows presented at marriage (pers obs.; Borgerhoff Mulder & Sellen 1994).

Wealth status, usually measured in terms of livestock numbers in pastoral communities, is thought to have a considerable impact on pastoral production strategies (Kerven, 1987; King *et al.*, 1984; Grandin, 1983), although the relevance of wealth in terms of livestock numbers to the nutritional status of a household has not been proven and there is some evidence that there is no positive correlation between the two: nutritional status depends on access to livestock products which depends on how conflicts between the objectives of herd managers and the nutritional demands of the household are resolved (Sellen, 1995; Galvin, 1992; Grandin, 1988). A larger livestock herd increases the potential access to cash from the sale of good quality animals (Sikana *et al.*, 1993; Sellen, 1995; Sperling, 1987). However, it is the poorest families which are more reliant on purchased goods throughout the year since, unlike wealthier herd owners, they would never be able to survive on livestock products alone (Sperling, 1987).

This inequality in access to cash through the sale of animals and animal products (e.g. milk, hides, etc.) could have considerable importance in determining the reliance of households on wild natural resources, particularly those with market value. However, Grandin (1983) points out that in pastoral communities greater wealth often necessitates larger families and groups of dependants which could increase reliance on wild resources rather than decreasing them.

#### *5.2.2.2 Measuring wealth in pastoral societies*

While it is common to measure wealth in pastoral communities in terms of livestock holdings, cultivation for subsistence is becoming an increasingly important strategy for food security for many pastoral communities, including the Samburu on the Lerroki Plateau (Perlov, 1984; Fratkin, 1994; Baxter & Hogg, 1990). This study found the majority of households on the plateau cultivated a small farm, growing maize, beans and other vegetables which are harvested at the start of the long dry season when range quality is poor and needs are high. The area of land cultivated and the relative importance of livestock and agriculture as sources of livelihood are therefore considered important measures of wealth in the context of this study. Finally, other classic measures of wealth, such as whether or not a household had tin roofing, household size (as a reflection of access to labour) and whether the sub-household hired non-family members to work on their land were also considered as potential measures of wealth.

### 5.3 Methods - The baseline survey

The main objective of the baseline survey was to describe and compare basic household composition, land holdings, livestock holdings, major sources of income, and activities within and between the study villages. The survey took place in January 1994 at Lpartuk and Ngorika and in August 1994 at Tamiyoi and Loikas. The questionnaire used at Tamiyoi and Loikas was based on the original baseline survey used in Upper Lpartuk and Ngorika, but also included a one-off forest use questionnaire. Care has been taken only to compare results from the surveys in Upper Lpartuk and Ngorika with those from Maralal when the data are truly comparable.

This section describes the methodology used for the baseline survey, beginning with a discussion of the main analytical units - village and sub-households. The terms 'village' and 'household' can have very different interpretations across different societies. Even within the same society, household definitions may vary with different studies, depending on the objective of the survey (Casley and Lury, 1987). The definition of village, household and sub-household in the context of this study is therefore discussed in some detail. This is followed by a description of the questionnaire and sample design.

#### 5.3.1 Villages & Households

Given the transhumant culture and social organisation of pastoral communities, the definition of a household in a pastoral context differs from the more general definitions suggested for settled societies (ILCA, 1983). Similarly, it is rare to find reference to a "village", normally assigned to a relatively permanent group of households, in the literature on the Samburu given the traditionally fluid nature of the society. This section defines and justifies these terms as used in the course of this study.

##### *5.3.1.1 The village*

Sperling (1985) describes Samburu residential arrangement as forming "four concentric rings: hut [sub-household], household (with members of a multi-hut family), base encampment and locality".

A "household" is the plot of a married man, his wives, children, related kinsmen and other dependants. Each wife, and often married sons, will have their own sub-household, "*Nkaji*", which may or may not be located in the same area. The base encampment comprises a cluster of sub-households contained within a thorn enclosure. The residents are a voluntary aggregation of family groups who may be related by kin, by clan or through friendship. Sperling describes these groups as the "basic unit of sociability and inter-household co-operation", sharing labour for tending livestock, and common security. Groups of base encampments found clustered together are described by Sperling as localities. Traditionally, elders from within the locality form a council which regulates use of grazing and water resources as well as settling inter-camp disputes. These councils are important in day to day running of the community.

Sperling's four-tier system differs from the more conventional description of Maasai settlement patterns found in the literature which adds another layer to the system (e.g. Jacobs, 1975; Homewood & Rogers, 1991; Spencer, 1988). Under this more conventional system, a group of base encampments make up a neighbourhood (the equivalent of a locality *sensu* Sperling) and a locality is a group of neighbourhoods which control enough wet and dry season grazing and water resources to support production in a normal year. Under this definition a locality would be a much larger entity than that described by Sperling.

There have been considerable changes in settlement patterns from this traditional norm among both the Maasai and the Samburu of Kenya, concurrent with changes in land use. The number of sub-households within a base encampment has declined from an average of 16 in 1965 (Spencer, 1965) to just 6 in 1987 in the case of the Samburu (Sperling, 1987) and from 6 to 12 households in 1965 to 2 to 3 households in 1983 in the case of the Maasai (Grandin *et al.*, 1991). Three factors are thought to have contributed to this change:

1. a reduction in livestock holdings which has reduced the need for co-operative herding;
2. increasing individualisation of production, particularly with the increase in cultivation as a means of production; and

3. the creation of Group Ranches and more recently, the subdivision of some ranches into individual holdings which has increased the desire by individual households to stake a permanent claim over a piece of land which would be passed on through familial lines (Grandin *et al.*, 1991; Hedlund, 1980).

No data are available describing past settlement patterns on the Lerroki Plateau, but there is good reason to expect the same changes to have occurred. Increasing involvement in cultivation on the plateau since the 1940's, which have altered the density and distribution of settlements, may even have served to accelerate the process from an earlier time. The trend towards cultivation, and more recently towards subdivision of the group ranches, provides an incentive for households in a particularly favourable area to retain a permanent base, resulting in relatively high densities of small base encampments in areas favourable to cultivation.

Using the more conventional definition, the 'villages' described in this study are groups of semi-permanent neighbourhoods, situated geographically close to each other, which share basic natural resources, such as grazing grounds and water resources and responsibility for those resources. Thus, "Ngorika village" as defined in this study included four neighbourhoods within 2km of Ngorika school: Lkujita, Ngorika, Porro and Nashoda, named after the temporary streams in the area. These were the neighbourhoods included during initial discussions on the area and population of Ngorika with elders at Ngorika itself. Hence the "village" of Ngorika as used in this study also had local meaning as an entity. Similarly, Upper Lpartuk incorporated households from a number of scattered encampments, and neighbourhoods included by the elders when creating the household list. Members of the community at Upper Lpartuk clearly differentiated themselves from Lower Lpartuk, located less than 2km to the south. In the case of Tamiyoi and Loikas, the areas were clearly differentiated as individual entities for administrative purposes and by local members of the community.

#### *5.3.1.2 The household and sub-household*

Bekure & Grandin (1991) define a household in a pastoral society as "an independent male producer and his dependants". As such it is the domain of the patriarch and seat of livestock ownership and management. The Samburu are polygynous[2] and a man's 'dependants' may include his wives, married sons and their wives, his mother (and siblings if his father is dead) and impoverished dependants (Sperling, 1987). This definition has been the basis for studies interested in livestock management and economy (e.g. Spencer, 1965, 1973; Grandin, 1991; Sperling, 1987; Sellen, 1995).

However, it is the sub-household, "*nkaji*", which is the locus for primary domestic activities. Thus, for this present study, it is the sub-household that best represents the smallest unit of shared natural resource utilisation, with the important exception of livestock grazing and watering.

Each wife, and the wives of any married sons, will have their own hut which will usually, but not always, be located geographically close to each other[3]. Each co-wife is responsible for building her own hut (and in some cases, granaries) in which she prepares food for her husband if he is present, her children, and any resident hired or borrowed labourers. Where the household has a shamba, each wife is responsible for cultivating her own crops, although there are exceptions where two wives may share the labour and the harvest (*pers obs*). Most daily chores, such as collecting firewood and water, and the household budget for purchasing items such as tea and sugar, will be the responsibility of each woman. (Again there are exceptions such as where an elderly woman may be helped by her daughters-in-law.). Some natural resources such as wild honey may be shared among all or many of the encampment residents irrespective of their household or sub-household. However, the majority of wild resources, for example medicine for children, timber for household construction and firewood, are collected specifically for use within a sub-household.

It is therefore the sub-household that is used as the main analytical unit throughout the rest of this thesis. In practice, a sub-household described those eating together on a regular basis in the same hut. The "head of household" refers to the person considered

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[2] At Ngorika, 70% of men had more than one wife and 27% had more than 2 wives

[3] A number of elders encountered in the study had wives living in different localities. In the course of the registration process for group ranches, some elders registered in more than one group ranch to increase his claim to access to the resources in both areas and one way of maintaining these claims would be to have a wife or married son resident in each.

responsible for major decisions regarding the sub-household: generally the husband, but occasionally a woman if she is divorced or widowed and has not remarried. Using this definition, a husband employed on a semi-permanent basis elsewhere would still be referred to as the head of the household by his wife, even though the sub-household was effectively being managed by the wife in her husband's absence.

It is important to differentiate between the sub-household and the family (Bender, 1967). Sobania (1979: 14) refers to the family as the "elementary production unit" among the Samburu. However, Sperling (1985) found that many Samburu families rely on additional labour to assist with herding duties and that much of this labour came from "children "borrowed" from kin and workers hired from relative strangers". These people would often be fed and housed by the "employers", sharing resources and eating from the same cooking pot without necessarily being kin.

The major flaw with using the sub-household as the main analytical unit in this study is that it excludes the moran from the sample frame. According to their culture, the moran are not allowed to eat either in the presence of others or to take food prepared by others, above all by women. There is no doubt that moran are an important group of natural resource users - they traditionally live in the forest and bush when they take their cattle to distant pastures. They do not generally build permanent housing, but rely on temporary bomas made from shrub and small tree species. Informal interview with morans and young married men suggests that within the area of study, their wild resource use activities, other than those directly related to management of livestock, are limited to infrequent hunting for meat and honey and occasionally building a fire to roast meat or for warmth. Temporary bomas are restricted to the very edge of the Forest Reserve and most morans are instructed by the elders to stay outside the Reserve at night. For the purpose of this study, morans' activities were monitored indirectly through the vegetation surveys, informal discussion and personal observation. Given their mobility and exclusivity, a detailed study was beyond the available time and resources of this study.

### *5.3.1.3 Livestock holdings and "nkaji"*

The usual definition of a household in a pastoral community as described above (an independent male producer and his dependants) has the advantage of corresponding closely with units of cattle ownership. Using the sub-household as the main analytical unit raises the problem of defining cattle holdings.

When a man marries he allocates a number of cattle to each wife. Similarly, livestock are 'given' both to the wife and to her children at set moments in their lives, such as when a child is born or circumcised (Spencer 1973). While the ultimate decisions concerning, for example, the sale or slaughtering of an animal rests with the man, the day to day milking, and often care of these animals when the man is not around, is the responsibility of the wife to whom the animals were allocated (or mother in the case of animals given to children). For this survey, it was made clear that the questions referred not to the man's entire stock, but to those animals to which the particular sub-household being surveyed had responsibility, - i.e. those cattle 'given' to the wife and her children. There was initial concern that this might be confusing to the respondents, but people seemed at ease with the definition, both during the pilot surveys when testing the questionnaire, and the actual surveys, suggesting the respondents' understanding of the questions were consistent within the limitations described.

Differences in livestock holdings between wives within the same household can be considerable due to differences in the initial number and quality of livestock given at marriage, differences in skill with which the livestock are managed and differences in losses over time due to disease or drought. Livestock holdings measured at the level of the sub-household, therefore, would arguably provide a more relevant measure of wealth among the community. The disadvantage of the measure is that livestock owned exclusively by the husband which are lent to others and/or not allocated to either a wife or his children would not be included in the final total.

### 5.3.2 Questionnaire design

Subjects covered by the questionnaire included:

1. household composition;
2. land holding size and crops grown for sale and home consumption;
3. livestock holdings;
4. the main sources of livelihood and economic activities; and
5. aspects of wild resource use.

**Household composition.** At Lpartuk and Ngorika all members of the household, family and non-family were recorded by gender and approximate age. Included in this section were questions about the gender and ethnicity of the household head [4].

Ethnicity was included in the survey due to the large population of displaced Turkana living around Maralal. These Turkana are essentially social or economic refugees driven from their original homes by economic necessity (such as the loss of an entire herd due to drought) or for protection against armed raiders (still a relatively common phenomenon in the area south of Lake Turkana). They have no rights to land in the area, few if any livestock, and rely heavily on relief food and short term employment or the sale of produce such as tobacco and charcoal for their livelihoods. The presence of these Turkana in the Maralal population is likely to result in lower mean measures of wealth such as livestock and land holdings. Identifying the ethnicity of the household head thus made it possible to establish whether there were differences in wealth between the villages taking this factor into account. The economic status of Turkana around Maralal does not represent that of the Turkana overall. Ethnic group as used here is a predictor of wealth, and within the current context of this study could also be defined as refugee status.

[4] The ethnicity of a sub-household was always defined according to the ethnic group of the household head, stated in the course of the surveys.

**Land holding size and crops.** The size of land holding was an estimate provided by the respondent. Where the respondent did not know, he or she would often ask the interviewer to assist in an estimation. The results are therefore very rough but do provide a clear idea of the general variation in land holding size. Any land fenced for fodder and the main crops grown on the shamba for home consumption and for sale were recorded as well as whether the sub-household employed any non-family members to work on the shamba.

**Livestock holdings** The problems associated with assessing livestock numbers in a pastoralist society have been discussed in some detail in chapter 2. Respondents were asked about specific parts of the herd in turn, in relation to their main uses, in an effort to improve accuracy of this data set. For example, questions on the number of cows currently in milk, unmilked cows and heifers were asked at the same time as a discussion of milk availability at the time and in general.

Details on livestock numbers held both at the homestead and elsewhere[5] and the number of animals which had been bought, sold or had died (due to disease or slaughter) were also asked of a sub-sample of households during multi-round surveys (with five repeats in the course of the year) at Ngorika and Lpartuk described in detail in chapter six. As well as providing data on seasonal differences in herd management, this data set also provided a cross check on livestock numbers quoted in the course of the baseline surveys. These multi-round surveys found considerable variation in livestock holdings during the course of the year, with an oscillation in both cattle and small stock herd size. The results and analysis of this data is shown in Box 5-1. In summary, livestock holdings peaked in July/August (the rainy season) and bottomed out in October - January (at the start of the dry season). The livestock data from the baseline surveys are used throughout the rest of this thesis to ensure comparison of like with like (in terms of interviewer familiarity) between the Maralal villages, and Ngorika and Lpartuk. However, the dynamic nature of livestock herd sizes should be

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[5] Only two households out of 25 interviewed at Lpartuk and Ngorika said that they had cattle kept away from the homestead at any time during 1994 (cf. Spencer, 1965, and his work with lowland Samburu communities). Field assistants confirmed that this was probably an accurate representation of the situation.

remembered, particularly when comparing data between Lpartuk/Ngorika and Tamiyoi/Loikas. Livestock holdings at Tamiyoi and Loikas were measured in August when holdings tend to peak according to the data in Box 5-1 (Table 1), whereas those of Lpartuk and Ngorika were taken in January when livestock holdings are at their lowest.

In addition to absolute numbers of cattle and small stock, Tropical Livestock Units defined by the International Livestock Centre for Africa (ILCA) are a useful way of defining one value for the entire livestock holding of any defined economic unit (Sellen 1995; cattle = 0.71 TLU, goats and sheep = 0.17 TLU). All three measures are used in the analysis.

**Main sources of livelihood and economic activities** A number of measures, such as type of roofing material; regular use of hired labour; degree of dependence on others for occasional assistance; and the main sources of income and livelihood (particularly when sources are irregular or risky) are frequently used as an indirect measure of a households disposable income and therefore wealth (Casley & Lury, 1987; Evers, 1994).

Type of roofing material used and use of hired labour were recorded in the baseline surveys. However, both were encountered too infrequently to be useful: at Lpartuk only two out of the 36 households interviewed had a tin roof; at Ngorika there was only one; similarly, only three households at Lpartuk and one at Ngorika employed people to cultivate their land.

The respondents were also asked to give their four main sources of livelihood in order of importance. The word for livelihood in Samburu implies those activities which sustain life and would include both subsistence production, gathered resources and income. Factors such as risk and reliability would be incorporated in an individuals assessment of the importance of any economic activity and the final ranking would not necessarily represent a financial measurement of income or economic value.

Data on wild resource use are presented and analysed in Chapter six.

## Box 5-1 Examining the livestock data

Accuracy in estimating livestock holding estimates has been discussed in chapter two. The results of livestock surveys may become more reliable with time as the respondents became more familiar with the study and the interviewers. However, in addition to deliberately over-or under-stating livestock holdings on the part of the respondent, discrepancies in livestock numbers may arise due to natural variations in livestock holdings due to market transactions, changing seasonal distributions and intrinsic growth rates. This box examines variation in livestock holdings between surveys to establish the effects of survey type and timing on livestock estimates. Any such effects could have implications for the interpretation of results of the baseline survey data.

The results from the baseline surveys at Lpartuk and Ngorika were compared those from the multi-round surveys. The results are summarised in Table 1 below.

**Table 1** Mean livestock numbers by survey (data from sub-households taking part in both surveys)

| Survey | Ngorika | | | Lpartuk | | |
|---|---|---|---|---|---|---|
| | No of sub-hh | Mean Cattle/shh | Mean shoat/shh | No of sub-hh | Mean cattle/hh | Mean shoat/hh |
| **Baseline (Jan)** | 13 | 5.00 | 14.20 | 13 | 7.50 | 9.42 |
| **March** | 14 | 4.87 | 17.62 | | | |
| **July** | 14 | 5.23 | 17.69 | 12 | 9.36 | 16.18 |
| **August** | 13 | 9.75 | 23.67 | 11 | 11.90 | 21.90 |
| **October** | 13 | 6.17 | 16.42 | 13 | 4.17 | 19.00 |
| **January** | 10 | 4.70 | 14.10 | 11 | 5.70 | 12.10 |

Herd size varied considerably across the year (Table 1), peaking in July/August (the rainy season) and bottoming out in October and January (the start of the dry season). Variation in cattle herd size is less pronounced than that for small stock. Given the difficulties associated with getting accurate livestock holding estimates, it is impossible to rule out error due to misinformation without carrying out gate-counts (Homewood & Rodgers, 1991) which were beyond the scope of this study. However, the consistency in the trends across the two villages and for both livestock types suggests that this seasonal variation is not an artefact of the data and the non-linear nature of the change in herd size rules out familiarity with the interviewers as a cause for the changes.

The average number of cattle and shoats bought and sold per sub-household in the course of the year, are shown in Table 2. Overall, more cattle and small stock were sold than were bought. However, the difference was slight and cannot explain the oscillations seen in Table 1.

**Table 2** Mean livestock transactions per sub-household by village from January 1994-January 1995

| Village | Cattle | | | Shoats | | |
|---|---|---|---|---|---|---|
| | Total sold per shh | Total bought per shh | Net transac-tions per shh | Total sold per shh | Total bought per shh | Net transact-ions per shh |
| **Ngorika** | **1.4** | **1.0** | **-0.4** | **2.93** | **2.13** | **-0.8** |
| **Lpartuk** | **1.3** | **0.3** | **-1.0** | **3.38** | **3.0** | **-0.38** |

Seasonal movement of herds from Lpartuk and Ngorika was not extensive within the time frame of this study. There were reports of cattle from Lerroki being taken to the Matthew's Range in 1993 (DMP, 1993), however, if this movement was the main cause of the oscillations, the number of cattle present in January 1995 should have been much higher given the better range conditions at this time. This was not the case. The function of seasonal changes in spatial distribution in herds in causing this pattern is even less relevant for smallstock since they are not typically moved large distances.

The reason for the oscillations is, therefore, more likely to be related to real changes in livestock ownership due to seasonal transactions and changing birth rates in the course of the year. Unfortunately no data was collected on livestock birth rates in the course of this study.

Samples of all questionnaires are given in appendix three. The baseline and the seasonal resource use questionnaires were written in English, often with just single words to provide a prompt. Leaving the exact wording of a question to the enumerator introduces the problem of uncertainty as to how the question has been phrased. On the other hand, "If the respondent is puzzled by the question, but the enumerator is constrained in the clarification he can offer, puzzlement may turn into bewilderment and annoyance." (Casley and Lury 1987, p.87). The strategy of leaving the questions open was decided on during initial discussions with the interviewers. Many of the people to be interviewed would not have been questioned on such issues before and it was thought that some respondents would require more detailed explanation of some of the questions being asked. Gaining the full confidence of the respondents was considered of greatest importance in assuring unbiased information and this needed some flexibility on the part of the interviewer.

Interviewing, whether informal or through questionnaires is a methodological minefield, all the more so when the questions are initially posed in a foreign language (Oppenheim, 1992). In the course of the study, three Samburu men were employed to carry out both the baseline survey questionnaires and the multi-round forest use surveys. All had experience in working with people in various capacities: one was a qualified teacher of blind children, and the other two had done survey work with non-governmental organisations and all worked well with both men and women.

The questionnaires were piloted in the field in November 1993, with the help of the extended family of one of the field assistants. Where questions were unclear, did not follow a natural order, or where subjects were felt to have been omitted, adjustments were made and the adapted questionnaires tested again. Several changes were also made to the questionnaire layout to improve the clarity and ease with which the forms could be filled in with least distraction to the interviewer.

Before beginning the surveys in January, two days were spent introducing all three interviewers to the overall objective of the study and the baseline survey. Each section of the questionnaire was discussed - what was meant by, and the reasons for asking, each question. Finally the interviewer would practise on two or more members of his family. The interviewers knew each other well and worked together discussing terms and phrases to be used. To begin with they also worked in pairs. In this way I was confident that all households interviewed were asked the same questions in the way best suited to each interviewer.

### 5.3.3 The sample

Stratified random sampling techniques were used throughout this study. For the questionnaire surveys, the sample was stratified according to wealth following the wealth ranking techniques described by Grandin (1988) and Hill (1956).

The sampling frame was established in the course of a number of meetings with elders from each of the study villages. At Ngorika and Lpartuk, the heads of all of the base encampments were listed: 31 in the case of Upper Lpartuk and 33 in Ngorika. This list was then subdivided into a list of sub-households. The communities at Tamiyoi and Loikas (Maralal) were enumerated in a similar way with the exception that the Turkana population living in at Loikas (not present in Upper Lpartuk or Ngorika) had to be treated separately, since the Samburu elders initially approached by us claimed they had very little knowledge of the Turkana families and their economic status.

Other means of creating the sampling frame, such as the use of pre-existing lists used in the allocation of food aid were rejected once it became clear that these included several families who were not actually resident in the area. Using the method described also had the important advantage of ensuring that the list referred to households in the way defined for this study. The communities were both small enough and coherent enough for the method to be considered accurate.

The wealth ranking exercise was carried out separately for each village. The name of the head of each sub-household in the community (using the husbands name only where he had only one wife, the woman's name plus the husbands name where there was more than one wife, and the woman's name where the household was female headed) was written on to a piece of card. The cards were then handed to a small group of elders and the group was invited to put the cards into three or more piles representing the main wealth groups. It was emphasised that the ranking was to represent the wealth of the individual sub-households, i.e. the resources accessible by each wife, rather than those of the husband or head of the family. Once the cards were all used up, the elders were asked to go through each group again to allow them to make changes or confirm their original position. Finally the informants were asked to explain the criteria they had used in order to rank the households to enable a comparison between the different communities.

Once the cards had been ranked, they were divided into male and female headed households and a proportion (approximately 30% of each wealth category) was picked at random from each pile by the elders as from a down-turned pack of cards. The results of the wealth ranking exercise and the details of the sample selected are shown in Table 5.1.

Each household thus selected was visited once and interviewed using the questionnaire. Where the head of the household was present s/he was usually interviewed. When s/he was not present, the wife or a grown child was interviewed in his/her place. The results were analysed by gender of respondent to determine whether responses given by women or men were statistically different.

### 5.3.4 Data analysis of the baseline survey

The baseline survey measured two different types of data: quantitative data on a small number of clearly defined socio-economic variables (livestock holdings (cattle and smallstock herd size), area cultivated, and sub-household size); and qualitative data on the relative importance of different land-use and socio-economic activities (the proportion of households growing crops for home-consumption and for sale and the relative importance of different income sources).

Where the data were continuous and quantitative, multiple regression analysis was used to identify whether variation in the data at sub-household level could be explained by one or more of the following factors: village (Tamiyoi, Loikas, Ngorika or Lpartuk), ethnicity of household head (Samburu/Non-Samburu); gender of household head (male/female); and gender of respondent. The analysis was carried out using GLIM4 given its ability to deal with a mixture of categorical and continuous data and non-normally distributed data sets. Multiple regression using GLIM4 also allows the significance of a co-varying factor to be tested taking the other co-variables into account (Crawley, 1993). For example, it was possible to test for the significance of ethnicity taking the identity of the village into account and *vice versa.*

Analysis of the data on land-use and socio-economic activities was essentially descriptive and carried out at the village level. This data provided qualitative measures of differences in wealth status and economic activities to support the results of analysis of the quantitative measures described above.

Finally, the data from the baseline surveys were compared with data from the wealth ranking exercise to test the relative importance of the various socio-economic variables measured in local concepts of wealth. The methods used, results of the analysis and a discussion of the results are described in Box 5-2.

**Table 5.1** Results of the wealth ranking exercise: Ngorika and Lpartuk

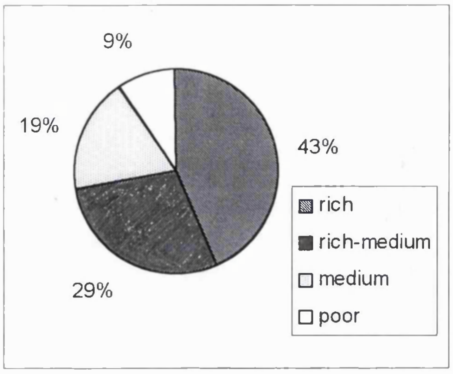
| Village | Rank | Definition[6] | No. of households in village by rank | % of total households in village | No. households in multi-round survey sample | prop of multi-round survey households as % of village total by rank |
|---|---|---|---|---|---|---|
| **Upper Lpartuk** | 1 | 40 cattle, 100-150 sheep and goats | 62 | 48% | 20 | 32% |
| | 2 | 10 cattle, 50 sheep and goats | 19 | 15% | 6 | 32% |
| | 3 | 1-2 cattle, 3-5 sheep and goats | 40 | 31% | 10 | 25% |
| | Unknown | | 7 | 6% | 0 | 0% |
| | **Total** | | **128** | **100%** | **36** | **28%** |
| **Ngorika** | 1 | Large herd of cattle - 50 cows | 51 | 43% | 17 | 33% |
| | 2 | 30 cows | 34 | 28% | 11 | 32% |
| | 3 | 5 cows | 22 | 20% | 10 | 45% |
| | 4 | 1 or 0 cows | 11 | 9% | 6 | 55% |
| | **Total** | | **118** | **100%** | **44** | **37%** |

[6] The livestock numbers used to define the ranks shown in Table 5.1 were those given during the exercise. They are clearly not definitive. For example, at Ngorika it is not clear from the table whether someone holding 40 cattle would be classified in rank 1 or rank 2. Wealth ranking is highly qualitative, and the final rank may depend on, for example the number of small stock he also owns or something as intangible as his standing in the community (Spencer, 1965; Borgerhoff-Mulder & Sellen, 1994).

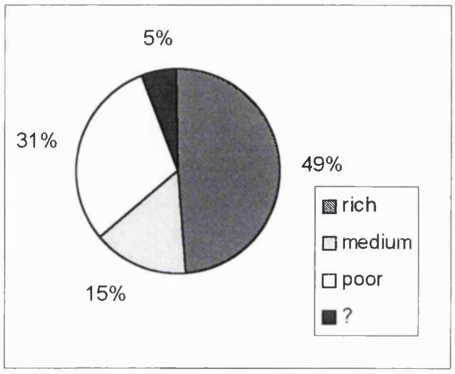
**Table 5.1** Results of the wealth ranking exercise contd.: Tamiyoi & Loikas

| **Village** | **Rank** | **Definition** | **No. of households in village by rank** | **% of total households in village** | **No. households in multi-round survey sample** | **prop of multi-round survey households as % of village total by rank** |
|---|---|---|---|---|---|---|
| **Tamiyoi** | 1 | 10 - 30 cows | 7 | 7% | 2 | 29% |
| | 2 | 1 - 3 cows and 2 - 4 sheep.<br>may have a son who works and some money | 25 | 26% | 11 | 44% |
| | 3 | No money, no livestock, no chickens | 64 | 67% | 15 | 23% |
| | **Total** | | **96** | **100%** | **28** | **29%** |
| **Loikas (Samburu)** | 1 | Has a plot of land & regular salary<br>50 head of cattle or 20 cattle & a large farm | 3 | 2% | 2 | 67% |
| | 2 | 10 cows & 30 shoats & farm | 14 | 12% | 3 | 21% |
| | 3 | 1-2 cows &/or 5 shoats<br>Makes charcoal for sale to save the one cow he/she has.<br>May have a small shamba. | 27 | 23% | 3 | 11% |
| | 4 | No cows, may have shoats (<5)<br>Includes people with nothing "not even a chicken". | 74 | 63% | 8 | 11% |
| | **Total** | | **118** | **100%** | **16** | **13%** |
| **Loikas (Turkana)** | 1 | Has a shop or butchery or any other kind of business | 3 | 7% | 3 | 100% |
| | 2 | Charcoal makers & beer brewers. Both risky - may miss a sale or get arrested.<br>May do odd jobs e.g. loading<br>Carvers selling to tourists.<br>May depend on salary sent from elsewhere, i.e. unreliable. | 11 | 26% | 5 | 45% |
| | 3 | Old people who cannot work and depend on charity | 29 | 67% | 6 | 21% |
| | **Total** | | **43** | **100%** | **14** | **33%** |

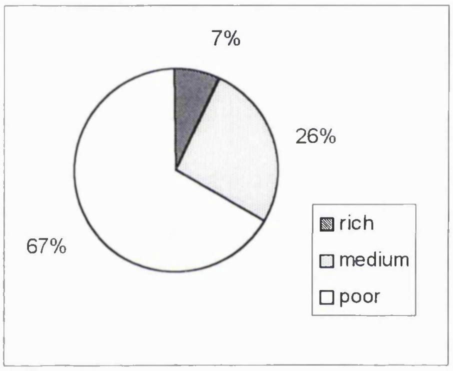
The results of the wealth ranking exercise show considerable differences between villages in the number of sub-households within each rank. These differences are shown diagrammatically in the pie charts below (Figure 5-2).



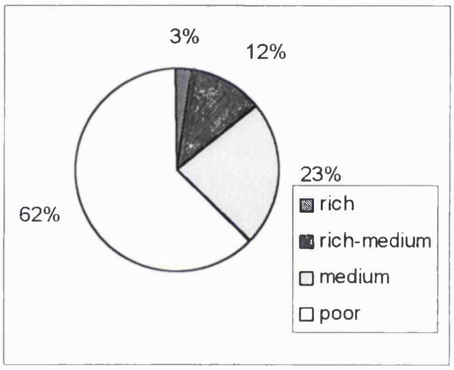

(a)




(b)




(c)




(d)

**Figure 5-1 a-d** Pie charts showing the proportion of sub-households within each wealth rank in each of the study villages: (a) Ngorika; (b) Lpartuk; (c) Tamiyoi / the Samburu population at Loikas (the results for Tamiyoi and Samburu sub-households at Loikas were identical); and (d) the Turkana population at Loikas. Proportions were calculated from the results of the wealth ranking exercise, shown in Table 5.1.

It is clear from the pie charts that the proportion of sub-households within the poorest strata form the minority at Ngorika and Lpartuk, whereas they form the majority at Tamiyoi and Loikas, both among the Samburu and non-Samburu populations.

## Box 5-2 Wealth and wealth ranks

Wealth ranks, defined by elders from the villages in the course of a wealth ranking exercise (summarised in Table 5.1) were used to stratify the sample frame.

Table 5.1 clearly shows that livestock numbers were the main criteria defining the wealth ranks at all four sites, with the exception of the Turkana at Loikas. Few of the Turkana owned any livestock, their status being almost that of refugees which would explain this difference. At Ngorika, in response to a question about the role of cultivation in determining a man's wealth once the exercise was finished one of the elders said:

> "Wealth is measured in terms of the number of livestock, primarily cattle and then sheep and goats. Number of children also counts. Cultivation is purely seasonal and does not count as wealth."

However, given the growing importance of cultivation in the area and the decline in livestock herds (chapter two), the wealth ranks defined by the elders were compared with other socio-economic variables to test the relative importance of cultivated area and sub-household size (and therefore labour availability) in local concepts of wealth.

Analysis was carried out using GLIM4. The definitions of ranks were very different between the four villages. Nested analysis of variance was therefore used to compare livestock and agricultural holdings and sub-household size across wealth ranks taking village identity into account (Loikas was split into two villages for this analysis given the different definitions of wealth rank).

Summaries for livestock holdings, area cultivated and sub-household size by rank and village are given at the end of this chapter in Table 5.9 and Table 5.10.

**Differences in distribution of wealth ranks across the study villages**

The proportion of sub-households in the poorest categories at both Tamiyoi and Loikas were very much greater than at Lpartuk or Ngorika. The results of the baseline survey show that poverty is indeed more acute around Maralal and the proportion of families relying largely on charity is much higher. There appear to be a greater proportion of sub-households within the richer categories and a smaller proportion of sub-households within the poorest category at Ngorika than at Lpartuk. However, this difference is difficult to quantify given the extra wealth rank defined at Ngorika.

**Sub-household size and wealth rank**

Sub-household size reflects labour availability - a crucial factor in pastoral production systems and one often thought of as closely associated with wealth (Sellen, 1995; Sperling, 1984; Grandin *et al.*, 1991). However, there was no significant relationship between sub-household size and wealth rank as defined by the elders.

**Land holding size and wealth rank**

There was, again, no significant relationship between the wealth ranks defined by the elders and the area under cultivation. A closer look at the results by village (shown in Table 5.10) suggests there are slight trends in area cultivated according to wealth rank within Lpartuk, Tamiyoi and Loikas but interestingly, these trends were not consistent. At Lpartuk and Tamiyoi and among the Turkana sub-households at Loikas, the wealthier sub-households have larger cultivated areas than the poorer sub-households, whereas the opposite is true of the Samburu sub-households at Loikas. There is no apparent trend at Ngorika.

**Land holding size and sub-household size**

Given the labour demands associated with land cultivation, one might expect a correlation between sub-household size and area under cultivation. A weak correlation was found at Ngorika ($r = 0.297$, $P = 0.050$), but not at Upper Lpartuk. Given the very small holding sizes these results suggest that the size of holding is not limited solely by the sub-household size - other factors may be more important.

**Livestock holdings and wealth rank**

Each livestock measure (cattle, small stock and TLU) and TLU per person was regressed with village and the interaction term for rank and village. In all three cases, the regression was significant (Table 1).

contd./p 197

**Table 1** Results of regression analysis of livestock holdings by rank, taking village identity into account

| Livestock type | χ2 | d.f. | P | % variance explained |
|---|---|---|---|---|
| **TLU** | 32.64 | 5 | <0.001 | 19% |
| **Cattle** | 35.63 | 5 | <0.001 | 18% |
| **Smallstock** | 17.79 | 5 | <0.01 | 15% |
| **TLU/person** | 23.37 | 5 | <0.001 | 13% |

Despite these correlations, the cattle herd sizes for Upper Lpartuk and Ngorika used to define wealth ranks in the wealth ranking exercise (Table 5.1) were very high compared with the results of the baseline surveys: from the wealth ranking table, more than 40% of all sub-households should have cattle herds of greater than 50 in both villages. This discrepancy could be due to a number of possibilities, the most likely being one or a combination of the following:

1. Livestock numbers given during the wealth ranking were overestimates based on ideals;
2. The herd size given during the baseline and multi-round surveys were grossly under-stated;
3. The ranks applied to the head of the family group who has overall control over all the smaller herds managed by their wives and married and unmarried sons, including "fora herds" (*sensu* Spencer, 1965), cattle kept in herds elsewhere, whereas the data in the baseline survey applied only to *nkaji*.

The wealth ranking exercise was carried out by groups of elders who would tend to know and reckon the overall herd 'belonging' to their contemporaries, rather than distinguishing as separate units the fragmented herds distributed amongst the smaller family units. Despite this, the elders were clear that the exercise was to rank sub-households (as testimony of this, members of the same larger family group were not always put into the same rank). The discrepancy in numbers from the ranking exercise and the surveys suggests that the elders preferred to reckon the household herd together, although they were well aware of the distribution of this herd among the smaller family units. The livestock numbers used to define the ranks in the two Maralal villages appear to reflect more closely the results from the baseline surveys. The groups ranking these sub-households were bigger and included women and younger men who would be more prepared to see herds in terms of small components allocated to smaller family units.

**Land holding size and livestock holdings**

A weak, but significant positive correlation was found between area under cultivation and livestock holdings (measured in TLU) ($F_{1,136}$=13.62, P<0.01, $r^2$=0.09).

**Discussion**

The only socio-economic variable that correlated with the wealth ranks defined by the elders were livestock holdings. Area under cultivation and sub-household size did not correlate with wealth rank overall despite the obvious importance of cultivated products to overall livelihoods in the area. At Tamiyoi and Loikas there did appear to be trends in area under cultivation, but the direction of the trends were not consistent. Data on area of land cultivated were estimates and therefore should be treated with caution, however, these results do reinforce the social importance the Samburu and the Turkana place on livestock and against cultivation in determining a sub-households social status (Hedlund, 1980).

Wealth ranks that do not take cultivation into account, as defined by elders, do not necessarily relate to a mans ability to support his dependants on the Plateau. Unfortunately no equivalent wealth ranking exercise was carried out among groups of younger men or women. Given their different priorities and pre-occupations, the results of such an exercise may well have been very different.

While wealth ranking may be a useful way of stratifying a sample, these results highlight the difficulty in using these definitions for ranks quantifiably. Categorising households by an arbitrary wealth measure (as typically used in rapid appraisal methods) tends to define households as "rich" or "poor". The results of this study has shown clearly that different villages and even different communities within the same village can have very different definitions of a "wealthy" and a "poor" household. With few, if any, households owning enough cattle to survive independently on livestock and livestock products alone (the aspiration of any pastoralist), such categories are highly relative.

The technique is, however, a useful way of establishing a stratified sample base from which more quantitative measurements of wealth can be made.

### *5.4 Results of the baseline survey*

Table 5.2 below summarises the results of the baseline surveys for the four study villages in terms of sub-household and village size, ethnic background and gender of household head, area cultivated and livestock holdings. The results for the Turkana population and the Samburu population at Loikas are shown separately.

These results and the results of the GLIM analysis are discussed in more detail below before the more qualitative data on economic activities and sources of livelihood across the four villages are presented.

A discussion of the results of the baseline surveys follows the presentation of the methods and results of the aerial photograph interpretation.

**Table 5.2** Summary of results from the baseline survey

| Village | Ngorika | Lpartuk | Tamiyoi | Loikas (Samburu) | Loikas (Turkana) |
|---|---|---|---|---|---|
| **Total number of sub-households (shh)** | 118 | 128 | 96 | 119 | 43 |
| **Number of shh in sample** | 44 | 36 | 28 | 16 | 14 |
| **Mean shh size (s.d.)** | 5.27 (2.17) | 4.81 (2.53) | 6.96 (2.38) | 7.60 (3.56) | 5.64 |
| **Estimated total population** | 622 | 616 | 668 | 881 | 243 |
| **% female headed household** | 7% | 27% | 25% | 41% | 36% |
| **Ethnic group of household head[a]** | 100% Sam | 97% Sam<br>3% Tug | 68% Sam<br>31% Tur | 47% Sam<br>3% Kik<br>50% Tur | |
| **Mean area cultivated in ha per shh (s.d.)** | 0.44 (0.31) | 0.57 (0.42) | 0.44 (0.43) | 0.16 (0.20) | 0.19 |
| **Proportion of shh owning shoats** | 98% | 94% | 57% | 50% | 14% |
| **Proportion of shh owning cattle** | 95% | 89% | 36% | 44% | 0% |
| **Proportion of shh owning any livestock** | 100% | 100% | 57% | 50% | 14% |
| **Mean no shoats per shh (range)** | 19.61 (0-150) | 15.65 (0-64) | 10.43 (0-64) | 17.93 (0-127) | 1.79 (0-20) |
| **Mean no of cattle per shh (range)** | 8.09 (0-27) | 11.14 (0-56) | 3.36 (0-27) | 2.24 (0-21) | 0 |
| **Mean no of TLU per shh (range)** | 9.1 (1.7-34.0) | 10.6 (0-51.7) | 4.2 (0-30.1) | 5.3 (0-36.5) | 0.3 (0-3.4) |
| **Mean no of TLU per person** | 1.72 | 2.27 | 0.60 | 0.63 | 0.05 |
| **Mean no of shoat per person** | 3.72 | 3.43 | 1.50 | 2.14 | 0.32 |
| **Mean no of cattle per person** | 1.54 | 2.38 | 0.48 | 0.27 | 0 |

[a]Sam = Samburu; Tug = Tugen; Tur = Turkana; Kik = Kikuyu

### 5.4.1 Population and sub-household structure

The four communities studied were similar in size, with the possible exception of Loikas due to its large immigrant Turkana population. The proportion of non-Samburu sub-households at Lpartuk and Ngorika was very low compared to the Maralal villages, and there was a significant difference in the proportion of Samburu and non-Samburu households interviewed in each village ($\chi 2 = 48.74$, d.f. = 3, $P<0.0001$, the proportion of non-Samburu interviewed at Ngorika, Lpartuk, Tamiyoi and Loikas being 0%, 3%, 11% and 47% respectively).

The mean sub-household size varied significantly across the four villages as shown below in Table 5.3 (Least Significant Difference test, $F_{3,134}= 6.102$, $P<0.01$). In summary, sub-households in both the Maralal villages were significantly larger than sub-households at both Ngorika and Lpartuk. However, there was no significant difference in sub-household size between Ngorika (5.27) and Lpartuk (4.81) and between the two Maralal villages (6.96 and 7.56 for Tamiyoi and Loikas respectively, taking the Samburu and Turkana population at Loikas together).

**Table 5.3** Significant differences in sub-household size using Least Significant Difference test

| | Ngorika | Lpartuk | Tamiyoi | Loikas[a] |
|---|---|---|---|---|
| **Ngorika** | - | n.s. | P<0.001 | P<0.001 |
| **Lpartuk** | - | - | P<0.001 | P<0.001 |
| **Tamiyoi** | - | - | - | n.s. |
| **Loikas[a]** | - | - | - | - |

a = Samburu and Turkana population combined

Mean sub-household size did not vary significantly with ethnic group of household head or gender of respondent alone. Sub-household size was slightly larger for male headed sub-households (mean of 6.08) as opposed to female headed sub-households (mean of 4.88), but this difference was not significant.

Difference in sub-household size is therefore best explained by the village within which the sub-household is found[7].

### 5.4.2 Direct measures of wealth

Table 5.2 shows considerable differences exist between the four villages in terms of land and livestock holdings. Overall, sub-households at Ngorika and Lpartuk are similar in terms of mean land and livestock holdings and tend to be richer than the sub-households from the two Maralal villages. Within Loikas, the Turkana clearly have less access to livestock and land as was suggested by the results of the wealth ranking exercise shown in Table 5.1.

The results of the GLIM analysis are discussed below for each variable in turn. The distribution of the livestock data closely resembled a Poisson distribution and the log-link function was used for all GLIM analyses of these data (Crawley, 1993).

#### *5.4.2.1 Land holding size*

In all villages, the proportion of sub-households in the baseline survey cultivating land was high: 98% in Ngorika; 97% in Upper Lpartuk; 81% in Tamiyoi and 60% in Loikas. The proportion of sub-households cultivating land at Loikas was lower than elsewhere, but within Loikas, the proportion cultivating land was the same for the Turkana and the Samburu populations. No household had an enclosed area specifically for providing fodder for cattle or small stock.

The size of land holding was an estimate provided by the respondent. Estimates were given by the respondents in acres and were converted to hectares for analysis. Where the respondent did not know the area, he or she would often ask the interviewer to assist in an estimation. The results are therefore very rough but do provide a clear idea of the general variation in land holding size.

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[7] In all cases, the "best fit" is necessarily limited to the explanatory variables and factors measured in the study. Given the complexity of human communities there will be countless other variables that could improve the fit of the model further.

The average area under cultivation in all the villages was relatively low: 0.18 ha in Loikas, 0.44 ha in Ngorika and Tamiyoi and 0.57 ha in Upper Lpartuk, with a maximum for any one sub-household of 1.61 ha. The mean area under cultivation per sub-household at Tamiyoi, Upper Lpartuk and Ngorika was significantly higher than that of both the Samburu and Turkana populations at Loikas (Least Significant Difference test, $F_{3,137} = 6.870$, $P < 0.0005$). There was no significant difference between Tamiyoi, Lpartuk and Ngorika. There was no significant relationship between mean area cultivated and ethnicity or gender of sub-household head when the village identity was taken into account. Again, difference in land holding size is best explained by the village within which the sub-household is found.

### *5.4.2.2 Livestock holdings*

Chi squared tests showed no significant difference in the proportion of sub-households owning livestock between Lpartuk (98%) and Ngorika (94%) and between Tamiyoi (57%) and the Samburu at Loikas (50%). The proportion of sub-households owning livestock at Lpartuk and Ngorika was significantly higher than that at Tamiyoi and Loikas (Samburu), while the proportion of Turkana sub-households at Loikas owning livestock was significantly lower than at all the other villages (14%. In all cases $P<0.0001$, 1 d.f.).

**Cattle**

The mean number of cattle per sub-household was significantly related to both ethnic group of household head (Samburu headed sub-household mean: 7.61; non-Samburu headed sub-household mean: 0.00; $\chi2 = 34.71$, d.f. = 1, $P<0.001$) and to village ($\chi2 = 14.65$, 3 d.f.) after model simplification in multiple analysis of co-variance.

Significant differences between the individual villages are summarised below in Table 5.4. In summary, (taking ethnicity into account) there was no significant difference in mean cattle herd size per sub-household between Ngorika (8.09) and Lpartuk (11.14) and between Tamiyoi (3.36) and the Samburu at Loikas (2.24), but sub-households from both Tamiyoi and Loikas have significantly fewer cattle than those at Ngorika and Lpartuk.

**Table 5.4** Significant differences in cattle herd size using least significant difference test.

| | Ngorika | Lpartuk | Tamiyoi | Loikas[a] |
|---|---|---|---|---|
| **Ngorika** | - | n.s. | P < 0.01 | P < 0.01 |
| **Lpartuk** | - | - | P < 0.01 | P < 0.01 |
| **Tamiyoi** | - | - | - | n.s. |
| **Loikas[a]** | - | - | - | - |

a = Samburu and Turkana population combined

**Smallstock**

Model simplification in multiple analysis of variance in GLIM found both ethnic group of household head and the gender of household head were significant factors in explaining variation in small stock holdings. (Mean for Samburu headed sub-households: 16.95; mean for non-Samburu headed sub-households: 1.35; $\chi 2 = 14.05$, 1 d.f., $P<0.01$. Mean for female headed sub-households = 5.92; mean for male headed sub-households = 16.64; $\chi 2 = 4.74$, 1 d.f., $P<0.01$). Mean small stock herd size did not vary significantly with village.

**Tropical Livestock Units (TLU)**

The results of the analysis for TLU matched those for cattle. The mean number of cattle per sub-household correlated significantly with both ethnic group and village after model simplification. (Mean for Samburu headed sub-household: 8.29; mean for non-Samburu headed sub-household: 0.2295, $\chi 2 = 16.28$, 1 d.f., $P<0.01$). The mean number of TLU per sub-household varied significantly with village in the same way as did cattle (Table 5.4. $\chi 2 = 9.34$, 3 d.f., $P<0.05$).

### *5.4.2.3 Summary*

The results of the analysis of the data from the baseline surveys bears out the initial impression of a significant difference in wealth across the four villages, with the two villages at Maralal (Tamiyoi and Loikas) significantly poorer than the two villages further away (Ngorika and Lpartuk).

Some of this difference can be explained by the differences in ethnicity between the two pairs of villages given the strong co-variation between village and the proportion of non-Samburu present[8]. However, ethnicity is better seen as a correlate of the differences in socio-economic composition between the two pairs of villages.

There was a significant relationship between ethnicity of the household head and mean cattle and TLU herd sizes, taking village identity into account. Taking ethnicity into account, mean cattle herd size was significantly higher at Lpartuk and Ngorika than in the Maralal villages, but there was no significant difference in herd sizes between Ngorika and Lpartuk, or between Tamiyoi and Loikas.

In contrast, there was no significant difference in overall means of smallstock herd sizes by villages, but there was a strong correlation with ethnic group of household head.

The timing of surveys is an important factor in determining livestock numbers and it has already been proposed that the timing of the surveys would probably have inflated the smallstock numbers at the Maralal villages (measured in August) relative to those at Ngorika and Lpartuk (measured in January). It is also possible that the mean smallstock herd size at Loikas was inflated for two other reasons: the sample interviewed contained a disproportionately large number of sub-households in the highest ranks; and one sub-household in rank 3 (i.e. relatively poor) had the largest livestock herd in the entire sample (the sub-household was clearly mis-ranked, probably deliberately: during the ranking exercises, there was a clear tendency for people present to try and rank themselves lower than appropriate).

Area under cultivation also varied significantly between the villages. However, unlike the livestock data, there was not such a clear difference between the two Maralal villages and Lpartuk and Ngorika. Sub-households at Tamiyoi cultivated similar areas to those at Lpartuk and Ngorika, while both Samburu and non-Samburu households at Loikas had significantly smaller farms.

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[8] It must be emphasised again, that ethnicity as used here is not an absolute measure - it cannot be said from these results that all Turkana sub-households are poorer than Samburu sub-households. The non-Samburu in the sample have been likened to a refugee population, settling in and around Maralal in response to economic hardship or political insecurity at their places of origin.

Sub-households were larger around Maralal. Differences in mean livestock and land holdings between the Maralal villages and Lpartuk and Ngorika level would, therefore, be even more pronounced at the per capita level.

### 5.4.3 Indirect measures of wealth

#### *5.4.3.1 Crop Production*

A summary of the crops grown both for sale and for home consumption is given below in Table 5.5. The main crops grown in for both areas are maize, beans, potatoes, kale and other vegetables.

The proportion of households that sell any crop is much greater at Lpartuk (72%) than at Ngorika (48%). This is a reflection of the greater market opportunities at Upper Lpartuk given its proximity to Maralal. Most of the crops sold in Ngorika are taken to Morijo - a small neighbouring village on the main Baragoi road where the potential market is very small when compared with Maralal.

However, the percentage of sub-households selling crops at Tamiyoi and Loikas are well below those for Ngorika. While access to a market is important, clearly having excess production to sell is of greatest importance. Smaller livestock herds and area under cultivation, together with larger sub-households at Tamiyoi and Loikas would increase dependence on agricultural production and could explain these differences.

The figures in Table 5.5 probably underestimate the number of sub-households that actually sell agricultural production on a very small scale. Many respondents said they did not grow a crop for sale. However, if they had a good year they would tend to try and sell some of their produce.

**Table 5.5** Percent of Sub-households growing crops for home consumption or for sale

| **Village** | **Upper Lpartuk** | **Ngorika** | **Tamiyoi** | | **Loikas** | |
|---|---|---|---|---|---|---|
| **Ethnicity** | **Samburu** | **Samburu** | **Samburu** | **Turkana** | **Samburu** | **Turkana** |
| **No of households** | 36 | 44 | 25 | 3 | 16 | 14 |
| **Crop** | **Percent of total sub-households growing crop for home consumption** | | | | | |
| Maize | 92% | 98% | 72% | 67% | 44% | 57% |
| Beans | 95% | 95% | 72% | 67% | 38% | 64% |
| Potatoes | 82% | 66% | 44% | 33% | 44% | 36% |
| Kale | 66% | 50% | 32% | 0% | 25% | 29% |
| Pumpkins | 18% | 16% | 8% | 0% | 6% | 7% |
| Onions | 16% | 41% | 4% | 0% | 13% | 7% |
| Cabbage | 16% | 2% | 4% | 0% | 0% | 0% |
| Other[a] | 22% | 30% | 56% | 33% | 25% | 43% |
| **Crop** | **Percent of total sub-households growing crop for sale** | | | | | |
| Maize | 21% | 18% | 0% | 0% | 6% | 7% |
| Beans | 18% | 9% | 4% | 0% | 0% | 7% |
| Potatoes | 24% | 5% | 4% | 0% | 6% | 7% |
| Kale | 45% | 23% | 0% | 0% | 6% | 7% |
| Pumpkins | 3% | 2% | 4% | 0% | 0% | 0% |
| Onions | 5% | 25% | 4% | 0% | 0% | 0% |
| Cabbage | 13% | 0% | 0% | 0% | 0% | 7% |
| Other[b] | 5% | 7% | 4% | 0% | 6% | 7% |
| **Any crop** | **72%** | **48%** | **12%** | **0%** | **6%** | **21%** |

[a] = Tomatoes, Green pepper, Peas, Green Gram, Sweet potato, Millet/ Sorghum
[b] = Green pepper, Peas, Green Gram, Sweet potato, Millet/Sorghum

### *5.4.3.2 Main sources of livelihood*

In the baseline survey, respondents were asked to give the main four sources of livelihood and the results are presented in Table 5.6 below. The word livelihood includes subsistence production, as well as other income and gathered resources and would include intangible factors such as risk and reliability in defining its importance to an individual. It does not necessarily represent a financial measurement of income or economic value. It is interesting and clearly illustrative of this fact that sub-households did not include relief food as an important source of livelihood.

While the results from the Ngorika and Upper Lpartuk are not very different, only 5% of sub-households in Ngorika placed their livelihood from crops before that from livestock, whereas 14% of sub-households in Upper Lpartuk put crops first. Since there is no significant difference in livestock holding size between the two villages (although the mean holding size is slightly larger for Upper Lpartuk), this result again reflects the importance of the distance to Maralal as a major market in the emphasis placed on cultivation of crops for sale.

Livestock provide an important source of livelihood to a much smaller proportion of the population in the two Maralal villages than at Ngorika and Lpartuk, consistent with the livestock holdings data above. The proportion of households quoting agriculture as an important source of livelihood is similar for all villages and all ethnic groups. However, the greater importance of earned income from the sale of charcoal, firewood and beer and from odd jobs in the two Maralal villages compared with Ngorika and Lpartuk clearly reflects the greater levels of poverty found in the preceding analysis of the socio-economic variables, as well as market opportunity.

A comparison of the main sources of livelihood of the Turkana and the Samburu at Loikas show some interesting differences between the two groups. In particular, the number of Turkana households depending on a regular salary (7%) is much lower than for the Samburu (37%), whereas the opposite is true of odd-jobs (79% of the Turkana households against just 19% of the Samburu households), charcoal making and brewing beer (in both cases, 64% of the Turkana households against 37% of the Samburu households), all of which tend to carry more risk and uncertainty. The main exception to this is the collection of firewood for sale which is more prevalent among the Samburu households.

On first analysis, forest products appear relatively insignificant as a source of income in Upper Lpartuk and Ngorika. However, if livestock are dependent on the forest even for a part of the year, then the forest assumes major importance when considering the local economy.

**Table 5.6** Percent of sub-households listing items as a major source of livelihood

| **Village** | **Upper Lpartuk** | **Ngorika** | **Tamiyoi** | | **Loikas** | |
|---|---|---|---|---|---|---|
| | | | Samburu | Turkana | Samburu | Turkana |
| **No of sub-households** | 36 | 44 | 25 | 3 | 16 | 14 |
| **Source of Income** | **Percent of total sub-households listing each source** | | | | | |
| Livestock | 84% | 98% | 56% | 0% | 50% | 21% |
| Crops | 57% | 55% | 64% | 100% | 50% | 57% |
| Cash aid (from friends/relatives ) | 35% | 23% | 32% | 100% | 25% | 21% |
| Salary | 22% | 14% | 40% | 0% | 37% | 7% |
| Milk | 11% | 0% | 0% | 0% | 0% | 0% |
| Charcoal | 5% | 0% | 16% | 33% | 37% | 64% |
| Local brew | 5% | 2% | 36% | 33% | 37% | 64% |
| Honey | 5% | 7% | 4% | 33% | 6% | 0% |
| Posts | 5% | 0% | 4% | 0% | 0% | 0% |
| Business | 3% | 5% | 4% | 0% | 6% | 14% |
| Pension | 3% | 0% | 0% | 0% | 0% | |
| Odd jobs | 0% | 0% | 28% | 33% | 19% | 79% |
| Kiosk | 0% | 0% | 0% | 0% | 0% | 0% |
| Carving | 0% | 0% | 0% | 33% | 0% | 0% |
| Blacksmith | 0% | 0% | 0% | 0% | 6% | 0% |
| Sale of firewood | 0% | 0% | 0% | 0% | 31% | 7% |

### 5.5 Methods - trends in housing and land use

Aerial photographs provide a useful historical record from which trends in settlement and land use patterns can be quantified over time.

This study draws on four sets of aerial photographs taken of the Lerroki Plateau which are summarised below in Table 5.7.

**Table 5.7** Aerial photography available for the Lerroki Plateau used in this study.

| Year | Agent | Scale | Cover |
|---|---|---|---|
| 1956 | Hunting Technical services for DOS (copy held at O.S.I., Southampton) | 1:30,000 | Samburu District |
| 1963 | Spartan Air Services for Survey of Kenya | 1:30,000 | Leroghi Forest Reserve |
| 1974 | RAF (copy held at O.S.I., Southampton) | 1:50,000 | Samburu District |
| 1993 | KIFCON for Survey of Kenya | 1:25,000 | Leroghi Forest Reserve |

The two comparative series of aerial photographs from 1963 and 1993 were interpreted by vegetation cover and used to investigate trends in vegetation cover over time. The methods and results of this analysis are described in chapter seven.

For the purposes of the present chapter, the 1974 and 1956 photographs (both held by Ordnance Survey International) and a selection of the 1993 photographs were used to examine trends in human settlement around the study sites in more detail. Every house or cluster of houses within a five kilometre radius of the centre of each study village (Ngorika, Lpartuk and Maralal for Tamiyoi and Loikas) was counted, with an estimate of the size of any fenced enclosures as a basis on which to estimate change in settlement patterns and, by association, in demands for building materials and other forest products in the last 40 years. These photographs were located and interpreted in the UK.

The number of enclosures at Maralal was discarded. Many of the houses in Maralal town itself were located in plots, which did not enclose livestock or a cultivated garden (*pers obs.*). Area enclosed at Maralal was measured only for those settlements further from the centre of town where cultivation was possible.

The differences in scale of the three sets of photographs are likely to affect the number of houses and fences that could be seen on the photographs. However, the scales for the three sites were the same within each year so differences between the study sites should reflect reality, if only in relative terms. It is also likely that some houses and enclosures would be obscured by vegetation. Again, this is likely to occur in all three locations and is not considered to create any systematic bias when comparing the data across the three villages.

Differences in rates of house construction and fencing of cultivated areas would reflect differences in woody resource use over the last 40 years that could greatly influence the current status of habitat distribution. The number of buildings does not necessarily reflect the number of people living in an area. However, an influx of people to an area (such as the Turkana moving to satellite villages around Maralal) is likely to have resulted in a rapid increase in the number of dwellings, over and above increases due to natural increase or the fragmentation of base encampments.

### *5.6 Results - trends in housing and settlement*

The overall results from the aerial photography interpretation are summarised below in Table 5.8.

**Table 5.8** Summary of results of aerial photo interpretation

| Parameter | Village | Total by year | Annual rate of increase | | | | |
|---|---|---|---|---|---|---|---|
| | | 1956 | 1974 | 1993 | 1956-1974 | 1974-1993 | 1956-1993 |
| **Scale of photos** | | 1:30,000 | 1:50,000 | 1:25,000 | | | |
| **No of enclosures** | Ngorika | 50 | 106 | 446 | 4.26% | 7.86% | 6.09% |
| | Lpartuk | 21 | 48 | 285 | 4.70% | 9.83% | 7.30% |
| | **Total** | **71** | **154** | **731** | **4.40%** | **8.54%** | **6.50%** |
| **No of houses** | Ngorika | 219 | 207 | 620 | -0.31% | 5.94% | 2.85% |
| | Lpartuk | 118 | 194 | 476 | 2.80% | 4.84% | 3.84% |
| | Maralal | 205 | 524 | 1432 | 5.35% | 5.43% | 5.39% |
| | **Total** | **542** | **925** | **2528** | **3.01%** | **5.43%** | **4.36%** |
| **Area enclosed (ha)** | Ngorika | 4.9 | 14.6 | 88.1 | 6.30% | 9.90% | 8.14% |
| | Lpartuk | 4.4 | 4.3 | 58.1 | -0.06% | 14.65% | 7.24% |
| | Maralal | 12.8 | 162.7 | 212.5 | 15.18% | 1.41% | 7.89% |
| | **Total** | **22.1** | **181.6** | **358.7** | **12.41%** | **3.65%** | **7.82%** |

Since the counts are total counts and not based on samples, it is not possible to make statistical comparisons of the data either by village or year. It is possible only to state the absolute increase in the number of huts and the area enclosed. The small scale of the 1974 photographs is likely to have reduced the number of houses that were visible on the photographs compared to the other sets of photographs. This would result in an underestimate the true rate of increase between 1956 and 1974 and an overestimate the true rate of increase between 1974 and 1993. The scale of the photographs from 1956 and 1993 were very similar and comparison of the data from 1956 and 1993 would be less susceptible to this bias.

The rates of increase in the number of houses and the number of enclosures around all three study sites since 1974 were considerably greater than the population growth rate for the area over a similar period (2.57% per annum from 1969-1989 for Lerroki and Karissia Divisions, chapter two). The problem of overestimating the rates of increase over this period due to differences in scale must be taken into account. However, even taking the overall rates of change from 1956 to 1993, the number of houses and the area under cultivation has increased at a greater rate than the population, with the possible exception of housing at Ngorika.

The overall rate of increase in the number of houses at the three sites between 1956 and 1993 is highest at Maralal (5.39% per annum) and lowest at Ngorika (2.85% per annum). This can in part be explained by the immigration of both non-Samburu and Samburu into the Maralal area recorded over the last 20 years (chapter two). However, comparison between the rate of increase from 1956 to 1974 and the rate of increase from 1974 to 1993 suggests that this difference in the rate of construction between villages is decreasing (the different scales of the aerial photographs analysed in each year may affect the absolute numbers of buildings seen within each area, but the relative differences between areas would be equivalent). In the last 20 years, the number of houses at Ngorika has been growing marginally faster than at Maralal and considerably faster than at Lpartuk. This increase in housing in the more rural areas relative to the overall population reflects both the trend towards smaller households in agro-pastoral areas (chapter two) and the construction of granaries (which will appear as small huts on the photographs and would have been counted as such) as cultivation becomes increasingly important.

In terms of absolute numbers, the increase in the number of houses built at Maralal in the last 40 years is much greater than in the other villages: In 1993 there were 1,227 more houses around Maralal; 401 more houses around Ngorika and 358 more houses around Lpartuk than there had been in 1956.

It was not possible to differentiate between enclosures for livestock and enclosures for cultivation. However, given the decline in livestock numbers over this time period (chapter two), any increases in area enclosed is likely to be due to land being brought under cultivation. The annual rate of increase in area enclosed at Maralal has reduced from 15.18% in the 18 years from 1956 to 1974 to just 1.41% per annum from 1974 to 1993. In contrast, the annual rate of increase in area enclosed at both Ngorika and Lpartuk increased in the same period from 6.3% to 9.9% at Ngorika and from -0.06% to 14.65% at Lpartuk.

The mean number of structures within each household averaged 1.51 at Lpartuk and 1.53 at Ngorika (data from the baseline survey). From these estimates and the data in

Table 5.8 the mean enclosed area per household is 0.22ha at Ngorika and 0.18ha at Lpartuk. These estimates are considerably less than those from the baseline survey, although they also show little difference between the two villages.

## 5.7 Discussion

### 5.7.1 The baseline survey

Sub-households at Lpartuk and Ngorika are wealthier than their counterparts at Tamiyoi and Loikas in terms of livestock holdings (both actual and per capita) and land holdings. This difference in wealth status is also reflected in the prevailing economic activities at each village, with short term employment and income generating activities such as beer-brewing and charcoal making much more common among sub-households from the two Maralal villages than Ngorika and Lpartuk and among the Turkana households than the Samburu households.

Livestock holdings per capita in all four study villages are well below the minimum required for a person to live primarily on pastoral production, estimated at roughly 6 cattle (4.26 TLU) per person (Dahl & Hjort, 1976). The mean number of TLU per person in the Samburu households around Maralal (0.6) resembles that of Kenya's mixed farming regions, whereas the figures for Ngorika (1.72) and Lpartuk (2.27) are mid-way between the mean for the mixed farming regions and for pastoral regions (3.6, de Leeuw *et al.*, 1991)

The mean area cultivated by all sub-households, irrespective of village is small, less than 0.5ha. All cultivation is by hand and there is little if any investment in inorganic fertilisers or pesticides outside of the large scale wheat farms. Manure, particularly that of small stock, is piled and then disposed of by burning and there is no perception or evidence of declining fertility in the area. Cultivation is clearly used as a means of supplementing pastoral production rather than replacing it. The Samburu on the Plateau remain pastoralists who cultivate rather than agro-pastoralists with a closely integrated mixed crop-livestock farming system (*sensu* Sperling & Galaty, 1990). Cultivation has similarly been adopted in other pastoral communities where livestock numbers have decreased, as a means of reducing risks due to climatic and economic uncertainties (Bayer & Waters-Bayer, 1994).

### 5.7.2 Displaced pastoralists, ethnicity and wealth

Some of the differences in wealth levels between the villages can be explained by the ethnic composition of the villages. However, even taking ethnicity of the sub-household into account there are still fundamental differences in wealth between the two areas, i.e. the Samburu at Tamiyoi and Loikas are poorer than their equivalents at Lpartuk and Ngorika.

The influx of poor pastoralists to towns in search of employment or an alternative source of livelihood is not unique to Maralal. Hogg (1987) has described similar populations around irrigation schemes in Turkana District where poor pastoralists were attracted to the schemes because of the shops and opportunities for trade and wage labour. Sikana *et al.* (1993) also note a tendency for wealthier herd owners to settle in trading centres to "maximise access to trading information networks as well as enjoy the amenities offered by urban life". These wealthy herd owners would keep the bulk of their herd at distant camps where forage availability is higher. It is possible, therefore, that some of the wealthier Samburu living at Tamiyoi and Loikas have cattle elsewhere which would not be recorded as it would not immediately be available to the sub-household. However, there is little doubt that many of the Samburu pastoralists living around Maralal as well as the Turkana households are genuinely poorer households, driven towards trading areas by necessity, rather than through a strategic choice (Sikana *et al.*, 1993).

While the main discussion on the effects of market demand and accessibility on resource use has focused on direct economic effects, such as lower opportunity costs (e.g. Sikana *et al.*, 1993; Abbot, 1996) the presence of a market may alter the effectiveness of local management institutions which could in turn alter observed levels of wild resource use (Shepherd, 1992). Greater demands on resources due to the presence of a market may make effective natural resource management harder while greater involvement in business activities can change the priorities of those members of the community responsible for natural resource management. Fairhead & Leach with Millimouno & Kamano refer to "the emergence of an anarchic charcoal-making and fuelwood business to supply the urban demand" as a factor responsible for "institutional disruption" (1994: 65). In the same report they discuss how "[m]odern poverty is thought to contribute to unsustainable resource use by forcing villagers to sacrifice long-term resource management for short-term uses to meet immediate needs".

Elders from Lpartuk responsible for natural resource management were frequently absent from the village, whereas elders at Ngorika were nearly always around the village and appeared to take a greater interest in their natural resources. Elders from both villages agreed that local institutions involved in natural resource management at Lpartuk were less efficient than those at Ngorika, in part due to the frequent absence of the elders, but also due to the pressure of illegal charcoal burning and pole cutting to meet the ready demand at Maralal. It is very hard to quantify the effectiveness of local institutions and resource management systems and the impacts of these institutions on levels of resource use. This study has focused on factors that are more easily measured, i.e. levels of poverty, geographical location. However, the role of resource management in forest conservation is important and will be discussed further in the course of this thesis.

### 5.7.3 Markets, poverty and the implications for wild resource use

The location of the study villages were chosen on the basis of their distance to Maralal. At the start of the study, it was proposed that distance to Maralal would be related to the potential for sub-households and individuals to market wild resources. Marketing of wild resources has been found to be a major factor in reducing sustainability of wild resource use (e.g. Cunningham, 1992). The results of this survey suggest that in addition to greater access to the market at Maralal, the people of Tamiyoi and Loikas have much greater need of cash with which to supplement their basic requirements, needs which can be potentially fulfilled by the exploitation of forest products either directly (such as firewood and charcoal) or indirectly (such as beer-brewing and blacksmithing, both of which demand high fuelwood consumption).

Little difference was apparent in levels of overall wealth between Ngorika and Lpartuk. Therefore any differences in levels of wild resource use between these two villages is likely to be due to different market demands given their accessibility from Maralal (Sikana *et al.*, 1993; Falconer, 1992). Higher levels of resource use in the two

Maralal villages may be due to market demands. However, the effect of market demands on resource use may be compounded by the wealth effects due to the comparative poverty of the Maralal villages. The effect of poverty on resource use, therefore, can only be measured by comparing levels of resource use by sub-households within the villages.

### 5.7.4 Trends in housing and settlement patterns

The annual rate of increase in the number of houses from 1974 to 1993 was greater than the annual rate of population increase from 1969 to 1993 in all three study areas. There has been a trend towards decreasing household size in the Maasai from both Tanzania and Kenya and in the Samburu which has been associated with individualisation of production, (Grandin *et al.*, 1991; Sperling 1987). Data on the magnitude and timing of this decrease is vague, but is thought to have occurred since the creation of the group ranches in Maasai land (Grandin *et al.*, 1991), and current estimates of household size appear to be half to one third of their values from around 30 years ago. Fragmentation of households into smaller entities at this scale could account almost entirely for the changes seen in the number of houses since 1974 in all three sites (although the different scales of the photographs may also confound this result). The overall effect, however, whether the population itself has increased or not has been a massive increase in housing which can be translated into a massive increase in demand for construction materials.

The decline in rate at which land is becoming enclosed around Maralal probably reflects a saturation of cultivable land. This may account for the smaller shamba sizes recorded at Loikas in the baseline surveys for both Samburu and Turkana households. (However, it is not clear why there should be a difference in shamba size between Loikas and Tamiyoi.) By comparison, the area being brought under cultivation every year around Lpartuk and Ngorika was much higher in the period from 1974 to 1993, than from 1956 to 1974, which supports the assumption of a growing interest in cultivation over this time.

## 5.8 Conclusions

The results of the baseline survey suggest considerable differences between the villages in terms of the wealth and status of the sub-households within them, which could also affect natural resource use. One striking difference between the two villages at Maralal and the two more distant villages is the presence of a large population of Turkana refugees with few if any livestock and little status within the communities. There are differences in wealth between the two Maralal villages and the two more distant villages, however, above and beyond those caused by the presence of this refugee community. The Samburu at Maralal were, according to the baseline surveys, significantly worse off than their counterparts in villages further from the town, particularly in terms of livestock holdings, and to a lesser extent in terms of the area under cultivation. It has been proposed that this may in part be due to households keeping livestock elsewhere, but it is also likely that poorer households have settled closer to the town out of necessity given the greater opportunities for employment or alternative sources of livelihood (Hogg, 1987; Sikana *et al.*, 1993).

Evidence from the literature suggests that poorer households have a greater dependence on wild resources. On the basis of these results, resource use at Maralal should be higher than at either Ngorika or Lpartuk irrespective of access to markets given the socio-economic status of the local community. However, the presence of the market is likely to exacerbate this difference. The similar levels of wealth among sub-households at Ngorika and Lpartuk would suggest that difference in observed levels of wealth in these two villages may be ascribed to the differences in accessibility. The effects of wealth on wild resource use can be tested, controlling for market effects, by comparing levels of resource use at the sub-household level within villages.

The effects of wealth and markets on levels of forest resource use will be tested in chapter six on the basis of the data presented in this chapter. The long term effect of demand for construction materials will be tested using evidence from aerial photography interpretation in chapter seven.

Table 5.9. Average livestock holdings by village and rank

| Village | Rank | Cases (Turkana) | TLU | | Cattle | | Smallstock | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | Range | Mean | Range | Mean | Range |
| **Ngorika** | 1 | 17 | 10.81 | | 10.00 | | 21.82 | |
| | 2 | 11 | 10.48 | | 10.91 | | 16.09 | |
| | 3 | 10 | 8.06 | | 5.20 | | 25.7 | |
| | 4 | 6 | 3.30 | | 2.33 | | 9.67 | |
| | **Overall** | **44** | **9.08** | **1.70-34.02** | **8.09** | **0 - 27** | **19.61** | **0 - 150** |
| **Upper Lpartuk** | 1 | 20 | 14.88 | | 15.90 | | 21.15 | |
| | 2 | 6 | 6.26 | | 6.00 | | 17.67 | |
| | 3 | 11 | 4.19 | | 4.70 | | 7.73 | |
| | **Overall** | **37** | **10.64** | **0-51.66** | **11.14** | **0 - 56** | **16.08** | **0 - 70** |
| **Tamiyoi** | 1 | 2 | 7.34 | | 6.50 | | 16.00 | |
| | 2 | 11 | 6.55 | | 6.09 | | 13.09 | |
| | 3 | 15 | 1.98 | | 0.93 | | 7.73 | |
| | **Overall** | **28** | **4.16** | **0-30.05** | **3.36** | **0 - 27** | **10.43** | **0 - 64** |
| **Loikas** | 1 | 2 | 12.11 | | 7.00 | | 42.00 | |
| | 2 | 3 | 12.69 | | 7.33 | | 44.00 | |
| | 3 | 3 | 6.44 | | 5.00 | | 17.00 | |
| | 4 | 8 | 0.49 | | 0.13 | | 2.38 | |
| | **Overall** | **16(14)** | **5.27** | **0-36.50** | **2.24** | **0 - 21** | **17.93** | **0 - 127** |
| **Loikas (Turkana)** | 1 | 3 | 1.42 | | 0.00 | | 8.33 | |
| | 2 | 5 | 0.00 | | 0.00 | | 0 | |
| | 3 | 6 | 0.00 | | 0.00 | | 0 | |
| | **Overall** | **14** | **0.30** | **0 - 3.40** | **0.00** | **0** | **1.79** | **0 - 20** |

**Table 5.10** Area under cultivation by village and rank (from baseline survey)

| Village | Rank | No of cases | Mean area cultivated (ha) | s.d. |
|---|---|---|---|---|
| **Ngorika** | 1 | 17 | 0.49 | 0.30 |
| | 2 | 11 | 0.39 | 0.43 |
| | 3 | 10 | 0.47 | 0.19 |
| | 4 | 6 | 0.37 | 0.27 |
| **Ngorika overall** | | **44** | **0.44** | **0.31** |
| **Upper Lpartuk** | 1 | 20 | 0.65 | 0.49 |
| | 2 | 6 | 0.54 | 0.40 |
| | 3 | 10 | 0.48 | 0.20 |
| **Upper Lpartuk overall** | | **36** | **0.57** | **0.42** |
| **Tamiyoi** | 1 | 2 | 1.2 | 1.14 |
| | 2 | 11 | 0.38 | 0.31 |
| | 3 | 15 | 0.39 | 0.34 |
| **Tamiyoi overall** | | **28** | **0.44** | **0.43** |
| **Loikas (Samburu)** | 1 | 2 | 0.10 | 0.14 |
| | 2 | 3 | 0.14 | 0.23 |
| | 3 | 3 | 0.17 | 0.21 |
| | 4 | 8 | 0.19 | 0.17 |
| **Loikas (S) overall** | | **16** | **0.16** | **0.17** |
| **Loikas (Turkana)** | 1 | 3 | 0.33 | 0.42 |
| | 2 | 5 | 0.12 | 0.17 |
| | 3 | 6 | 0.17 | 0.15 |
| **Loikas (T) overall** | | **14** | **0.19** | **0.23** |

**Table 5-11** Mean household size by village and rank (from baseline survey)

| Village | Rank | No of cases | Mean household size | s.d. |
|---|---|---|---|---|
| **Ngorika** | 1 | 17 | 4.94 | 1.78 |
| | 2 | 11 | 4.18 | 1.72 |
| | 3 | 10 | 5.9 | 2.33 |
| | 4 | 6 | 7.17 | 2.56 |
| **Ngorika overall** | | **44** | **5.27** | **2.17** |
| **Upper Lpartuk** | 1 | 20 | 4.75 | 2.49 |
| | 2 | 6 | 4.17 | 2.48 |
| | 3 | 10 | 4.90 | 2.60 |
| **Upper Lpartuk overall** | | **36** | **4.81** | **2.53** |
| **Tamiyoi** | 1 | 2 | 7.00 | 2.83 |
| | 2 | 11 | 7.91 | 2.59 |
| | 3 | 15 | 6.27 | 2.09 |
| **Tamiyoi overall** | | **28** | **6.96** | **2.38** |
| **Loikas (Samburu)** | 1 | 2 | 9.50 | 2.12 |
| | 2 | 3 | 8.67 | 4.04 |
| | 3 | 3 | 10.67 | 6.43 |
| | 4 | 8 | 7.00 | 2.88 |
| **Loikas (S) overall** | | **16** | **8.31** | **3.75** |
| **Loikas (Turkana)** | 1 | 3 | 5.67 | 2.52 |
| | 2 | 5 | 6.40 | 3.36 |
| | 3 | 6 | 5.00 | 2.83 |
| **Loikas (T) overall** | | 14 | 5.64 | 2.82 |

# 6. Markets, poverty, forests and wild resource use

## 6.1 Introduction

This chapter looks at overall levels of use of wild and forest resources by the forest-adjacent community. Levels of wild resource use are investigated in the context of sub-household wealth, access to market and seasonality. The importance of closed canopy forest as one of many habitat types in supplying these resources is also assessed.

The potential importance of wealth and market demands on wild resource use were introduced in chapter five. In summary, evidence from the literature suggests that as distance to markets decreases, the opportunity costs of time spent travelling to markets are also lower, which encourages higher levels of resource use. This in turn accelerates degradation of the resource base (Sikana *et al.*, 1993; Cunningham, 1993). Access to markets often implies access to a road system (Allen & Barnes, 1985; Cline-Cole *et al.*, 1990; Shepherd, 1992). Poorer sub-households, with limited resources to meet contingencies and short term needs, may rely on natural resources to a greater extent than wealthier sub-households (Chambers & Leach, 1987). This relationship is not always found, however, particularly where communities are isolated and there are few alternatives to wild resources (Evers, 1994). Moreover, the effect of wealth on natural resource use can fluctuate with seasonal periods of stress (Koppell, 1992).

In the next section, a literature review outlines the general importance of wild resource use to forest-adjacent communities, the seasonality of wild resource use and the importance of different habitats in providing wild resources. The hypotheses and predictions examined in the course of this chapter are then stated explicitly and the methods used to gather the data to test these hypotheses are described. The results are presented in four main sections: resource use and markets; seasonality of resource use; resource use and wealth; and habitat selection in resource use. The effects of market access, wealth and seasonality are, to some extent, inter-related, and the results relating to these factors are discussed together with a review of the hypotheses presented at the start of the chapter. The results and discussion relating to habitat selection (i.e. the relative importance of closed canopy forest) and availability follow. Finally, the implications of these results for forest management are briefly summarised in the conclusion.

## *6.2 Context*

Forested areas are often isolated, with poor access to markets, and forests can provide a valuable source of a wide range of products to communities in such areas (Godoy & Bawa 1993, KIFCON, 1994). The use of forest resources by communities living close to forest areas has been extensively studied and documented (e.g. Koppell 1992, Hartley, 1992, Cunningham *et al.* 1993, Nepstad & Schwartzman 1992; Carter, 1996; Hughes, 1987; Evers, 1994; Abbot, 1996; Fairhead & Leach, 1994; Kiwasila & Odgaard, 1991).

Documentation of ethnobotanical studies has traditionally been in the form of lists of plants with local uses (e.g. Morgan, 1981; Becker 1986 and Heine *et al* 1988 for Samburu; see also Fleuret, 1980; Prance, 1991). However, listing the potential uses of wild plants does not provide any measure of the actual, current importance of the resource. For example, a general decline in interest and knowledge of wild resource use in younger generations has been proposed in the literature (e.g. Brokensha & Riley, 1980; Ogle & Grivetti 1985; Dei *et al.*, 1989; Evers, 1994) although Fleuret (1979) questions whether such reports of a general decline in wild food use is justified.

Listing the uses made of wild plants alone also cannot provide any measure of the potential impact of that use. With increasing concerns over the degradation of natural resources and sustainability of natural resource use, a more holistic approach has become more common, looking at natural resource use in an ecological context (e.g. Heine *et al.*, 1993; Bronner, 1992, for Samburu; also Medley, 1993; Smiet, 1992; Hall & Rodgers, 1986; Shackleton, 1993). An ecological approach to wild resource use implies an interest in the long term sustainability of that use which needs a proper impact assessment. A complete impact assessment of forest resource use requires quantification of both resource use and resource availability (Cunningham, 1992). Quantifying resource use needs data on the quantities collected, the plant parts used, the time of year they were collected, the number and type of people using the resource, and long term trends in demand for the product (Carter, 1996). Quantifying resource availability requires long term phenological and population studies of the entire plant communities involved (Carter, 1996; Cunningham 1992). These are beyond the scope of most studies, including the present one. In this study, patterns of spatial and temporal variation in socio-economic parameters and current and historical levels of resource use (around Maralal, Ngorika and Lpartuk) were used together with data on spatial variation in long term vegetation change (from the analysis of aerial photo interpretation) to generate insights into the relative importance of wild resource use in determining vegetation cover.

### 6.2.1 Defining wild resources

Many useful forest species are either found outside forest habitats or else may be substituted with other species that are (Koppell, 1992; Fairhead & Leach, 1994; Evers, 1994). The resource use surveys in this study therefore included a wide range of *wild* resource uses, not necessarily specific to forests. Using information gathered on the source of all wild resources collected, the relative importance of forest compared to other habitats could be extracted from the data for specific categories of resource use.

The wide variety of uses made of wild resources makes it necessary to categorise use. The study included, as far as possible, all non timber forest products (*sensu* Falconer & Arnold 1988) and timber products extracted at the sub-household level. Using too many categories creates problems in analysing and interpreting data (Medley, 1993), but combining the categories can result in important information being lost (cf. Prance 1988). For example, firewood and charcoal would easily sit within one category of fuel wood. However, firewood is often preferred as a fuel type in rural areas, while charcoal, made in rural areas, tends to be sold to urban areas (Mung'ala & Openshaw, 1982; this study). Informal discussions with informants from the local communities, officers from the Forest Department and other local informants established appropriate categories of wild resource use made of the forests and other habitat types on Lerroki. The 24 categories identified included: wild fruits and vegetables, firewood, charcoal, poles and posts for house construction, wild honey, human and veterinary medicines[1], basketry (mainly donkey baskets) and household tools. All 24 categories were used in the surveys. Some categories were then combined in the course of the analysis, to ease interpretation, where no important differences between them were identified.

### 6.2.2 Seasonality of wild resource use

Seasonal cycles result in cycles of primary production which in turn create cycles of labour requirements, input requirements, and availability of food and income (Raikes, 1981). This seasonality in supply and demand may indirectly affect the market value of agricultural products. For example, the price of livestock per animal is highest in the rainy season, when requirements for purchased products are lowest, and slumps during the dry season when pastoral produce is scarce and demands for purchased products are high (e.g. Kerven, 1992).

Periods of seasonal stress, when food and labour demands are highest and supplies lowest, are not necessarily the same for pastoral and agricultural communities. In pastoral communities, production is lowest and labour demands are highest in the dry season (Swift 1981). In agricultural communities, the lean period is the start of the agricultural season or pre-harvest when the previous harvest has run out and labour demands associated with preparing fields for cultivation are at their highest (Dei 1989). Agro-pastoral communities should benefit from this difference by maintaining a food supply throughout the year (Bayer & Waters-Bayer, 1994). However, this is largely dependent on producing a big enough harvest to last the dry season and on labour constraints.

The importance of access to wild food resources during these lean periods is well documented for both pastoral and agricultural communities (*e.g.* reviewed in Scoones *et al* 1992; Koppell 1992; Maikhuri & Ramakrishnan, 1991; Thomas & Leatherman, 1990; Campbell 1987).

Swift (1981) differentiates between this regular seasonal stress and variability in climate from year to year. In climates with a high coefficient of variation in mean

[1] most households would collect their own medicinal plants although there were people who were acknowledged as having a very good knowledge of medicinal plants and who would occasionally be sought out to give advice.

annual rainfall levels, this variability is a greater problem for local communities than the regular intra-annual fluctuations described above. Access to wild resources during these drought periods are of particular importance (De Garine & Koppert 1988).

Seasonality of wild resource use will be a function of supply as well as demand (Godoy *et al.*, 1995), particularly in the case of wild foods (Grivetti, 1979). Fruit and leaves of wild species are only available at certain times of the year, although Campbell (1987) found seasonality in fruit use in Zimbabwe correlated more closely with hungry periods than availability.

Availability of woody products, such as charcoal and poles and posts is less dependent on season and income from their sale may be an important strategy in alleviating seasonal stress. However, such a strategy carries the problem of competing for labour at critical periods. For example, Thomas and Leatherman (1990) found that communities in the Peruvian Andes preferred to conserve energy prior to the harvest than to undertake income generating activities.

Finally, provision of food under drought relief programmes will mitigate the impacts of seasonal stress and reduce reliance on wild resources, particularly when gathering wild resources carries high energetic costs (Campbell, 1987). Food rations on the Lerroki Plateau enable people to spend the time preparing their shambas for the start of the next growing season rather than expend valuable energy on the collection of wild resources. Sperling (1987b), in a study looking at drought response mechanisms in a Samburu community during the 1982-84 drought when relief food was distributed, found only limited levels of reliance on wild foods among both rich and poor.

### 6.2.3 Wild resources and habitats

This study focuses on closed canopy forest and emphasis in the analysis has been placed on forest products. However, while the closed canopy forest is the focus of conservation efforts, there is growing evidence that non-forest habitats may actually be preferred by local communities: secondary vegetation may offer greater species diversity and is often more accessible to the village (Koppell, 1992; Shepherd, 1992; Hartley, 1992; Castro, 1991; Prance, 1991; Fairhead & Leach, 1994). Castro (1991), discussing indigenous knowledge of wild resources states that the "knowledge of plant resources derived from close interaction with, and dependence on, a range of local ecozones". In the course of this study many women complained that the forest was not safe for them, mainly due to wild animals (particularly feared were elephants, buffalo and lion) and wild leaves such as *Amaranthus graecizans* (*'nterere'*) were encouraged to grow as weeds within cultivated plots as were wild fruits.

### 6.2.4 Generating hypotheses

In chapter five, the results of the baseline survey at Tamiyoi, Loikas, Ngorika and Lpartuk showed differences in overall wealth and market access within and between the study villages. The preceding discussion, together with those results, suggests a number of hypotheses for testing which relate the importance of market demands, season, wealth and habitat availability to levels of wild resource use on the Lerroki Plateau.

The following hypotheses are tested in the course of this chapter:

**Hypothesis 1**. Levels of wild resource use differ with respect to the market value of the resource and the distance from the village to the main market ('market access').

**Prediction 1**. Those resources with highest market values will be gathered with greater frequency at Lpartuk, which is situated on a main road and close to Maralal, than at Ngorika which is further from Maralal with poor road access.

**Hypothesis 2**. Wild resources provide the poorest members of the community with a way of meeting contingencies and daily needs.

**Prediction 2**. Overall levels of wild resource use and the frequency of marketable resource collection by the poorest sub-households will be higher than those of the wealthier families within villages.

**Hypothesis 3**. Collection of wild resources provides a buffer against seasonal shortages.

**Prediction 3**. Frequency of collection of marketable products will peak with need (towards the end of the dry season in January/February), although this may depend on the wealth of the sub-households (needs will be more acute for poorer households).

Frequency of collection of wild foods will relate to this need instead of, or as well as, seasonal availability.

**Hypothesis 4.** Levels of wild resource use are limited by the availability of labour to collect and process the resources.

**Prediction 4.** Wild resource collection overall should be lowest during the period of highest seasonal stress when food availability is at its lowest and labour demands at a peak. This may be over-ride the effects of seasonal needs suggested by hypothesis 3.

**Hypothesis 5**. There is habitat selection in the overall collection of wild natural resources which favours more open and species diverse habitats, irrespective of habitat availability.

**Prediction 5**. Overall, wild resources will be collected from all the different habitat types available. Secondary bush and shrub habitats, which offer the most diverse array of products, are likely to be the most important in terms of overall frequency, but this may depend on the resource use category and availability of the habitat in each area.

## 6.3 Methods

Wild resource use was investigated in the course of the baseline surveys in all the study villages and during multi-round surveys at Lpartuk and Ngorika. These surveys had two main objectives with respect to wild resource use:

1. to test hypotheses relating levels of forest resource use to access to markets, seasonality and household wealth; and
2. to establish the relative importance of closed canopy forest as a source of wild resources, relative to its availability.

During the baseline surveys at Ngorika and Lpartuk (January, 1994) and at Tamiyoi and Loikas (August, 1994), respondents were shown a number of picture cards depicting different categories of wild resource use, e.g. grazing of cattle or smallstock, collection of firewood or poles for construction, hunting and wild honey gathering (shown in appendix five). The respondent was asked to select the cards that showed a category of resource use that they, or any other member of the sub-household, ever took part in. For each picture thus selected, they were asked whether the resource was ever collected for sale and then to rank each resource use category in order of importance to the sub-household by placing the card in a line. These ranks were compared across villages and the results were given in chapter three. (p 95).

Fifteen of the sub-households interviewed during the baseline survey at Ngorika and Lpartuk were selected from each village according to wealth rank and the co-operation they had shown in the baseline, for multi-round wild resource use surveys. Each sub-household selected in each village was visited every day for a week on five separate occasions: in March/April, early July, late August and October 1994 and in January 1995.

Each day of the survey, a person from the sub-household (nearly always the female head of the sub-household) was shown the picture cards used in the baseline surveys and asked which category they or any other member of the sub-household had engaged in since the visit the previous day. For each activity they were asked which species was used, whether the resource was collected for home use or for sale, the type where the resource had come from and which member of the sub-household had gone for the resource.

Five vegetation types were defined at the start of the surveys on the basis of personal observations and discussions with the interviewers to ensure each vegetation type had a local currency, i.e. could be clearly defined in the vernacular. The vegetation types were loosely defined as: closed canopy forest; degraded/open bush forest, with an open tree canopy but a high woody cover overall; shrub/bush with high woody cover but a canopy between 1-3m in height; open shrub with lower woody vegetation cover <1m in height and some grass or open ground ; and open grassland. Schematic pictures of the five vegetation types were used for the surveys which the respondents could pick out rapidly for each reported wild resource use. The resource user was loosely categorised as adult man, adult woman, girl or boy.

The use of pictures had three major advantages: once the respondents had become familiar with them they could rapidly go through the pictures themselves picking out the activities done in the previous 24 hours which speeded up the interview; the pictures were always in a different order, reducing bias associated with a long list; and finally the pictures helped the respondent in recalling his/her activites.

These surveys thus provided data on:

1. frequency of natural resource use for a number of defined resource use categories for each sub-household at five times in the course of one year;
2. frequency with which different vegetation types were used (overall and by individual resource use categories) at different times of the year for each sub-household;
3. the diversity of species actually used; and
4. the main user groups.

Multiple visit formal surveys have a number of advantages (ILCA 1983): they provide data to test for seasonal fluctuations in levels of use; they are more likely to define actual events by delimiting a time span (i.e. between surveys); and the relationship built between respondent and interviewer can result in greater trust and a more ready flow of information. The disadvantages of repeated surveys are the reduced number of sub-households that can be visited (ILCA 1983) and the potential for the respondents to lose patience in the process if the survey starts to demand too much of their time (the "rejection effect", Beaton *et al.,* 1979).

The one-off questionnaire survey at Tamiyoi and Loikas in August used the same picture cards to ask whether any member of the sub-household had collected the resource within the last week and the number of days when the resource collection had taken place. Weekly recall is much less reliable than 24hr recall, particularly when considering day to day activities such as collecting firewood, or taking cattle to water. The use of any recall data, however, can be problematic given the difficulty in establishing error estimates (Bernard *et al.*, 1984). The implications of using different types of surveys are discussed below in Section 6.4.

### 6.3.1 Data analysis

A total of 24 different resource use categories taking place at sub-household level were defined. However, the low frequency of many of these were such that these were reduced to 18 categories: cedar bark (preferred as a thatching material); charcoal burning; firewood; poles and posts; timber; fodder and veterinary medicines; human medicines; honey and honey hives; rope; wild foods; water - shoats; water - cattle; grazing - shoats; grazing - cattle; other wood uses (furniture, cattle trough, carving, basket making, and household tools); and other general (hunting & cultural).

The total number of times each category was reported during the multi-round surveys was used to calculate a weekly frequency for each sub-household over the whole year and for each month surveyed. At Loikas and Tamiyoi a weekly frequency was calculated from the weekly recall during the baseline survey.

#### *6.3.1.1 Analysing the effects of markets and seasonality*

The frequency data were analysed using non-parametric techniques. Comparisons of the frequency of each resource use category per week per household were made between villages and between seasons using the Kruskal Wallis test. Where a significant difference was identified for the overall data, each month or village was compared in turn with the others using the inequality described in Siegel & Castellan (1984) shown by the equation in Box 6-1. When multiple comparisons are made within the same data set, the probability of finding spurious significant results increases depending on the probability level selected (e.g. one in 20 tests is likely to be spuriously significant with $P<0.05$). The inequality in Box 6-1 effectively reduces the levels of probability at which a difference is found significant to avoid rejecting the null hypothesis incorrectly.

**Box 6-1 Multiple comparison of non-parametric data** (from Siegel & Castellan, 1984)

The null hypothesis that the two groups are the same may be rejected if:

$$\left|\bar{R}_1 - \bar{R}_2\right| \geq z_{\alpha / k(k-1)} \sqrt{\frac{N(N+1)}{12}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}$$

where: k = number of samples or groups (e.g. four villages or five periods);

$n_j$ = number of sub-households in the jth village or period;

N = total number of cases in all villages or periods (the sum of the $n_j$'s);

$\bar{R}_j$ = mean of the ranks in the jth village or period from the Kruskal Wallis test;

$\alpha$ = required level of significance; and

$z_{\alpha / k(k-1)}$ = is the percentage point of the standard normal distribution corresponding to an upper tail probability of $\alpha / k(k-1)$

#### *6.3.1.2 Analysing the effects of wealth on wild resource use*

Partial redundancy analysis (RDA) was used to look for any relationship between the frequency of natural resource use at sub-household level and three environmental variables: wealth (measured by turn in terms of tropical livestock units; area cultivated; and sub-household size), the month in which the survey took place and the village in which the sub-household was found. The different parameters representing wealth were included in the analysis as representative of the main livelihood strategies found on the plateau (i.e. subsistence agriculture and pastoral production). Redundancy analysis allowed the combined data on all categories of resource use to be analysed. Using partial RDA, the effect of each environmental variable can be identified, taking co-variation with the other variables into account, as well as any interaction effects between them (Qinghong & Brakenhielm, 1995). The analyses were tested using the Monte Carlo permutation test. All analysis was carried out using the CANOCO programme (Ter Braak, 1987).

#### *6.3.1.3 Analysing habitat use and selection*

Forests and forest conservation are the focus of this study. However the multi-round surveys to be analysed in the course of this chapter included all wild resource use regardless of whether it took place within closed canopy forest or not. Closed canopy forest is one of many habitat types which supply communities with their wild resource needs. It is important to establish the relative importance of forests as a source of these resources when considering overall levels of wild resource use. The relative importance of forest as a source of wild resources has important implications for forest management.

Analysis of habitat selection data would not make sense without a measure of availability (Aldrege & Ratti, 1986; 1992). The results of aerial photograph interpretation (described in detail in the following chapter) provided a measure of current availability of forest and other habitats within a defined area which could be used to assess the importance of different habitats as a source of wild resources to local communities.

Data from the resource use surveys were compared with current availability of habitat types within a 5km radius of the village or town centre. Nine vegetation types were defined for the aerial photo interpretation compared to the five defined for the household surveys. However, by pooling the data across a number of different vegetation types for the API it was possible to form five data sets, equivalent to those from the multi-round surveys, which allowed a legitimate comparison. These are shown in Table 6.1 below.

**Table 6.1** Comparison of aerial photograph vegetation types and habitats used in resource use surveys.

| **Resource Use Survey Vegetation Types** | **Aerial Photograph Vegetation Types[a]** |
|---|---|
| Open grassland | Grassland |
| Grassland/shrub | Woodland, Grassland/shrub |
| Bush/shrub | Shrub, Bush |
| Degraded forest/bush | Bush/Forest, Bush/Woodland |
| Forest | Forest |

[a] Definitions for the vegetation types used in the course of the aerial photograph interpretation are described in detail in chapter seven

Frequency of use of each habitat type per sub-household per week was calculated on the basis of the count of the number of times each vegetation type was used in each day by different members of the sub-household. Where more than one activity was carried out in the same vegetation type by the same user type on the same day, the two counts could not be taken as independent, and would be scored as one count. The same rule applied when the use was specified for the analysis, i.e. in the case of marketable products. In this way, frequency of use per week of any one vegetation type could exceed seven if more than one user type frequently made use of that vegetation type.

The proportion of counts within each habitat type were compared with the expected values from the results of the aerial photograph interpretation using a selection ratio described by Manly *et al.* (1993) and shown in Box 6-2 below.

**Box 6-2: Measuring habitat selection** (adapted from Manly *et al.* (1993))

The selection ratio is defined by the equation:

$\hat{w}_i = u_{i+} / (h_i u_{++})$

where:

$\hat{w}_i$ = the selection ratio using totals for all sub-households for habitat type i
$u_{i+}$ = the count of type i resource units used by all sub-households
$h_i$ = the proportion of availability of habitat i
$u_{++}$ = the total count of units used by all sub-households.

The variance of $\hat{w}_i$ (var($\hat{w}_i$)) can be calculated and used to find Bonferroni confidence intervals for population selection ratios to establish resource selection.

$$\text{var}(\hat{w}_i) = \{\sum_{j=1}^{n}(u_{ij} / h_i - \hat{w}_i u_{+j})^2 / (n-1)\}\{n / u_{++}^2\}$$

where:

n = the number of sampled sub-households

Confidence intervals with an overall confidence level of approximately 100(1-α)%, are calculated for the equation:

$\hat{w}_i \pm z_{\alpha/(2I)} se(\hat{w}_i)$,

where $z_{\alpha/(2I)}$ is the percentage point of the standard normal distribution corresponding to an upper tail probability of α/(2I), and I is the number of habitat types. These confidence intervals are based on the assumption that $\hat{w}_i$ is normally distributed. Comparison of the data from this study with similar data tested for normality in Manly *et al.* (1993), suggest that this is a reasonable assumption, provided there are more than 6 observations within each habitat type.

The analysis of aerial photographs by site differentiated vegetation cover inside and outside the reserve. Overall resource use was compared with availability both inside and outside the reserve. However, given the very low levels of timber extraction and charcoal making within the reserve recorded in the initial vegetation surveys (chapter two) habitat selection for marketable products compared use levels with habitat availability outside the forest reserve only.

## *6.4 Appraisal of methods*

### 6.4.1 Comparing frequencies

No data were collected quantifying the amount of resource concerned; measuring all wild resources collected was beyond the scope of this study and estimates of resource quantities from memory are notoriously unreliable (Dangour, 1995).

Using mean frequencies, however, assumes that the quantities collected on each occasion and at each sub-household are not likely to vary with time or across sub-households or villages. This will inevitably depend on accessibility of resources and time limitations. For example, if there is a shortage of firewood and collection involves covering long distances, women will tend to collect firewood in larger quantities less frequently (Abbot, 1996; Smith, 1983, reviews the application of optimality theory in anthropological studies). Thus, where availability differs greatly from one area to another, a lower frequency may not always guarantee lower absolute levels of use. Availability may vary throughout the year for some resources such as honey or wild fruit due to season. However, for most woody resources (e.g. charcoal, firewood, poles & posts) there is no reason to expect such changes. For example, Hartley (1992) found no difference in the average weight of a head load of firewood in the wet and dry season in Sierra Leone.

The implications of availability of, for example, wild foods are taken into account in the analysis. While there are proportional differences in vegetation cover at Lpartuk and Ngorika, all main habitat types are available close to the village and frequency data on resource use across these two villages are compared directly. However, availability of woody products was not equivalent between the two Maralal villages and Ngorika or Lpartuk. For example, during the baseline survey, 82% of respondents at Tamiyoi and 54% of respondents at Loikas reported regularly travelling further than one km for firewood[2]. Few respondents at Lpartuk and Ngorika were able to judge distances in metres or kilometres, but from personal observations it was clear that distances from sub-households to firewood collecting areas were not this great. A

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[2] the accuracy of the distances quoted by the women at Tamiyoi and Loikas was verified by personal observations - groups of women could frequently be seen more than 2km along the track leading into the forest from Maralal

lower frequency in, for example, firewood collection in this instance could not be taken as meaning people were collecting less wood: they could well have been collecting heavier bundles on fewer occasions. Lower availability of woody resources around Maralal would thus tend to reduce frequency of collection at Maralal relative to Ngorika or Lpartuk without necessarily reducing the volume of resources extracted.

### 6.4.2 Survey method and bias

The data from the two Maralal villages and from Lpartuk and Ngorika are from two different types of survey: at Ngorika and Lpartuk, the data come from multi-round surveys, repeated five times over a period of ten months; the data for Tamiyoi and Loikas come from the one-off baseline survey. The data for Lpartuk and Ngorika, therefore, are 24 hour recall data, taken from sub-households familiar with the study and the interviewers. The data for Tamiyoi and Loikas, in comparison, are weekly recall data taken from sub-households for whom it was the first time they had met the interviewers and were answering questions related to (often illicit) forest resource use.

The implications of the nature of the survey become apparent if data from the multi-round surveys are compared with those from the original baseline survey at Lpartuk: of the six sub-households at Lpartuk that collected charcoal for sale in the course of the resource use surveys (table 6.1), only two had admitted to charcoal making in the baseline survey. It is interesting to note that even within the baseline survey at Loikas, more Turkana sub-households admitted to selling charcoal when asked about their main sources of livelihood (9) than when directly asked whether or not they sold the charcoal they collected (7). These comparisons clearly demonstrate the hazards of using data from one-off surveys, particularly when considering illegal wild resource use. This bias is likely to have resulted in under-reporting of resource use at both Tamiyoi and Loikas and arguably renders any direct comparison between the two Maralal villages and the two more distant villages non-viable.

### 6.5 Results

The results describing the relationship between the frequency of wild resource use (the dependent variable) and market access, wealth and season (independent variables) are presented in turn below. The results are summarised for each independent variable with reference to hypotheses one to four stated above. There is potential for overlap in the effects of the three independent variables; for example, poorer households may extract marketable wild resources at a greater frequency during periods of seasonal stress as a source of cash to meet contingencies. Evidence of interactions between the three variables is assessed in the discussion following the presentation of the results.

This is followed by the results for and discussion of the analysis of habitat selection in wild resource use.

Appendix two lists all the species encountered in the course of the study (i.e. the household surveys as well as the vegetation surveys). The species actually used in the course of the household surveys and the uses to which they were put are listed separately in the same appendix.

A total of 227 botanical species, from 65 families, were identified in the course of the study, and a further 13 plants were named in the vernacular, but not identified. Fourteen botanical species were given more than one vernacular name and 27 vernacular names were given to more than one botanical species.

Out of the total of 240 species and unidentified plants, only 82 were actually used in the course of the study (counting all possible species where one vernacular name was given to more than one botanical species). This is considerably less than might be expected when comparing the results with other studies which have systematically listed plant species with their potential use (Heine *et al.*, 1988). Heine *et al.* (1988) describe a study carried out by Esser in 1986 in Samburu District who identified a total of 300 species and their potential uses. Esser's results are summarised by category and not all of his categories are directly comparable with those from this study. However, Table 6.2 compares the number of species with potential use value recorded by Esser with the number of species which were actually used in the course of this study for those categories which are comparable.

**Table 6.2** Comparison of the number of plant species with potential for use by the Samburu and the number of species which were actually used in the course of this study

| Use category | Number of plant species with potential use (from Esser in Heine *et al.*, 1988) | Number of plant species actually used in the course of this study |
|---|---|---|
| **(Total count of all plant spp)** | (300) | (240) |
| **Food** | 83 | 19 |
| **Household goods, rope & weapons** | 47 | 33 |
| **Fuel** | 80 | 18 |
| **Medicinal use** | 122 | 38 |
| **Ritual/custom** | 46 | 7 |
| **Total number of species used** | (not stated, but at least 122) | 82 |

It is clear from Table 6.2 that the number of species routinely used are considerably less than the potential as recorded by Esser. Two species only accounted for more than 50% of all plant use (where plant use is measured as the number of times each plant species was said to have been collected): *Juniperus procera* and *Olea europeana* ssp *africana*. These species are the preferred species for firewood, charcoal, construction materials and weapons. Eighteen plant species accounted for more than 90% of all plant use. Of those, 5 were tree species, 6 were shrub species, 5 were climber species (used for rope) and 2 were herbaceous species. Full details of the species used in the course of the household surveys and their relative importance are provided in appendix two.

### 6.5.1 Resource use and markets

#### *6.5.1.1 Identifying marketable resources*

The proportion of sub-households which engaged in each resource use category during the course of the year (in the case of Lpartuk and Ngorika) or claimed that they would do so (in the case of Tamiyoi and Loikas) is compared with the proportion of sub-households that sold, or claimed to sell, the resource for each village in Table 6.3.

**Table 6.3** Proportion of sub-households at each village collecting (CR) and selling (SR) wild resource products at each study village.

| Village | Ngorika[a] | | Lpartuk[a] | | Loikas[b] (Samburu) | | Loikas[b] (Turkana) | | Tamiyoi[b] | |
|---|---|---|---|---|---|---|---|---|---|---|
| No of sub-households | 15 | | 14 | | 16 | | 14 | | 28 | |
| | Percent of all sub-households collecting (CR) or selling (SR) each resource type | | | | | | | | | |
| Use category | CR | SR | CR | SR | CR | SR | CR | SR | CR | SR |
| Bark | 80 | 0 | 93 | 0 | 40 | 0 | 71 | 0 | 52 | 3 |
| Charcoal | 7 | 0 | 36 | 36 | 60 | 40 | 64 | 50 | 24 | 14 |
| Firewood | 100 | 0 | 100 | 0 | 93 | 40 | 100 | 29 | 100 | 14 |
| Fodder & veterinary | 93 | 7 | 86 | 7 | 47 | 0 | 21 | 0 | 52 | 0 |
| Honey | 60 | 0 | 36 | 0 | 27 | 13 | 7 | 0 | 17 | 3 |
| Medicines | 100 | 0 | 100 | 0 | 93 | 7 | 79 | 7 | 86 | 7 |
| Other general | 40 | 0 | 64 | 0 | 60 | 0 | 7 | 0 | 28 | 0 |
| Other wood | 93 | 0 | 86 | 7 | 73 | 7 | 57 | 21 | 86 | 7 |
| Poles & Posts | 87 | 7 | 93 | 93 | 80 | 7 | 79 | 7 | 72 | 7 |
| Rope | 100 | 0 | 64 | 0 | 33 | 0 | 21 | 0 | 3 | 0 |
| Timber | 7 | 0 | 43 | 7 | 0 | 0 | 21 | 0 | 0 | 0 |
| Wild food | 100 | 0 | 93 | 0 | 100 | 0 | 93 | 0 | 90 | 3 |

[a]data from the multi-round surveys
[b]data from the baseline survey

Wild resources were used for subsistence use by all sub-households interviewed. The most important resource use categories across all the villages (in terms of the number of households reporting that use) were firewood, wild foods, medicine, bark for thatch, poles for construction and an assortment of other wood products, such as weapons, household tools and furniture. Fodder and veterinary products were collected by the majority of households at Ngorika and Lpartuk, but were of less importance around Maralal (where livestock holdings were lower, chapter five). Fibrous plants used for rope were also collected by a greater proportion of households at Lpartuk and Ngorika than at Maralal.

Few sub-households collected resources for sale at Ngorika during the course of the surveys, with just one sub-household selling veterinary medicine and poles and posts.

At Lpartuk, the main wild resources collected for sale were charcoal, poles and posts and timber. Thirteen out of the 14 sub-households interviewed both collected and sold poles and posts during the course of the year and six out of the 14 sub-households collected and sold charcoal. Again, only one sub-household at Lpartuk reported selling either veterinary products, timber or other wood products.

At Loikas and to a lesser extent Tamiyoi, a much smaller proportion of sub-households sold poles and posts, but a greater proportion sold medicine, firewood, honey and other wood products (mainly carved statuettes for sale to tourists). The problem of comparing results from the two Maralal villages with those from either Ngorika or Lpartuk have been discussed above. The proportion of sub-households selling products at Loikas and Tamiyoi are likely to be under-estimates, but they are still indicative of the situation and there are interesting differences in the types of resources sold.

There is little difference in the proportion of sub-households selling wild products between the Turkana and the Samburu sub-households at Loikas. The proportion of sub-households collecting and selling charcoal at Tamiyoi is considerably lower than either group at Loikas.

At Ngorika and Lpartuk, the proportion of occasions when a wild resource had been collected for sale was calculated from the original data, summarised in Table 6.4. The majority of poles and posts and charcoal collected by sub-households at Lpartuk over the course of the year, were collected for sale.

**Table 6.4** Comparison of the proportion of all observed occurrences of charcoal, poles and posts and timber collection made for sale at Ngorika and Lpartuk, using data from the multi-round surveys at Lpartuk and Ngorika.

| | **Ngorika** | | **Lpartuk** | |
|---|---|---|---|---|
| **Use Category (UC)** | **Total no. of occurrences of UC** | **% occurrences when product was for sale** | **Total no of occurrences of UC** | **% occurrences when product was for sale** |
| **Charcoal** | 6 | 0% | 32 | 84.4% |
| **Pole & posts** | 102 | 1% | 128 | 66.4% |
| **Timber** | 2 | 0% | 20 | 10% |

### *6.5.1.2 Women and the marketing of resources*

During the multi-round questionnaire, respondents were asked which member of the sub-household was involved in collecting the produce. Table 6.5 below shows the number of occasions on which men or women collected firewood or timber or burnt charcoal and the proportion of which were for sale.

**Table 6.5** Differences in levels of collection and sale of market-products by men and women

| | | Ngorika | | Lpartuk | |
|---|---|---|---|---|---|
| **User** | **Use category** | **Total no of counts** | **Proportion of counts for sale** | **Total no of counts** | **Proportion of counts for sale** |
| **Woman** | **Poles & posts** | 71 | 0% | 77 | 69% |
| | **Charcoal** | 4 | 0% | 25 | 88% |
| | **Timber** | 0 | 0% | 12 | 0% |
| **Man** | **Poles & posts** | 24 | 4% | 50 | 74% |
| | **Charcoal** | 1 | 0% | 8 | 88% |
| | **Timber** | 1 | 0% | 3 | 100% |

In both villages, women collected poles and posts and made charcoal on more occasions than men. The proportion of occurrences when the resource was sold at Lpartuk were similar for men and women with the exception of timber. The survey did not ask who would be selling the produce, or even who would be receiving the income. However, informal discussions suggested that the person collecting the resource for sale would also be directly involved in its sale and receive the profits.

### *6.5.1.3 Differences in resource use by village - Lpartuk and Ngorika*

Frequency with which each resource use category was reported per week was calculated individually for each sub-household and for each month surveyed for Lpartuk and Ngorika. Mean frequency over the entire year was compared for these villages using a Mann-Whitney U-test and the results are given in Table 6.6

**Table 6.6** Comparison of frequency of resource use categories at Lpartuk and Ngorika

| Resource use category | Mean frequency over entire year | | Significance |
|---|---|---|---|
| | **Lpartuk** | **Ngorika** | |
| Firewood | 5.85 | 5.80 | n.s. |
| Charcoal | 0.55 | 0.10 | <0.01 |
| Poles & posts | 2.70 | 1.65 | <0.001 |
| Timber | 0.26 | 0.03 | <0.01 |
| Rope | 0.56 | 1.92 | <0.001 |
| Weapons | 0.64 | 1.54 | <0.01 |
| Honey | 0.05 | 0.38 | <0.01 |
| Fodder/Veterinary | 1.28 | 1.31 | n.s. |
| Wild food | 3.08 | 2.92 | n.s. |
| Medicine | 2.81 | 3.27 | n.s. |
| Other - general | 0.26 | 0.23 | n.s. |
| Other - wood | 0.38 | 0.49 | n.s. |
| Bark | 0.83 | 0.98 | n.s. |

These results indicate that those resource use categories with the greatest market value, i.e. the collection of poles and posts, timber and charcoal, are significantly more frequent in Lpartuk than in Ngorika.

The overall frequency with which poles and posts were collected for sale and for home use were calculated from the original multi-round survey data. At Lpartuk, poles and posts were collected for sale 1.46 times per week compared with 0.02 times per week at Ngorika. There was no significant difference in frequency of collection for home use between the two villages. The difference in frequency shown in Table 6.6 can, therefore, be entirely attributed to the collection of posts for sale.

There is little or no difference between the two villages in frequency of other types of wild resource use that have no market potential. Where there is a significant difference, frequency is actually higher at Ngorika which is the more isolated of the two villages.

#### *6.5.1.4 Differences in resource use by village - Lpartuk, Ngorika, Tamiyoi and Loikas*

It has been argued that a direct comparison of the data from the two sets of villages is not viable due to survey bias and different availability of woody resources. However, an exploratory comparison of the frequency of wild resource use across all four villages (Lpartuk, Ngorika, Tamiyoi and Loikas) from the August surveys[3] identified two interesting results which could not be entirely attributed to survey bias:

1. Wild food collection (not marketed) was significantly more frequent at Loikas than at any other village.
2. Charcoal was collected more frequently at Loikas than at any other village (the difference was significant at the 95% level for Tamiyoi and Ngorika). Collection of poles and posts, however, were hardly reported at all at either Loikas or Tamiyoi.

#### *6.5.1.5 Summary*

The most economically important resource use categories, in terms of products sold, are also potentially the most potentially destructive - charcoal, poles and posts, firewood and other wood products.

Frequency of resource collection at Lpartuk was significantly higher than at Ngorika only for those products that were routinely sold. Other products were collected with equal or greater frequency at Ngorika. Sale of wild resources at Lpartuk was found to be of particular importance to women.

Frequency of charcoal collection was greater at Loikas than elsewhere, despite the tendency for this data to be under-reported due to survey bias.

The difference in levels of resource collection between the Maralal villages and Lpartuk or Ngorika may be due to survey bias or wealth effects as well as market access. However, sub-households at Ngorika and Lpartuk were shown to be similar in terms of mean livestock and land holdings (chapter five) and distribution of wealth.

[3] Frequency data for Tamiyoi and Loikas were calculated from weekly recall during the one-off survey which took place in August

These results, therefore, support the hypothesis that better market access increases the frequency with which wild resources are collected (hypothesis one).

### 6.5.2 Seasonality of resource use

The resource use surveys were repeated over the course of a year at Ngorika and Lpartuk with the intention of comparing resource use in wet and dry seasons. However, after a dry period from 1992 - 1993, 1994 proved to be a very wet year with good rainfall from March 1994 continuing until December. The dry season was only just starting, therefore, in January 1995 and the seasonal extremes spanned by the surveys were not representative of a 'normal', drier year.

At the time of the first resource use survey in March/April, it was raining heavily at Ngorika, while Lpartuk remained completely dry. Bearing in mind the highly localised intra- and inter-annual variability in rainfall levels in this area in general (chapter two), and the differences in overall frequency and objectives of wild resource collection between the two villages (Table 6.6), the data were analysed for each village and for each month separately.

The months during which the surveys took place are described below in terms of food and labour availability and the main agricultural and pastoral activities:

**April:** In terms of seasonal stress, April was probably the most difficult month in the multi-round surveys for the population. Rainfall had been poor since the drought of 1992-93 and the previous year's harvest had failed. Labour demands were high as people prepared their fields for the rainy period and food supplies were low. Labour demands on herders were still high at Lpartuk where there had been no rain, but at Ngorika heavy rain fell the week before the survey and there was plenty of fresh grass and surface water available. Relief food was still being distributed roughly every two weeks. Cattle started to leave the forest in preference for the fresh growth of grass outside.

**July:** By early July range conditions and therefore milk production was good for those with livestock. Labour demands were relatively low, the main demand being from weeding of gardens, but relief supplies had fallen to once every 4 - 6 weeks.

**August:** The harvest began properly in late August and milk supplies were good for those with livestock. Labour demands were high for agricultural activities, but low for pastoral activities, with plenty of surface water and good grazing readily available for livestock. Relief supplies continued as for July.

**October:** In October, the main maize harvest was completed and there was still good fodder for the livestock ensuring milk production.

**January:** By January, the vegetation had started to dry out, milk production was declining and labour demands for livestock management had increased. Cattle had still not started to use the forest for grazing.

In conclusion, the driest months included in the survey were April and January. However, April came at the end of a long drought and a failed harvest, and nutritional stress and labour demands were high whereas January came at the end of a long rainy period, range quality was still quite good and households were under less nutritional stress following a good harvest.

The inequality described above (Box 6-1) was used for a multiple comparison of differences between each of the five surveys for each resource use category.

The results are summarised in Figure 6-1 & Figure 6-2 and Table 6.7 for Ngorika Figure 6-3 & Figure 6-4 and Table 6.8 for Lpartuk.

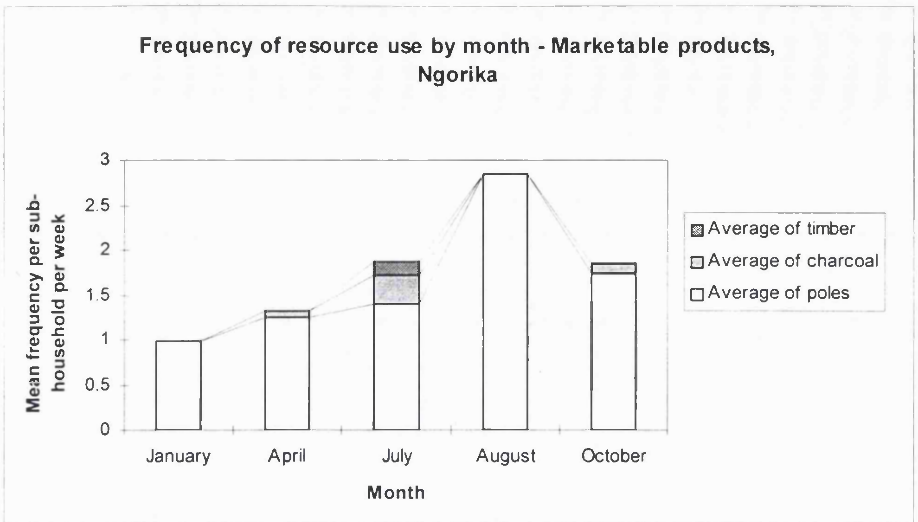



**Figure 6-1** Frequency of resource use by month, marketable products, Ngorika.

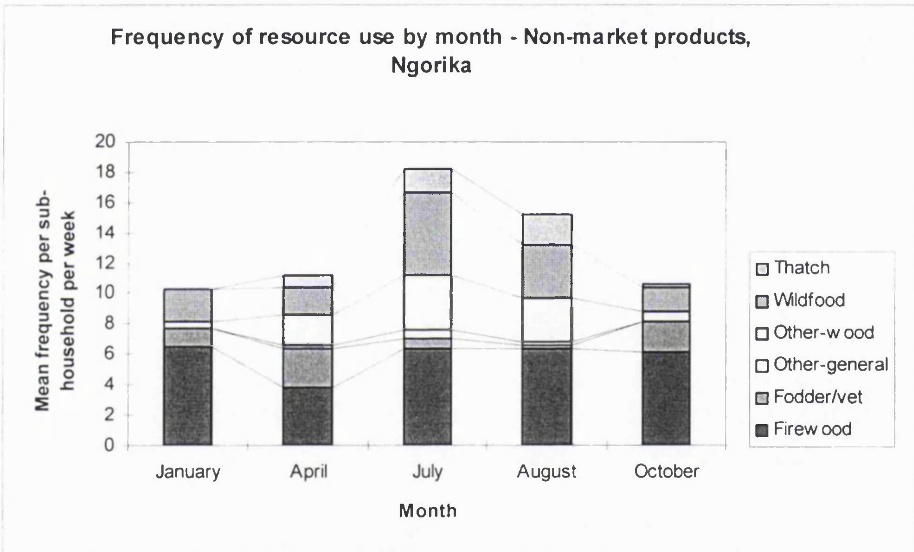



**Figure 6-2** Frequency of resource use by month, non-marketable products, Ngorika.

**Table 6.7** Results of multiple comparison test by month for Ngorika (showing categories for which a significant difference was found[a]).

| NGORIKA | Significance of difference between the specified months | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Resource use category** | **Jan & Apr** | **Jan & July** | **Jan & Aug** | **Jan & Oct** | **Apr & Jul** | **Apr & Aug** | **Apr & Oct** | **Jul & Aug** | **Jul & Oct** | **Aug & Oct** |
| **Firewood** | **<0.01** | n.s. | n.s. | n.s. | **<0.01** | **<0.01** | n.s. | n.s. | n.s. | n.s. |
| **Fodder/ Veterinary** | n.s. | n.s. | n.s. | n.s. | n.s. | **<0.05** | n.s. | n.s. | n.s. | n.s. |
| **Medicine** | n.s. | n.s. | n.s. | n.s. | **<0.05** | n.s. | n.s. | n.s. | n.s. | n.s. |
| **Ropes** | n.s. | **<0.01** | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| **Other wood** | n.s. | **<0.01** | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | **<0.05** | n.s. |
| **Wild food** | n.s. | **<0.01** | n.s. | n.s. | **<0.01** | n.s. | n.s. | n.s. | **<0.01** | n.s. |

[a]No significant difference was found for charcoal, honey, hunting and cultural, poles and posts, bark, timber or 'other wood products'.

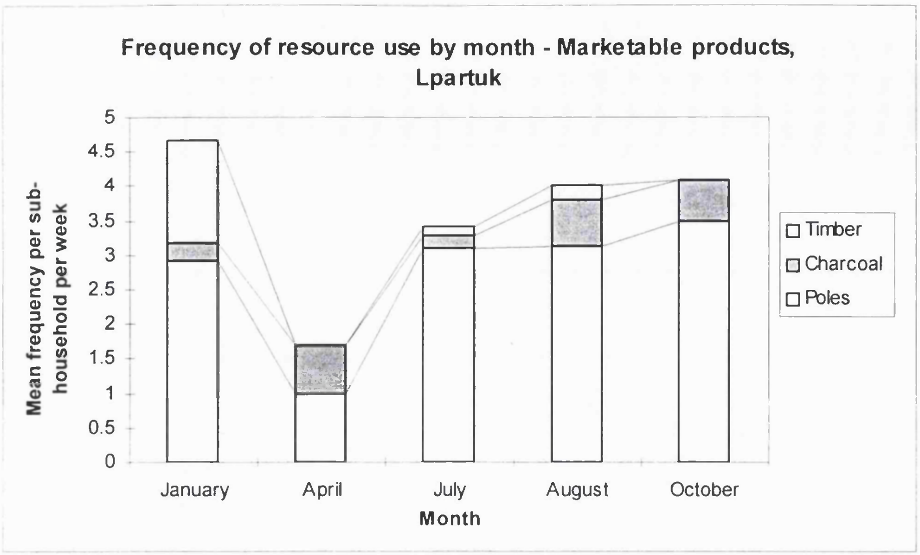



**Figure 6-3** Frequency of resource use by month, marketable products, Lpartuk

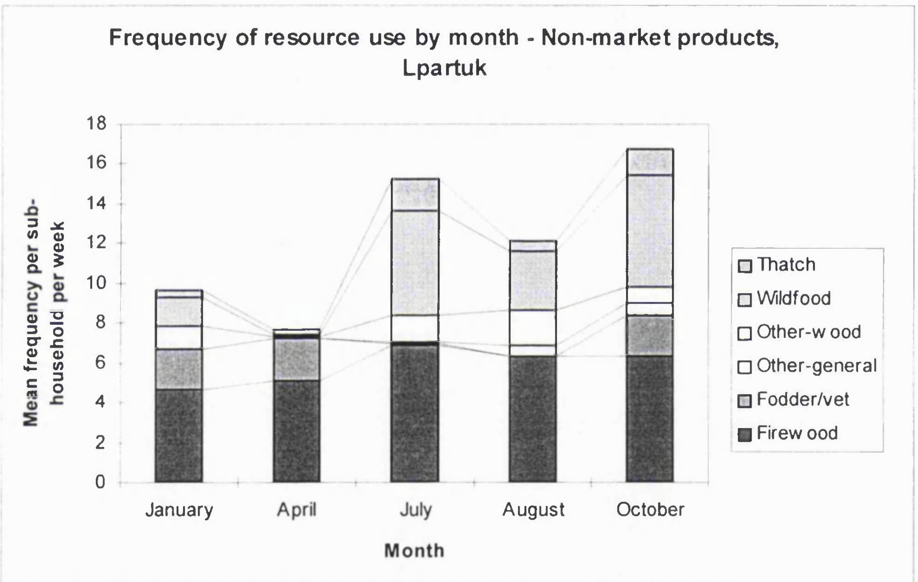



**Figure 6-4** Frequency of resource use by month, non-marketable products, Lpartuk

**Table 6.8** Results of multiple comparison test by month for Lpartuk (showing categories for which a significant difference was found[a]).

| LPARTUK | Significance of difference between the specified months | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Jan & Apr | Jan & July | Jan & Aug | Jan & Oct | Apr & Jul | Apr & Aug | Apr & Oct | Jul & Aug | Jul & Oct | Aug & Oct |
| Firewood | n.s. | **<0.05** | n.s. | n.s. | **<0.05** | n.s. | n.s. | n.s. | n.s. | n.s. |
| Fodder/ Veterinary | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | **<0.05** |
| Other - wood | n.s. | n.s. | **<0.05** | n.s. | n.s. | **<0.05** | n.s. | n.s. | n.s. | n.s. |
| Poles | n.s. | n.s. | n.s. | n.s. | **<0.05** | **<0.05** | **<0.05** | n.s. | n.s. | n.s. |
| Bark | n.s. | n.s. | n.s. | n.s. | **<0.05** | n.s. | n.s. | n.s. | n.s. | n.s. |
| Wild food | n.s. | **<0.05** | n.s. | **<0.01** | **<0.01** | **<0.05** | **<0.01** | n.s. | n.s. | n.s. |

[a]No significant difference was found for charcoal, honey, medicine, hunting and cultural, ropes or timber.

Since the multiple comparison test was repeated for the different resource use categories, some spurious significant results (Type I errors, Sokal & Rohlf, 1993) might be expected: 1 in 20 if using a 95% probability or 1 in 100 if using a 99% probability. With thirteen resource use categories, caution must be applied when considering isolated significant results which are significant at the 95% level. Differences at the 99% level are robust.

At both Ngorika and Lpartuk, **overall use** was lowest in April and January, peaking in July and August and in the case of Lpartuk remaining high in October.

At Ngorika, collection of both **marketable and non-marketable** products followed the same pattern. At Lpartuk, however, collection of marketable products peaked in January.

The resource use categories which significantly varied in frequency over the year in both villages were firewood, fodder/veterinary and wild food. The pattern with which frequency of collection of these resources varied was similar for both villages.

Frequency of **firewood collection** was highest during the rainy and cold periods (June-October) at both villages reflecting the importance of firewood as a heat source as well as a fuel for cooking. Frequency was lowest in April.

**Fodder and veterinary** plant products were collected less frequently during July and August than at other times in both villages. July and August marked the peak of the rains when fodder availability and quality was high and there was less need to go elsewhere to collect particular species.

Similarly, frequency of **wild food collection** was highest in July and August in both villages when availability of fruits and leaves were highest.

Where different categories varied over the course of the year in the two villages, they all reflected similar trends, with a decline in frequency of resource collection in April and to a lesser extent, January. At Ngorika, frequency of medicine and rope collection varied significantly, peaking in July and reaching lowest levels in April and January. At Lpartuk, bark was collected more frequently in July than in April and 'other wood products' were collected more frequently in August than in January or April.

Frequency of collection of poles and posts at Lpartuk remained high from July until January before dropping to levels similar to those at Ngorika in April.

The data on frequency of collection of poles and posts at Lpartuk were analysed further given their importance as marketable products. Figure 6-5 shows a clear trend in the proportion of poles and posts sold throughout the year.

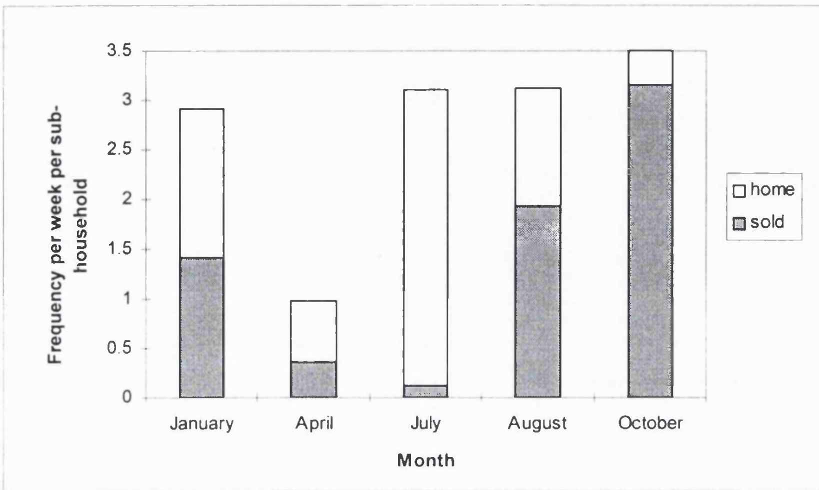



**Figure 6-5** Frequency of collection of poles and posts for sale and for home use per sub-household per week for the five survey periods at Lpartuk.

The proportion of posts collected for sale was highest in October, August and January. The proportion of posts sold in April was slightly lower than in January, but overall levels were very low compared to all other months. In July, very few of the poles collected were for sale, although the overall frequency of collection was high.

Fifty percent of poles and posts collected at Lpartuk in January were reportedly for sale. Reducing the frequency of pole collection at Lpartuk in January by 50% results in a level of frequency similar to that seen Ngorika in the same month (Figure 6-1). Frequency of collection of marketable products at Ngorika during April was very similar to that at Lpartuk (1.3 times per sub-household per week at Ngorika; 1.5 times per sub-household per week at Lpartuk).

#### *6.5.2.1 Summary*

Frequency of wild resource use varied considerably across the year. The pattern with which different categories of resource use changed in frequency over the year varied, but overall, frequency of resource use was lowest during April when labour demands were high and food supplies (both milk and grain) low following a year of drought and a failed harvest.

Marketing of poles and posts at Lpartuk appeared to explain the higher levels of their collection further into the dry season compared to Ngorika.

Frequency of collection of wild foods and fodder followed seasonal patterns of availability rather than need.

These results support the hypothesis that marketing of wild resources can provide a buffer against seasonal shortages (hypothesis three). Wild foods, however, were not used to relieve seasonal shortages, frequency of collection being more closely related to availability. During periods of high nutritional stress and labour demands, it appears that energetic needs ultimately limit the amount of wild resource collection that takes place (supporting hypothesis four).

Every effort was made to explain the purpose of the study and to reassure respondents that all information they gave would be treated confidentially. However it was possible that respondents changed what they were prepared to say as they became more familiar with the surveys and the interviewers, particularly with respect to illegal activities. A systematic change in accuracy of response, due to increasing familiarity, could mask or alternatively accentuate seasonal differences in frequency of resource collection. The proportion of sub-households at Lpartuk and Ngorika reporting charcoal, poles and posts or timber collection in the course of the repeated resource use surveys were regressed against the visit number using an arc sine transformation (Bailey, 1981) and there was no significant trend for either village. However, it is clear from the results that reported levels of wild resource use was consistently lower in the first interview in April than during the other interviews. It is possible that this is an artefact of reporting bias, rather than, or as well as, seasonality.

### 6.5.3 Resource use and wealth

Partial redundancy analysis was used to look for any relationship between wealth (measured in turn as TLU, area under cultivation and sub-household size) and frequency of wild resource use at Ngorika and Lpartuk. Village identity and survey month have been shown to significantly affect frequency of wild resource collection and were therefore included in the analysis as co-variables (Qinghong & Brakenhielm, 1995). The analyses were tested using the Monte Carlo permutation test. All analysis was carried out using the CANOCO programme (Ter Braak, 1987).

Frequency data from all resource use categories were included except for livestock watering and grazing since these would inevitably influence the data with respect to livestock wealth. The analysis was centred and standardised by use category which respectively weights each resource use category by the variance of its abundance and then divides each category value by its standard deviation. This has the effect of weighting all categories equally so that rarer use categories (such as honey collection) have the same influence over the results as the most common use categories (such as firewood collection). The analysis was repeated for the three different measures of wealth: TLU, wealth rank and area under cultivation. The results for the analysis with the livestock data is shown in Table 6.9 to demonstrate the process of partialling out the proportion of variation that can be explained by each variable.

**Table 6.9** RDA analyses (using CANOCO) used to divide explained variation among the defined environmental variables

| **Variable or interaction** | **Environmental variable** | **Co-variable** | **Proportion of variation explained by variable or interaction** | **P** |
|---|---|---|---|---|
| **Village** (V) + **Month** (M) + **Livestock** (L) | | None | 0.204 | |
| **Pure V** (PV) | Village | Month + Livestock | **0.037** | <0.005 |
| **Pure M** (PM) | Month | Village + Livestock | **0.154** | <0.005 |
| **Pure L** (PL) | Livestock | Month + Village | **0.012** | n.s. |
| PL + PV + L*V | Village + Livestock | Month | 0. 048 | |
| PL + PM + **L***M | Month + Livestock | Village | 0. 166 | |
| PM + PV + V*M | Month + Village | TLU | 0.192 | |
| **Livestock*Village interaction** | | | 0.166-(0.154+0.012) = **0** | |
| **Livestock*Month interaction** | | | 0.048-(0.037+0.012) = **0** | |
| **Month*Village interaction** | | | 0.192-(0.154+0.037) = **0.001** | |
| **Livestock*Month*Village interaction** | | | 0.204-(0.192+0.012) = **0** | |
| **Unexplained** | | | 1-0.204 = **0.796** | |

In summary, village identity alone explained 3.7% of the variation observed in resource use, and month of survey explained 15.4% (in both cases the relationship was significant, both with $P<0.01$). No interaction effect was found between the villages and the month of survey, which demonstrates that the changes in frequency of resource use across the year did not differ significantly between the two villages. These results confirm the results of the previous analyses (sections 6.5.1 and 6.5.2).

Neither the livestock holdings, nor the area cultivated, nor the size of a sub-household could explain more than 1.2% of the variation in wild resource use and in no case was the effect significant. Nor was there any interaction effect between any of the wealth measures and either village or month.

#### *6.5.3.1 Wealth and the collection of marketable goods.*

The partial RDA was repeated using frequency data for marketable goods only, i.e. poles and posts, charcoal and timber. The results were very similar to those for all use categories combined, although interestingly, village accounted for 7.3% of the variation (almost double that for all use categories combined), while month accounted for 12%. Area cultivated, household size and livestock holdings all accounted for less than 1% of the variance in frequency of collection. Again, there were no significant interaction effects.

However, when the mean frequency of collection of charcoal and of poles for sale and for home use throughout the year were plotted against livestock holdings (TLU) for each sub-household, some trends were apparent at Lpartuk:

1. Excluding the wealthiest sub-household, there was a significant negative relationship between the frequency of collection of poles for sale per household per week and the livestock holdings of that household ($F_{1,10} = 6.10$, $P = 0.03$, $r^2 = 0.3$). In contrast, there was no clear relationship between the frequency of collection of poles for home use per household per week and the livestock holdings of that household. With the wealthiest household included in the curve, the relationship was still negative, but not significant ($P=0.13$). The pattern thus approaches that reported by Wily, with levels of resource use highest in the poorest and (to a lesser extent) the wealthiest sub-households.

2. Excluding the wealthiest sub-household, there was a positive relationship between the frequency of collection of charcoal for sale per household per week and the livestock holdings of that household ($F_{1,10} = 4.30$, $P = 0.06$, $r^2 = 0.3$). The wealthiest household did not collect charcoal. Thus the frequency of charcoal collection for sale showed the parabolic relationship with livestock holdings reported by Evers (1994) and Godoy *et al.* (1995). Again, there was no relationship between livestock holdings and frequency of charcoal collection for home use.

No such trends were found at Ngorika.

Finally, the frequency with which marketable resources were collected is summarised by wealth rank (defined during the wealth ranking exercises, chapter five) and month for Lpartuk in Figure 6-6 and for Ngorika[4] in Figure 6-7.

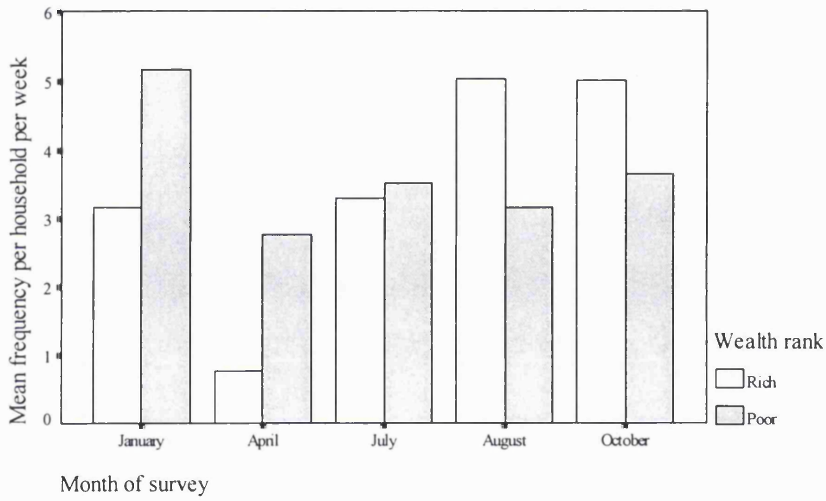



**Figure 6-6** Overall frequency of marketable resource collection at Lpartuk by month and rank.

[4] At Ngorika wealth ranks 1 and 2 were combined to represent rich and 3 and 4 combined to represent poor to increase sample size within each category and make statistical analysis possible.

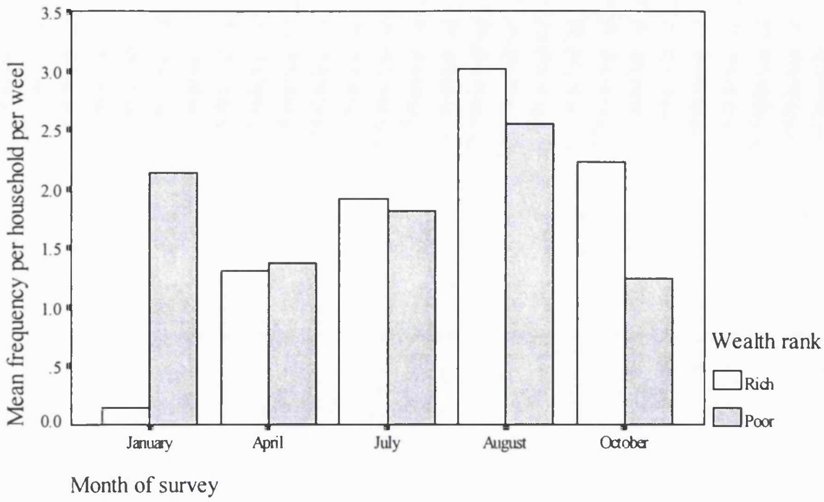



**Figure 6-7** Overall frequency of marketable resource collection by month and rank, - Ngorika

Comparison of the two graphs shows a very similar pattern between the two villages, despite sale of produce being almost non-existent at Ngorika. This suggests the difference between the wealth ranks may be a question of labour availability as well as economic needs. Livestock management uses male labour. During January, when livestock labour demands are high, one might expect a higher proportion of men collecting poles and posts in the poorer sub-households than in the richer sub-households. There are too few observation at Ngorika for the two villages to be tested individually, however, overall there is a significantly greater number of men from poor sub-households collecting poles and posts in January than from rich sub-households ($\chi 2=5.15$, df = 1, $P<0.05$).

#### *6.5.3.2 Wealth, ethnicity and wild resource use*

The Turkana community at Loikas were found to be considerably poorer than the Samburu community in terms of livestock holdings and to a lesser extent land holding size (chapter five). However, a Mann-Whitney U test found no significant difference in frequency of charcoal collection between the Samburu community and the Turkana community at Loikas. Similarly, there was very little difference in the proportion of Turkana and Samburu sub-households who admitted to collecting and to selling marketable resources (Table 6.3).

#### *6.5.3.3 Wealth and the collection of wild foods*

The frequency of collection of wild foods for each month separately and overall was regressed against livestock holdings, area cultivated and household size for the two villages. A significant negative relationship was found at Ngorika between the area under cultivation and the frequency of resource collection in August ($P=0.04$, $r^2=0.35$) which was when the harvest began. The result was influenced by one household which cultivated 1.6ha and collected no wild foods in August. No other significant relationships were found. Similarly, no relationship was evident between livestock holdings and the frequency of collection of medicinal plants.

#### *6.5.3.4 Summary*

In chapter five, livestock holdings were found to be significantly lower in the two Maralal villages and amongst the non-Samburu community at Maralal. Given the difference in wealth between villages, a wealth effect would be expected between the two Maralal villages and the two other villages. However, there were two problems in using this comparison to test the hypotheses regarding wealth and resource use: comparing different types of survey can lead to bias in the results; and any effect of wealth could be obscured or enhanced by the proximity of the market at Maralal For this reason, the effect of wealth on wild resource use was mainly examined within villages and not across villages.

No relationship was found between wealth and wild resource use at Lpartuk or Ngorika, when both season and village identity were taken into account. Where there were significant trends in the collection of poles and charcoal for sale at Lpartuk, the relationships were not consistent: collection of charcoal for sale was most frequent among the households of medium livestock households and lowest among the poorest households, while the opposite was true of the collection of poles for sale. There was no discernible difference in levels of collection or sale of wild resources between the Samburu and the non-Samburu at Loikas, despite considerable wealth differences between the two (chapter five).

These results do not support the hypothesis that wild resources provide the poorest members of the community with a way of meeting contingencies and daily needs (hypothesis two) within the levels of wealth found in the study area and within the seasonal extremes occurring during this study.

However, four factors make it impossible to reject this hypothesis entirely:

1. there was evidence that labour constraints associated with livestock management could affect levels of resource collection in households with and without livestock (although this reflects the different labour demands associated with agricultural and pastoral activities rather than wealth *per se* (Dei *et al.*, 1989; Swift, 1981));

2. there was some evidence that sub-households at Lpartuk with the lowest livestock holdings did collect poles for sale more frequently than those with higher livestock holdings (although, in comparison, the frequency of charcoal collection was lowest among the richest and the poorest households);

3. sub-households at Loikas collected wild food significantly more frequently than those from Ngorika or Lpartuk, despite a tendency for one-off surveys to under-estimate use levels. Wild foods are not marketed and this result may reflect the greater levels of poverty found at Loikas (chapter five); and finally

4. the allocation of relief food in this area, to both Samburu and Turkana households, may reduce the reliance of poorer households on wild resources (Campbell, 1987).

In conclusion, the difference in wealth between the richest and poorest within Lpartuk and Ngorika and within Loikas and Tamiyoi were not great enough to show any wealth effect in wild resource collection, with the possible exception observed at Lpartuk. The sale of poles and posts and charcoal in the area appears to be particularly important to women (Koppell, 1992; Scoones *et al.*, 1992).

These results do not rule an effect of wealth over wild resource use where greater wealth differences exist and where relief food is not available.

### 6.5.4 Discussion: Wild resources markets, seasons and wealth

A number of hypotheses were proposed at the start of this chapter which may now be reviewed in the light of the results presented above.

**Hypothesis 1**. Levels of wild resource use differs with respect to the market value of the resource and the distance from the village to the main market ('market access').

The products with greatest market potential and value were poles and posts, charcoal and other wood products. i.e. those types of resource collection which are potentially the most damaging to the forest.

The results from Ngorika and Lpartuk support the hypothesis that better market access increases levels of collection of marketable wild products (Koppell, 1992; Scoones *et al.*, 1992).

The assumption that differences between levels of resource use at Ngorika and Lpartuk could be related to differences in market access was based on the fact that little or no difference in wealth measures was found between the two villages. The influence of institutions responsible for managing woody resources (in this case local, being the elders, and governmental, being the Forest Department and its forest guards) may also play an important role in limiting (or not) extraction of wild resources (Shepherd, 1992; Allen & Barnes, 1985), and the two factors are not necessarily independent of each other.

The greater frequency with which some wild resources such as fibrous plants are used for rope and honey may reflect an interesting corollary to the hypothesis that markets affect levels of wild resource use: easier access to markets is likely to decrease levels of collection of those resources that have cheap manufactured substitutes, such as rope (also observed by Godoy *et al.*, 1995).

It is interesting to note that frequency of charcoal collection was very high at Loikas compared to the other villages (in spite of a tendency for one-off surveys to under-estimate levels of illegal activities). The frequency with which poles and posts were collected at Tamiyoi and Loikas, however, was very low compared to the other villages (particularly when compared to the high proportion of households who admitted collecting poles and posts for home use). It is proposed here that the low frequency with which poles and posts are collected for sale around Maralal is a function of availability. The opportunity costs of finding, preparing and transporting heavy poles and posts were too high to make their collection for sale worth while.

**Hypothesis 2**. Wild resources provide the poorest members of the community with a way of meeting contingencies and daily needs.

For this analysis, wealth was measured in terms of livestock holdings, area under cultivation and household size.

The results of this survey do not support the hypothesis that wealth influences ~~levels~~ degree of reliance on wild resources (cf. Dei *et al.*, 1989; Koppell, 1990; Scoones *et al.*, 1992; Chambers & Leach, 1987). However, this conclusion is limited to the difference in wealth levels found within the study villages and may have been influenced by the allocation of food relief. All sub-households, irrespective of livestock holdings, were receiving food rations throughout most of 1994 up to the harvest in September/October following a very poor harvest in 1993 (Drought Monitoring Project, 1993). Sperling (1987b) also found no difference in reliance on wild foods among the richest and poorest Samburu households during the drought of 1983-84 and attributed this to the availability of relief food (also Campbell, 1987).

Wealth differentials within the study villages were not as great as between the two Maralal villages and Ngorika or Lpartuk and the greater extent to which sub-households at Loikas relied on wild foods may be a reflection of these greater differences. The greater frequency of collection of charcoal at Loikas may also be a reflection of this wealth differential. However, it is impossible to control for the effect of greater market access in determining levels of marketable wild resource use.

**Hypothesis 3**. Collection of wild resources provides a buffer against seasonal shortages.

The question of seasonality in resource use was considered particularly important if it varied across the different wealth strata. Access to wild resources may be particularly important to poorer sub-households to meet basic food and cash needs at certain times of year, such as in the late dry season when the previous years harvest has run out (Scoones *et al.*, 1992).

The results are consistent with the hypothesis that frequency of resource use varies systematically within a year. However, the degree to which this is a response to seasonal needs rather than availability or energetic constraints depends on market access.

There was little evidence that seasonality of resource use was more acute for poorer households and levels of resource collection were at their lowest during April when seasonal stress in terms of both food availability and labour demands, was at its highest. Wild food collection appeared more closely determined by availability than need, even for the poorest households. Wild food collection was highest in July and August when fruit and leaves used as vegetables are most available and there was no strong relationship between frequency of wild food collection and any measure of wealth.

Low frequency of wild food collection in the driest periods again confirm Sperling's conclusions (1987b) that the Samburu do not tend to gather wild food as a response to drought (c.f. Campbell, 1987). Again, distribution of relief food may be important in mitigating seasonal demands for wild resources.

Two factors should be taken into account when interpreting the results of the seasonal comparison in this study:

1. The region is characterised by high inter-annual variability in rainfall (chapter two) which can itself influence both demand and supply. The resource use surveys were repeated over the course of a year at Ngorika and Lpartuk with the intention of comparing resource use in wet and dry seasons. However, following a prolonged dry period from February 1993 to March 1994, rainfall from April 1994 until December 1994 was above average (DMP, 1993) and the multi-round surveys did not include the extremely dry conditions that characterised the first three months of 1994; and
2. The very low levels of resource use may be an artefact of reporting bias, rather than, or as well as, seasonality of use (discussed above in section 6.5.2.1).

**Hypothesis 4.** Levels of wild resource use is limited by the availability of labour to collect and process the resources.

The pattern of frequency of resource collection supports the hypothesis that energetic costs associated with gathering wild resources can over-ride seasonal needs in determining levels of resource use (cf. Thomas & Leatherman, 1990). Overall frequency of collection of wild resources was lowest in April, the time of highest seasonal stress included within the survey, and peaked between July and October when demands for labour were low (July-August) and food availability from the harvest good (October). The opportunity costs of gathering scarce resources that are labour intensive has already been proposed as an explanation for the very low levels of poles and posts collected at Tamiyoi and Loikas. However, the fact that marketable resources were collected at greater frequencies further into the dry season at Lpartuk than at Ngorika seems also to support the hypothesis that the market value of posts over-rides energetic constraints up to a certain point, maintaining levels of resource collection higher further into the lean period.

During a meeting at the end of the study, when some initial results of the study were discussed with a group of men and women from the villages, many women stated that they would not go out to collect resources so frequently during periods of seasonal stress because they did not have the energy to do so.

Energetic constraints will depend on seasonal labour demands and dietary intake. For example, it has been proposed that sub-households with fewer livestock are less subject to labour constraints associated with livestock management during the dry season. This returns to the question of wealth influencing wild resource use. The importance of these labour constraints in limiting wild resource collection, particularly in relation to different wealth indicators, such as size of actual harvest and livestock herds, would make an interesting future study.

Hypothesis five relates to habitat availability which is investigated in the following section.

### 6.5.5 Resource collection and habitat types.

The results of the multi-round surveys presented above suggest that market access increases the frequency with which marketable products (mainly charcoal and poles and posts for construction) are collected. These marketable products were identified as being potentially the most destructive uses of forest; both charcoal making and extraction of poles and posts involve tree felling. Before any statements as to the potential impact of these activities can be made, however, it is important to establish where these resources are coming from. This section looks at the relative importance of the different habitat types available in the area of study in providing wild resources in general and marketable resources in particular.

Availability of each of the five habitat types defined in the multi-round surveys was calculated within a five kilometre radius of Lpartuk and Ngorika from the vegetation maps (drawn on the basis of aerial photograph interpretation and described in chapter seven) and is summarised in Table 6.10 below. The results differentiate between vegetation cover overall and cover outside the reserve.

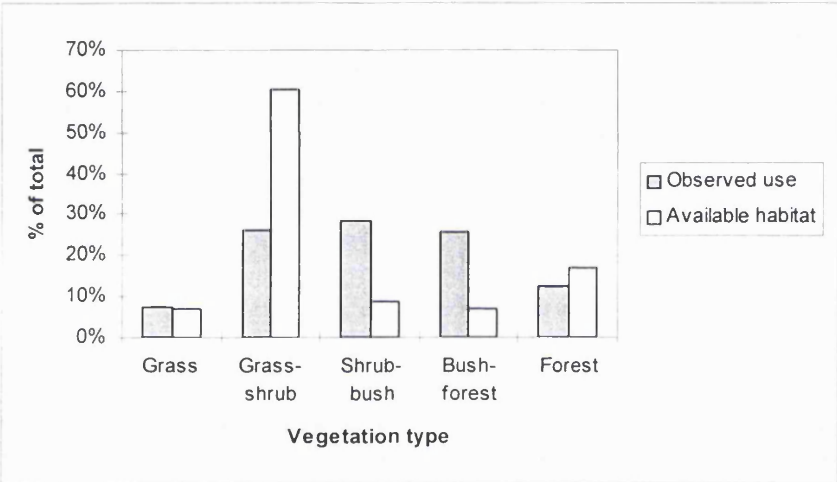
**Table 6.10** Summary of results from aerial photo interpretation showing availability of habitat types overall and outside the forest reserve for Lpartuk and Ngorika.

| **Forest Use Survey Vegetation Types** | **% cover (from API)** | | | | | |
|---|---|---|---|---|---|---|
| | **Lpartuk** | | | **Ngorika** | | |
| | All | Inside Reserve | Outside Reserve | All | Inside Reserve | Outside Reserve |
| **Open grassland** | 9.2% | 2.3% | 16.2% | 7.0% | 10.8% | 3.8% |
| **Grassland/shrub** | 45.2% | 69.1% | 32.4% | 60.6% | 52.5% | 66.6% |
| **Bush/shrub** | 10.5% | 5.2% | 0.9% | 8.5% | 1.2% | 17.9% |
| **Degraded forest/bush** | 9.9% | 15.8% | 15.1% | 6.9% | 5.8% | 7.5% |
| **Forest** | 25.3% | 7.6% | 35.4% | 17.1% | 29.7% | 4.1% |

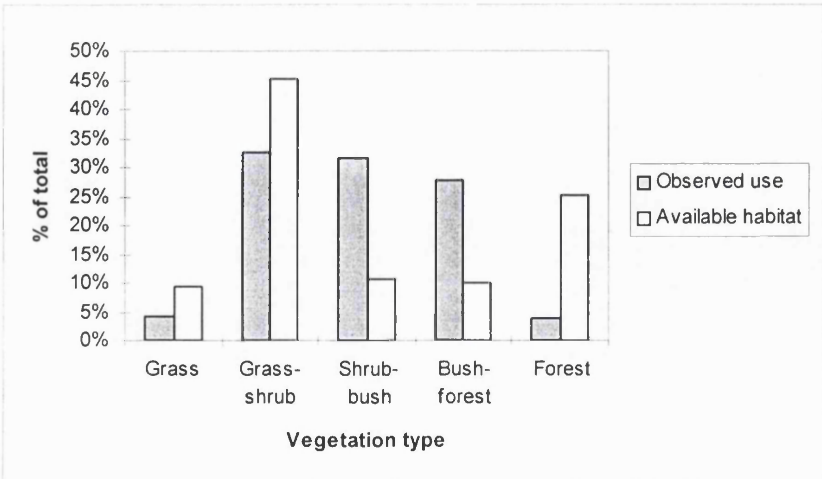
#### *6.5.5.1 Habitat selection in overall resource use*

The proportion of all observations within each habitat type for all categories of resource use over the entire year were compared with overall availability from the aerial photographs both inside and outside the reserve using the equations shown in Box 6-2 above. This calculates a selectivity index based on the total number of observations of resource use and the availability of each habitat type. If the selectivity index lies on or around unity, then the proportion of counts of resource use within that vegetation type is proportional to availability, i.e. there is no active selection for or against. If the selectivity index lies below unity, the habitat is used less than would be expected on the basis of availability alone and the opposite is true if the selectivity index lies above unity. The significance of the difference of the selectivity index from unity can be tested by calculating the variance of the selectivity index and defining the upper and lower confidence limits.

Differences between the availability of habitats and their overall use are shown in Figure 6-8. The results of the analysis are summarised for the overall data in Table 6.11.




(a) Ngorika




(b) Lpartuk

**Figure 6-8** Differences in availability and use of habitats at (a) Ngorika and (b) Lpartuk, showing the proportion of observed counts within each vegetation type and the expected proportions from the aerial photograph interpretation.

**Table 6.11** Summary of results showing the selection ratio ( $\hat{w}$ ) and direction of habitat selection in overall wild resource use.

| | Total no. of cases | Percent of total cases | Percent available habitat | Selectivity index ($\hat{w}$) | Lower 95% conf. limit | Upper 95% conf. limit | Selection ($P<0.05$) |
|---|---|---|---|---|---|---|---|
| **NGORIKA** | | | | | | | |
| Grass | 133 | 7 | 7 | 1.06 | 0.46 | 1.66 | **0** |
| Grass-shrub | 473 | 27 | 61 | 0.43 | 0.39 | 0.48 | **-ve** |
| Shrub-bush | 511 | 28 | 8 | 3.36 | 2.83 | 3.89 | **+ve** |
| Bush-forest | 462 | 26 | 7 | 3.73 | 3.34 | 4.13 | **+ve** |
| Forest | 220 | 12 | 17 | 0.72 | 0.55 | 0.88 | **-ve** |
| Total | 1799 | 100 | 100 | | | | |
| **LPARTUK** | | | | | | | |
| Grass | 75 | 4 | 9 | 0.44 | 0.23 | 0.65 | **-ve** |
| Grass-shrub | 606 | 32 | 45 | 0.72 | 0.66 | 0.79 | **-ve** |
| Shrub-bush | 587 | 32 | 11 | 3.02 | 2.67 | 3.38 | **+ve** |
| Bush-forest | 517 | 28 | 10 | 2.80 | 2.35 | 3.25 | **+ve** |
| Forest | 71 | 4 | 25 | 0.15 | 0.09 | 0.22 | **-ve** |
| Total | 1856 | 100 | 100 | | | | |

Overall, most wild resource activities take place in grass-shrub, shrub-grass and bush-forest. The proportion of overall resource use counts recorded in each of these vegetation types is very similar in both villages (between 26% and 33%). Closed canopy forest habitats account for just 4% of all wild resource activities at Lpartuk and 12% at Ngorika, while open grassland accounts for 4% and 7% respectively.

Comparing use with availability, shrub-bush and bush-forest are both actively preferred as a source of wild resources in both villages, while grass, grass-shrub and closed canopy forest are avoided. Availability of grass-shrub is disproportionately high (60% of the whole area at Ngorika and 45% at Lpartuk) which may explain the evidence for selection against the habitat. Grassland and forest, however, account for just 7% and 17% of total vegetation cover respectively at Ngorika and 9% and 25% of total vegetation cover respectively at Lpartuk. The significant avoidance behaviour in these vegetation types is, therefore, a reflection of their low levels of use and not an artefact of availability.

#### *6.5.5.2 Habitat selection for marketable products*

Human disturbance surveys inside and outside the forest reserve at Lpartuk clearly demonstrated that people differentiated between the two areas, with almost all stumps and all charcoal pits located outside the reserve (chapter two). For this reason, levels of use within each vegetation type were compared with availability outside the reserve only (Table 6.10). Where more than one activity was carried out in the same habitat type by the same person on the same day, only one count of that habitat was made since the choice of habitat for the second activity may not have been independent of the first.

Analysis of these count data used the same selectivity index shown above in Box 6-2. The results are summarised in Table 6.12 below. A comparison of frequency of use of each vegetation type for all marketable products in Lpartuk and Ngorika is shown in Figure 6-9

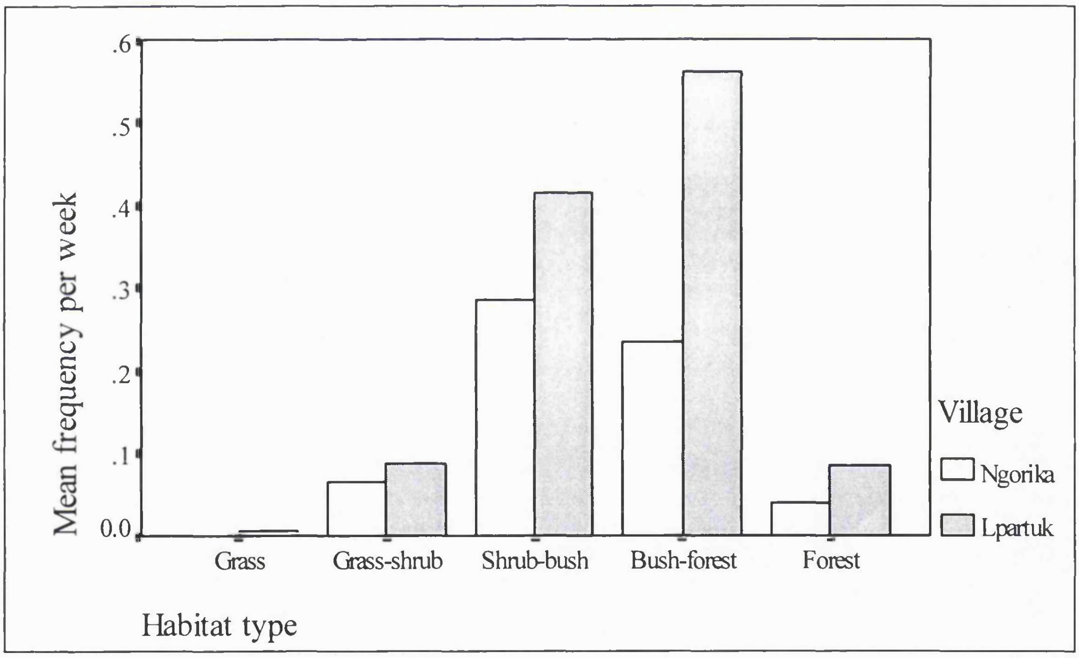



**Figure 6-9** Frequency of use of the different habitat types for the collection of marketable products (charcoal, poles & posts and timber).

**Table 6.12** Summary of results showing the selection ratio ( $\hat{w}$ ) and direction of habitat selection for marketable produce over the entire year.

| | Total no. of cases | Percent of cases | Percent available habitat | Selectivity index ( $\hat{w}$ ) | Lower 95% conf. limit | Upper 95% conf. limit | Selection (P<0.05) |
|---|---|---|---|---|---|---|---|
| **NGORIKA** | | | | | | | |
| **Grass** | 1 | 1 | 4 | 0.22 | -0.34 | 0.77 | (-) |
| **Grass-shrub** | 17 | 14 | 66 | 0.21 | 0.10 | 0.32 | -ve |
| **Shrub-bush** | 48 | 40 | 18 | 2.21 | 1.62 | 2.80 | +ve |
| **Bush-forest** | 46 | 38 | 8 | 5.04 | 3.78 | 6.31 | +ve |
| **Forest** | 9 | 7 | 4 | 1.80 | 0.09 | 3.51 | 0 |
| **Total** | 121 | 100 | 100 | | | | |
| **LPARTUK** | | | | | | | |
| **Grass** | 0 | 0 | 16 | 0 | 0 | 0 | |
| **Grass-shrub** | 19 | 8 | 32 | 0.25 | -0.001 | 0.50 | -ve |
| **Shrub-bush** | 99 | 42 | 2 | 48.70 | 7.91 | 89.50 | +ve |
| **Bush-forest** | 105 | 44 | 15 | 2.93 | 0.57 | 5.30 | 0 |
| **Forest** | 14 | 6 | 35 | 0.17 | 0.00 | 0.33 | -ve |
| **Total** | 237 | 100 | 100 | | | | |

Around 80% of all marketable products collected come from bush-forest and shrub-bush habitats in both villages. Closed canopy forest provides just 6% of marketable goods at Lpartuk and 7% at Ngorika.

Comparing levels of use with availability outside the reserve, bush forest is selected for at Ngorika but not at Lpartuk while closed canopy forest is selected against in Lpartuk, but not at Ngorika. The greater availability of both closed canopy forest and bush-forest outside the reserve at Lpartuk (37% and 21% respectively) compared to Ngorika (4% and 8% respectively) may account for these differences.

*6.5.5.3 Use of closed canopy forest*

These results might suggest that closed canopy forest is relatively unimportant to the forest adjacent community. The proportion of each resource use category which took place in closed canopy forest was calculated to examine whether specific resource use categories made much use of closed canopy forest in relation to other habitat types. All counts were included as it was impossible to know which category was the primary reason for choosing closed canopy forest. The results are shown in Table 6.13 below.

**Table 6.13** The proportion of wild resource use activities taking place in closed canopy forest both in terms of the total number of counts within closed canopy forest and the total number of counts for each resource use category. The data is combined for Ngorika and Lpartuk.

| Use category | % of total no. of counts within closed canopy forest (N=401) | Total no. of counts for each resource use category | % of total no. of counts within closed canopy forest |
|---|---|---|---|
| Water - cattle | 33% | 546 | 24% |
| Medicines | 12% | 427 | 11% |
| Water - shoats | 8% | 205 | 17% |
| Other wood | 7% | 203 | 14% |
| Firewood | 6% | 817 | 3% |
| Poles & posts | 5% | 319 | 6% |
| Rope | 5% | 165 | 13% |
| Bark/Thatch | 5% | 142 | 15% |
| Grazing cattle | 4% | 758 | 2% |
| Grazing shoats | 3% | 851 | 2% |
| Fodder/veterinary | 3% | 168 | 7% |
| Honey | 3% | 32 | 34% |
| Ceremony/ritual | 3% | 21 | 33% |
| Wild food | 1% | 447 | 1% |
| Timber | 1% | 19 | 16% |
| Hunting | 1% | 12 | 33% |
| Charcoal | 0% | 43 | 5% |
| **Total** | **100%** | **5175** | **8%** |

Overall, only 8% of counts of wild resource use took place within closed canopy forest. In summary, the resource use categories which took place in closed canopy forest with most frequency over the course of the year were watering cattle and collecting medicines. Closed canopy forest represented 24% of the total number of counts for watering cattle, 17% of all counts for watering shoats and 11% of all counts for medicine collection. Closed canopy forest was also the site for 34% of the total number of counts for honey collection and 33% of all counts for ceremonial and hunting (of the twelve times hunting was reported as an activity, the hunters were never successful in capturing or killing their prey). Interestingly, closed canopy forest accounted for just 2% of all counts of cattle and shoats grazing, although, these figures would only include days on which most of the time was spent in closed canopy forest. (In contrast, cattle spent most of the day grazing in degraded forest bush on 16% of occasions recorded over the course of the year.)

#### *6.5.5.4 Discussion: Habitat selection and availability.*

The results of this study support the hypothesis that closed canopy forest is not a preferred source of wild resources, even for those such as poles and posts and charcoal. This corresponds with the results from a number of studies of wild resource use (e.g. Fairhead & Leach, 1994; Evers, 1994; Hartley, 1992; Castro, 1991; Prance, 1991; Koppell, 1990). Overall, closed canopy forest was selected against, most activity taking place in degraded bush forest, shrub bush and grassland shrub where the diversity of products available is likely to be highest.

The products with greatest market value were found to be those most closely identified with forest: charcoal, poles and posts and other wood products. However, the results presented in this chapter show that degraded bush forest was the preferred source of these products and not closed canopy products. A number of reasons were proposed for this in particular the fact that women who collected most of these resources were afraid to enter closed canopy forests because of wild animals and robbers.

These results suggest that pressure on closed canopy forest is greatly reduced by the availability of other habitat types. Conversion of forest to a more mosaic and degraded vegetation type in effect creates a buffer zone around the closed canopy forest. In terms of forest conservation, the important question this raises is whether this buffer zone can continue to supply the needs of the population, or whether gradual encroachment into more closed canopy forest areas will continue (Hall & Rodgers, 1986).

The die-back of *Juniperus procera* seen around the Maralal area over the past 20 years must be remembered here (discussed in chapter two). Most respondents claimed that the trees they cut for posts were already dead. Clearing these dead trees may well provide a better environment for further regeneration of *Juniperus,* a light demanding pioneer species. There is also, however, the risk that too rapid clearing will desiccate the micro-climate, reducing the regenerative potential (Longman & Jenik, 1992).

The results of this study, therefore, support hypothesis five at the start of this chapter which stated: 'there is habitat selection in the collection of wild natural resources, irrespective of habitat availability, which favours the more open and species diverse woody habitats'. This should not be taken to mean that access to closed canopy forests is not important to forest adjacent communities. Specific resource use categories that use and need access to closed canopy forest are the collection of honey and medicines, cultural ceremonies and access to water for livestock. These are all essentially non-consumptive, non-destructive uses of the forest, with the possible exception of honey collection which has been blamed as a major cause for forest fire outbreaks (District Annual Report, 1984). Improved technologies, using protected smoke sources to collect fire would quickly and easily remedy this fire risk.

## 6.6 Measuring wild resource use

Two issues relating to the methods used in measuring wild resource use were raised in the course of this survey. Given their implications for forest management they are discussed briefly here.

### 6.6.1 Forest resources versus wild resources

In the initial stages of this study, various uses made of the forests on the Lerroki Plateau by the local communities were identified through informal discussion with people from the area. The focus of the study was the forests and it was introduced as such. It was clear, however, from personal observations and informal discussion, that forest was not the only source available for these products. The results of this survey highlight the significance of establishing the relative importance of all the different habitat types available to the communities involved. This has serious implications for both the communities themselves and for ecologists assessing the impact of wild resource use on any one particular habitat type.

### 6.6.2 Multi-round surveys versus one-off surveys

The advantages of multi-round, longer term studies over rapid one-off surveys are clearly demonstrated from the results of this study. Repeating surveys over the course of the year allows seasonal variability in resource use to be established as well as allowing greater confidence in the quality and viability of the data collected.

## *6.7 Conclusion*

This chapter has used the results of chapter five to test for significant relationships between wild resource use and wealth and between wild resource use and market access. In addition, multi-round surveys allowed any seasonality in wild resource use to be tested. Finally, the results of aerial photography interpretation was used to compare habitat selection at Ngorika and Lpartuk, taking habitat availability into account.

The results presented in this chapter show a number of differences between the areas of study which could have important implications for forest conservation. In particular, the proximity of a market encourages higher levels of extraction of marketable products such as charcoal and poles and posts. However, preference is given to open or degraded forest and bush over closed canopy forest as a source for these products.

If levels of resource use are unsustainable, this should be evident from long term changes in vegetation cover. In chapter seven, the results of aerial photography interpretation are used to determine the extent and distribution of change in vegetation cover over the last thirty years. This is used in conjunction with the results from this chapter and the results of the aerial photograph interpretation presented in chapter five to establish whether there are direct correlations between past and present levels of resource use and vegetation changes.

# 7. Long term vegetation change on the Lerroki Plateau

## 7.1 Introduction

Aerial photographs provide a unique qualitative and quantitative impression of vegetation change over time (UNESCO, 1978). In conjunction with other socio-economic and political data, long term change can be related to particular land uses and population pressures (Lambin, 1994; Kummer, 1991; Fairhead & Leach, 1994, Dewees, 1993; Guyer & Lambin, 1993).

This study uses the results of aerial photo interpretation together with the results of the vegetation, socio-economic and forest resource use surveys (presented in chapters three to six) to assess the long term implications of forest use on closed canopy forest cover. Vegetation cover was mapped from two comparative series of aerial photographs, taken in 1963 and 1993, using conventional mirror stereoscopy. These vegetation maps, covering most of the Leroghi Forest Reserve and some adjacent land to the west, were used to examine the extent and distribution of changes in vegetation cover over the last 30 years around specific sites within the study area.

In the following section, a review of the literature examines ways in which aerial photographs have been used to examine long term trends in vegetation change. The hypotheses to be examined in the course of this chapter using the results of the aerial photograph interpretation (API) are then developed using the results from chapters three to six. The methods section includes an extensive review of the process of mapping from aerial photographs in which sources of error in the mapping process are identified and assessed. The results are presented in three sections: overall vegetation change (comparing vegetation cover over the entire area mapped); local vegetation change (comparing vegetation change within a five mile radius from the centre of each study village, inside and outside the Forest Reserve); and change in an area of high cattle grazing intensity (comparing change in vegetation cover inside the boundaries of the forest reserve in an area around Saanata, heavily used for livestock grazing during the dry season). Finally these results are discussed and the hypotheses presented at the start of the chapter are, where possible, accepted or rejected.

### *7.2 Context*

Foresters have traditionally used aerial photographs for mapping and for monitoring fire, insect and disease damage since the 1930s (Wolf, 1983; Avery, 1969). More recently, aerial photographs and remotely sensed images have been used in conjunction with complex socio-economic and political data to assess the potential driving forces behind deforestation (see Lambin, 1994 for an extensive review). Wildlife managers and ecologists have similarly used aerial photographs to relate long term changes in woody vegetation cover within protected and dryland areas to large herbivore populations, rainfall and fire regimes (e.g. Norton Griffiths, 1979; Buechner & Dawkins, 1961; Stafford-Smith & Pickup, 1993).

Remote satellite images have the advantage of being relatively cheap compared to intensive aerial surveys (Grainger, 1983) and in the last decade there have been extensive developments in evaluating the application of remote sensing for environmental monitoring (e.g. Sader *et al.*, 1990 for a review of remote sensing and monitoring of tropical forests; also Lambin, 1994). However, satellite images cannot provide the temporal dimension that historical aerial photographs provide. It is also not always possible to make a direct comparison of data from aerial photographs and satellite images (Fairhead & Leach, 1994).

Lambin (1994) has extensively reviewed the ways in which aerial photographs as well as satellite images have been used to model deforestation processes. These have often been on a global or national scale (e.g. Allen & Barnes, 1985; Kummer, 1991); for example, Allen and Barnes (1985) found deforestation on a global scale related to population growth, agricultural expansion and the past rate of wood use. Such large scale studies, however, do not always take differences within and between regions and countries into account. The large scale felling of forests for agricultural and pastoral expansion typical of the Amazon basin is not seen to the same extent in West Africa where gradual degradation is perceived as a greater problem (Gilruth & Hutchinson, 1989). Other examples of aerial photographs being used to quantify changes in vegetation cover and land use on a more local scale include Guyer & Lambin (1993);

Lambin (1994); Dewees (1993); Rickards & Cushing (1982); Chenevix Trench *et al.* (in prep).

Identifying correlations between socio-economic or political factors and vegetation change does not identify the actual processes that cause deforestation: such an approach, particularly on a large scale, tends to identify ultimate rather than proximate causes for deforestation (Fairhead & Leach, 1994; Lambin, 1994). For example, Kummer (1991) found the development of roads to be the main driving force behind initial forest depletion in post-war Philippines, with population density playing more important role over time. While these factors may have ultimately driven the deforestation, they do not address *how* the areas were deforested (Lambin, 1994). Drawing causal relationships from correlations depends on a thorough understanding of the particular ecological and social situation under study (e.g. Fairhead & Leach, 1994).

Finally, data from aerial photographs are verifiable and quantifiable in a way that oral histories and archival material are not, and analysis of change using aerial photographs can be a useful way of convincing experts and managers to reconsider strongly held assumptions about ecological systems (Fairhead & Leach, 1994). Dublin (1991) used aerial photographs to develop an historical description of vegetation changes in the Maasai Mara National Park and in doing so found the system to be highly dynamic, with woody vegetation cover oscillating over time. Fairhead & Leach used aerial photographs to challenge the widely held assumption that forest islands typical of West African savannas were 'relics' of a former extensive forest that had been converted into savanna. They supplemented the forest cover data with socio-economic and land-management data to suggest ways in which local practices actually encouraged forest growth in what would otherwise be fire-maintained savanna (Fairhead & Leach, 1993; 1994).

## 7.3 Generating hypotheses

Specific observations from previous chapters were used to develop hypotheses relating to the long term sustainability of wild resource use in the system as a whole. These observations are summarised below before stating the working hypotheses that are tested in the course of this chapter using the results of aerial photo interpretation.

**Observation 1** (from chapters three and four) Evidence from within the forest suggests that livestock use of closed canopy forest does not have an effect on forest vegetation in the long term.

**Observation 2** (from chapter five) There has been an increase in demand for construction materials throughout the plateau around settlements. In absolute terms and in the context of the study villages, this demand has been greatest in the area around Maralal, followed by Ngorika and finally Lpartuk.

**Observation 3** (from chapters five & six) The wild resources with greatest market potential are also those whose use incurs the most potential for degrading forest resources: charcoal, poles and posts, honey and other wood products. Frequency of collection of these products is higher at Lpartuk than at Ngorika and it has been proposed that this difference is due to easier access to the market at Maralal and greater market demands from lorries passing through the village. A high proportion of sub-households around Maralal also sell woody resources although it was not possible to quantify the frequency to compare with Lpartuk.

On the basis of these observations, aerial photo interpretation is used to test the following hypotheses:

**Hypothesis 1.** Cattle, in the densities present around the Leroghi Forest Reserve, do not reduce forest cover over the long term.

**Prediction 1.** Forest cover will remain constant in an area used extensively by cattle in the dry season. The area around Saanata within the forest reserve is an ideal place to test this hypothesis, since it contains a number of dry season water points and is therefore heavily used by cattle. It is also rarely used for other activities.

**Hypothesis 2.** The market for construction material and other woody resources causes levels of extraction to exceed sustainable levels.

**Prediction 2.** Forest and bush cover will have declined around Lpartuk and Maralal in the last 40 years, but not Ngorika. Comparing change around Lpartuk and Ngorika takes into account the potential long term impact of demands for subsistence construction materials, since these were greater around Ngorika than Lpartuk. Maralal has had the greatest increase in construction demands as well as greater market demands. The reduction at Maralal is likely therefore to be greater than at Lpartuk and Ngorika, due to a combination of both subsistence and market forces.

### 7.4 Methods

Vegetation cover, in and around the Leroghi Forest Reserve, was mapped using two comparative series of aerial photographs taken in 1963 and 1993. The results were plotted on to base maps prepared from the existing 1:50,000 topographic maps using a digital mapping system (MAPINFO).[1]

The maps covered approximately 18,000 hectares outside the reserve to the west (including Maralal Town and Upper Lpartuk) and 80,000 hectares inside the reserve. The total area in hectares covered by each defined vegetation type (not taking topography into account) can be calculated by MAPINFO.

The maps were used to quantify changes in vegetation cover inside and outside the forest reserve from 1963 to 1993 in the following areas:

1. the entire area mapped from the API, both inside and outside the Leroghi Forest Reserve;

2. the area within a five mile radius from the centre of each study village, inside and outside the Forest Reserve (unfortunately the vegetation map did not cover an area reaching 5km to the west of Lpartuk and Maralal so the area sampled in those cases is slightly smaller than that sampled around Ngorika); and

3. an area within the forest reserve around Saanata, to the south of Ngorika, which is heavily used by cattle from all over the Plateau during the dry season (this area included the dry season water points from the cattle census described in chapter three and two large forest glades within Saanata itself).

The areas analysed are shown in Figure 7-1. The mapping process itself is discussed further below.

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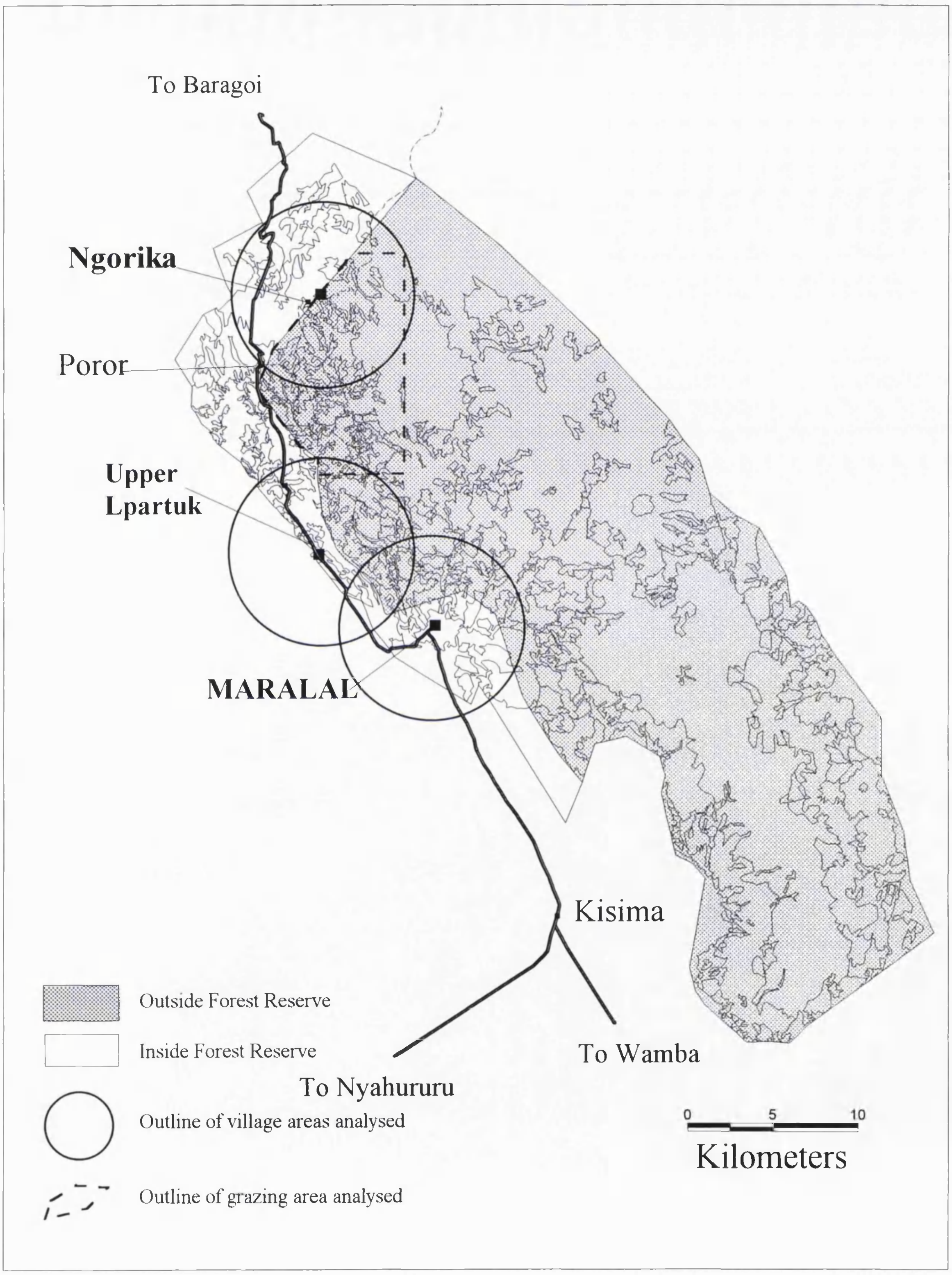
[1] The interpretation and mapping took place in Kenya. The 1993 photographs were analysed for the Kenya Indigenous Forest Conservation Project (KIFCON, 1994) as part of a programme to map all of Kenya's forest reserves. The 1963 photographs were analysed for the first time explicitly for this study.

**Figure 7-1 Map showing village areas and grazing area analysed using API results**



### 7.4.1 Forest Mapping from Aerial Photo Interpretation (API): the process

In this section, the entire mapping process is described briefly. A detailed description of planning and executing an aerial photograph survey, can be found in many photogrammetry text books, such as Avery (1984) and Wolf (1983).

#### *7.4.1.1 Production of the photographs.*

Details of all aerial photographs used in the course of the present study are given in Table 5.4 in chapter five. The photographs used for the mapping exercise described in this chapter are summarised below in Table 7.1:

**Table 7.1** Aerial photography available for the Lerroki Plateau used for mapping vegetation cover.

| Year | Agent | Scale | Cover |
|---|---|---|---|
| 1963 | Spartan Air Services for Survey of Kenya | 1:30,000 | Leroghi Forest Reserve |
| 1993 | KIFCON for Survey of Kenya | 1:25,000 | Leroghi Forest Reserve |

The scale of an aerial photograph is a function of the focal length of the camera and the height of the camera above the ground. Both sets of photographs interpreted were produced using a 6" focal length, taken from 15,000ft and 12,500ft respectively to give a scale of approximately 1:30,000 for 1963 and 1:25,000 for 1993 (Spartan, 1963; KIFCON 1994). Clearly, unless the terrain is completely flat, scale will alter as the terrain altitude increases and decreases. This study assumes an average scale across the terrain, which is equivalent for both sets of photographs.

#### *7.4.1.2 Interpretation of the photographs and vegetation classification*

The aerial photographs for this study were interpreted by vegetation cover. To interpret the photographs, a vegetation classification system was defined for which it was important: a) to ensure that the interpreter could consistently recognise each type; and b) that the system can be universally recognised.

The vegetation classification system used in this study was based on five main physiognomic types described in Trapnell and Langdale-Brown (1962) and developed by Pratt *et al.* (1966) and White (1983). These classification systems are adapted from the system accepted at the Specialist meeting on Phytogeography at Yangambi in 1956 and the system proposed by Greenway in 1940 (Pratt *et al.* 1966). This system has been widely adopted (e.g. Hedberg & Hedberg 1968), the main discrepancy between the various adaptations being in the preference for a clearer distinction between grassland, wooded grassland, bushed grassland etc. than that provided by the term "savanna" (Langdale-Brown *et al.,* 1964).

The five main physiognomic types that form the basis for the classification system is shown in Table 7.2.

**Table 7.2.** The main physiognomic types used for the vegetation classification (from White 1983).

| | |
|---|---|
| Forest | A continuous stand of trees at least 10m tall, their crowns interlocking, with a canopy cover of 80% or more. |
| Bushland | An open stand of bushes, usually between 3 and 7m tall with a canopy cover > 40% (closed stands are sometimes referred to as thicket). |
| Shrubland | An open or closed stand of shrubs up to 2m tall with a canopy cover > 40%. |
| Grassland | Land covered with grasses and other herbs, woody plants canopy cover < 10%. |
| Woodland | An open stand of trees at least 8m tall, with a canopy cover of 40% or more. The field layer is usually dominated by grasses. |

The details of the classification system used in the API for this study included is shown in Table 7.3. The present study makes no attempt at distinguishing between seral stages and climax communities in the interpretation of aerial photographs.

**Table 7.3.** Classifications of land use and vegetation type in API

| Vegetation type | Definition |
|---|---|
| Bush | Bush > 80% |
| Farm/Shamba | Enclosed / cultivated > 50% |
| Forest | Forest > 80% cover |
| Forest/Bush | Intermediate between forest and bush, cover >80%; |
| Grassland | Grassland > 80% |
| Grassland/Shrub | Intermediate between grassland & shrub |
| Plantation | Plantation (tree cover may be as low as 10% because of failure of plantation to establish, but the planned plantation boundary is clear) |
| Shrub | Shrub > 80% |
| Woodland | Scattered tree cover >30% |
| Dam | Water |
| Maralal Town/trading centres | Dense settlement |

#### *7.4.1.3 Stereoscopy*

The interpretation was drawn directly onto one of the photographs under the effect of stereoscopic, three-dimensional vision.

Stereoscopy is defined as "the science and art of viewing two different perspectives of an object, recorded on photographs taken from nearby camera stations, so as to obtain the mental impression of a three-dimensional model of the object." (Howard 1991).

The aerial camera records a perspective view, with all objects displayed radially outwards from the point on the ground vertically beneath the camera (the nadir). Stereoscopy uses this radial displacement across pairs of photographs to create a three-dimensional image.

Contiguous pairs of aerial photographs are taken so that they overlap (by 60-80% in the direction of the flight path and by 20-45% in adjoining flight paths (Howard, 1970)). The degree of overlap determines the 'effective area' of each photograph. Within this area, radial displacement becomes minimal (Howard 1991, Avery 1985) and control points, which tie the data layer (in this case defining vegetation types) to a base map, may be more accurately plotted.

#### *7.4.1.4 Positioning photograph objects in relation to the UTM grid on ground*

The results of the photo-interpretation in this study were plotted on to base maps prepared from the existing Survey of Kenya 1:50,000 topographical maps, using a digital mapping system. Three control points were identified on each photograph, and given UTM co-ordinates from the 1:50,000 topographic maps. Control points typically used clearly identifiable features such as peaks, rocks and the intersection of roads or rivers. These control points ensure correct orientation of the photographs with respect to each other and with respect to ground control (Spurr, 1960). Each photograph was positioned geographically in relation to the UTM grid, using the grid reference for each control point. The outlines of the vegetation types, drawn onto the photographs using a fine nibbed drawing pen, were then transferred directly from the photographs to a computer using a digitiser.

### 7.4.2 Forest Mapping from Aerial Photo Interpretation : the problems

Problems associated with API are both technical and analytical. "Success in photo-interpretation will vary with the training and experience of the interpreter, the nature of the objects being interpreted and the quality of the photographs being used" (Wolf 1983).

Visual photo-interpretation requires a firm understanding of the scientific fundamentals of photogrammetry and stereoscopy; it also requires imagination and skill in identification and classification of images, in this case classifying vegetation types, which involves a degree of subjectivity (Avery 1960). "The most capable photo-interpreters have keen powers of observation plus imagination and a great deal of patience" (Wolf 1983 p163). An experienced interpreter was employed to carry out the work for this study.

The potential sources of error in the production process of making a vegetation map from API are summarised below within the context of this study. The discussion is not exhaustive, but introduces the most important processes with references to the main texts on photogrammetry and photo-interpretation.

#### *7.4.2.1 Production of the photographs.*

Photographic resolution is a function of the camera lens, film quality and processing. Errors occur during production but vary in their significance, particularly in the context of interpretation, and particularly when comparing two sets of photographs to provide a measure of relative change over time. It is impossible to make an entirely flawless lens and all photographs are subject to distortions. However, technological advances and the use of combinations of lenses make such problems negligible (Howard, 1970).

Photographic paper and film are subject to shrinkage, dependent particularly on the methods used in drying and storing photographs which alters the scale of the photographs (Wolf, 1983). Unsystematic distortions due to shrinkage can occur, but errors would be minimal (E. de Merode, *pers comm.*).

#### *7.4.2.2 Interpretation of the photographs and vegetation classification*

Of greatest importance to this study are errors due to the subjectivity of defining vegetation types during visual photo-interpretation.

There are two potential sources of error in the interpretation of vegetation cover from aerial photographs: identifying where one vegetation type changes to become another (a continuous error); and identifying the vegetation type within the boundaries drawn (a binary error).

No matter how clearly the vegetation classification may be defined, the exact positioning of the boundary between two vegetation types will often be subjective. In some cases, the vegetation boundary may be very clear from the photographs. This is generally true of forest surrounded by fire-maintained grassland (Buechner and Dawkins, 1961; Hopkins, 1992). Where bush gradually changes to shrub, or shrub to grassland, however, the exact position of the boundary between the two is much harder to define. The topography of the Lerroki Plateau was in this case an advantage, since much of the wooded vegetation is limited to hill tops and river valleys, and boundaries between vegetation types were easier to identify. In addition, using one experienced interpreter to define the boundaries for all the photographs made the interpretation equivalent for each set of photographs.

Identifying each vegetation type from the photographs requires considerable experience and knowledge of the vegetation types typical of the area on the part of the interpreter, and a clearly defined classification system. It is possible to test the accuracy with which vegetation types have been identified using a system of ground truthing: a series of random points within the area interpreted are identified and the classification on the photograph is compared with the vegetation on the ground (Howard, 1991, Wolf 1983, Avery 1965). However, this system cannot be applied when considering old photographs which cannot be verified and Avery (1965) suggests that this should make for greater restrictions in defining vegetation classes. Using a complex classification system increases the probability of incorrectly identifying areas of vegetation from the aerial photographs.

Nine land-use categories were defined in addition to a category for Maralal Town and other trading centres and a dam. This relatively high number of categories is justified on the basis that all photographs were of relatively large scale, and interpreted by the same interpreter who had 30 years of API experience in Kenya and who was confident that he could follow the classifications defined. The classification system differentiates between closed canopy forest and degraded forest/bush. It is, of course, impossible to differentiate between areas of forest which are not subject to human activities and those where levels of human activities have not had an impact on the forest canopy from the photographs alone.

The aerial photo interpretation of the 1993 photographs took place too late for extensive ground truthing. However, I carried out most of my field work around Ngorika and knew the area well enough to ground truth a small area by cross checking the mapping classifications from the photographs themselves. 59 points around Ngorika and 10 around Lpartuk were selected on the photographs using a random design of points on acetate which were systematically laid over the photographs[2]. The vegetation type at each point was identified from memory of the area and this was

[2] More points were selected at Ngorika than Lpartuk partly as a function of the area with which I was familiar and partly because a selection of photographs around Ngorika been enlarged to a scale of 1:10,000 making it easier to identify the specific area in question.

compared with the corresponding point on the vegetation map. The error matrix tested is shown in Table 7.4.

**Table 7.4** Error matrix for API showing percentage accuracy for each vegetation type

| **Classification on map** | **Actual vegetation type** | | | | | |
|---|---|---|---|---|---|---|
| | **Forest** | **Bush-forest** | **Bush** | **Shrub** | **Shrub-grassland** | **Grassland** |
| **Forest** | **23** | | 1 | | | |
| **Bush-forest** | | **4** | | | | |
| **Bush** | | | **3** | | 2 | |
| **Shrub** | | | | **2** | 2 | |
| **Shrub-grassland** | | | | | **18** | |
| **Grassland** | | | | | 1 | **12** |
| **Farmland** | 1 | | | | | |
| **% Accuracy** | **96** | **100** | 75 | **100** | **78** | **100** |

Analysis of the data combined for all vegetation types suggests that the vegetation identification was 90% accurate with a standard error of 5%. It is possible that some vegetation types were easier to identify than others, for example bush and shrub-grassland had a lower percentage accuracy than grassland and shrub (Table 7.4). However, to test for each vegetation type it would be necessary to identify approximately 50 points for each classification which was not possible for this study (Hord & Brooner, 1976).

In summary, therefore, the overall level of accuracy achieved in the interpretation of the 1993 photographs was at least 82% (with 95% confidence) and there is no reason to expect that the same level of accuracy was not achieved for the 1963 photographs. This *post hoc* verification is far from ideal, but it does provide a useful impression of the error associated with the vegetation identification.

### *7.4.2.3 Stereoscopy and positioning photographic objects.*

Stereoscopy uses radial displacement to create a three dimensional effect, thereby reducing errors due to radial displacement considerably. However, tilt and terrain displacement can still affect the accuracy of the interpretation: where objects occur at a different altitude to the nadir, their position on the photograph will be displaced in relation to the image of nadir.

Errors of this sort lead to the incorrect positioning of photographic objects in relation to the UTM grid on ground. The difference between the true ground co-ordinates and the data layer co-ordinates is called the geometric positional error (Bostad *et al.*, 1993). Geometric positional error may also occur due to atmospheric refraction; tilt and terrain displacement; map distortions due to shrinkage (discussed above); mistakes in point identification and digitisation procedures; and where the stereo-pair are not oriented accurately. In this study, stereoscopy and digitisation were carried out by two people who had considerable experience in the processes involved. It is therefore assumed that human error was kept to a minimum in these processes.

**Identification of control points** is subject to correctly relating data from the photograph to the base-map. This can be problematical in closed canopy forest. However, given the topographical features of the area and the experience of the interpreter, errors caused this way are considered negligible. There are also errors within the base map itself: under international mapping standards (set by the US Geological Society), a map with a scale of 1:24,000 should be accurate to within 0.63mm, corresponding to 15m on the ground with a probability of 90% (in Maling, 1991). For the purposes of this study, which is essentially comparative, such errors were assumed to be random and unbiased.

**Atmospheric refraction** occurs where light is deflected from a straight path as a result of heat or dust particles, and is often related to topography and the height at which the photographs are taken. Since this study is comparing the same area, using photographs taken at similar heights and scale, refraction is likely to be equivalent for both sets of photographs and effects of atmospheric refraction can be ignored (Wolf 1983).

**Tilt displacement** occurs when the plane from which the photograph is being taken is not flying horizontally to the earth's surface. Tilt displacement is impossible to avoid and the exact angle and direction of tilt are rarely known to the interpreter. Provided the interpretation uses only the effective area, the effects are considered negligible where tilt is less than $3^{\circ}$ (Avery 1985).

**Terrain displacement** occurs when objects at the edge of the photograph are at a different altitude to the nadir. The risk of errors caused by both terrain and tilt displacement increases where terrain is very uneven. Terrain displacement is directly correlated with the actual height of an object and its distance from the nadir, and by correlation with the focal length of the camera used. The greater the variation in altitude within one photograph, the greater the error due to terrain displacement. Terrain displacement can be minimised by restricting analysis to the centre of the photograph - the "effective area" defined above.

Graphs can be prepared in which the parallax error of photographs can be read off according to changes in tilt and differences in ground elevation (Howard 1970), and the system of radial line triangulation controls for displacement effects. However, these controls would have had to be carried out for hundreds of photographs and were prohibitively time consuming for this study. Since the focal length used was the same in both sets of photographs, and the terrain surveyed is the same, such error is assumed to be random for this study and therefore negligible when comparing the overall changes in vegetation cover over time[3].

#### *7.4.2.4 Production of the map*

Errors may occur in drawing the map due to the thickness of the pen, the number of points used to define each polygon and concentration errors in inputting the data.

The pen used had a nib width of 0.3mm, the equivalent of 7.5m on the ground at a scale of 1:25,000. This error would be random and negligible. The effect of using a different frequency of points per unit length to define the outline of a patch of vegetation can have an impact on the accuracy of the final map. The more points used to define the area the more accurate the final calculation of the area will be. However, the more points used in digitising a map, the slower and more cumbersome becomes the computer programme and there is a temptation for the digitiser to use fewer points, particularly if the job is rushed. Unfortunately it is impossible to avoid this

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[3] Errors caused by displacement could be considerable if the flight line followed a linear topographic feature, such as a river valley or ridge, for some distance. Since the flight lines would have been different for each set of photographs, it was not considered possible to compare the vegetation from each set of photographs at a single point or within a very small area defined on the UTM grid.

problem, although placing an emphasis on accuracy over speed at the start of the process is important. The errors caused by this process are, again, likely to be negligible in comparison to those caused by terrain displacement or in defining the vegetation boundaries.

#### *7.4.2.5 Summary*

The production process in making a vegetation map from API and the potential sources of error are summarised in Table 7.5 below.

**Table 7.5** Potential sources of error in the production of vegetation maps from aerial photographs

| Source of error | Potential degree of error |
|---|---|
| Defining vegetation types | 10% ± 8 % |
| Error in base map | ± 15m on the ground (negligible) |
| Paper and film shrinkage | 2%[4] (negligible) |
| Lens distortions | negligible[4] |
| Tilt displacement | negligible[4] |
| Pen nib width | ± 7.5m on the ground (negligible) |
| Orienting stereo pair | negligible / N/A[5] |
| Atmospheric refraction | N/A[6] |
| Terrain displacement | unknown - N/A |
| Identifying control points | unknown - n/a[7] |
| Inputting control co-ordinates | unknown (negligible)[7] |
| Inputting data points | unknown (negligible) [7] |
| Number of points/unit length | unknown (negligible) [7] |

[4] Wolf 1983

[5] The same experienced interpreter interpreted both sets of photographs - such error is likely to be random with no bias and is therefore not considered in this study

[6] height of flight path & terrain the same for both sets of photographs therefore not considered in this study

[7] The same person, experienced in inputting data into the digital mapping system used, digitised both sets of photographs - such error is likely to be random with no bias and is therefore not considered in this study

In summary, the greatest potential source of error is from locating the boundaries of, and correctly identifying, each vegetation category. Ground truthing of the 1993 interpretation from the photographs suggests the vegetation was correctly identified at least 82% of the time, with 95% confidence. There is no reason why the 1963 photographs should not have been interpreted with equal accuracy. Other sources of error will fall within the margins of error in identifying the vegetation types.

Unfortunately the results of the error matrix analysis cannot be used as a standard to provide a statistical test of change since the problem of defining boundaries is likely to compound error when considering change in vegetation type which occurs at the boundaries (de Merode, *pers comm.*). However it does provide a guide to the overall accuracy of the data.

### 7.4.3 Data Analysis

The vegetation maps were analysed by summing the total area covered by each vegetation type. This can be computed by MAPINFO. The results are presented as absolute areas and the change from 1963-1993 presented as a percent of the total area under analysis as well as net change. The area estimates provided are relative as they make no allowance for the topography of the plateau.

## *7.5 Results*

### 7.5.1 Overall change in vegetation, 1963 - 1993

The overall results from the photo-interpretation are shown in Figure 7-2 and Figure 7-3, and summarised in Table 7.6.

Within the reserve, the area of closed canopy forest actually increased in the thirty years from 1963 to 1993, although it is interesting to note that closed canopy forest covers less than 30% of the total area of the forest reserve. While it is not possible to know exactly how the vegetation has changed, it is noticeable that the increase in area of forest and bush/forest is greater than the decrease in area of bush suggesting encroachment of bush and forest over the last 30 years.

Also within the reserve, open-shrub has increased in cover against a decline in more dense shrub and open grassland.

Outside the reserve, the area of closed canopy forest cover decreased by 33% over the thirty years. The increase in bush/forest (347 hectares) was not as great as the decline in forest, bush and woodland (807 hectares). Thus, overall woody vegetation cover (excluding shrub) declined by 7% over the 30 years under study.

The area under grassland has decreased dramatically against an increase in area under cultivation or enclosed manyatta and grassland/shrub. The increase in area under cultivation or settlement (1,435 hectares) accounts for just 50% of the decline in grassland (2,866 hectares), suggesting an encroachment of shrub species over much of what was previously grassland.

**Figure 7-2 Results of API showing vegetation cover on the Lerroki Plateau in 1963**

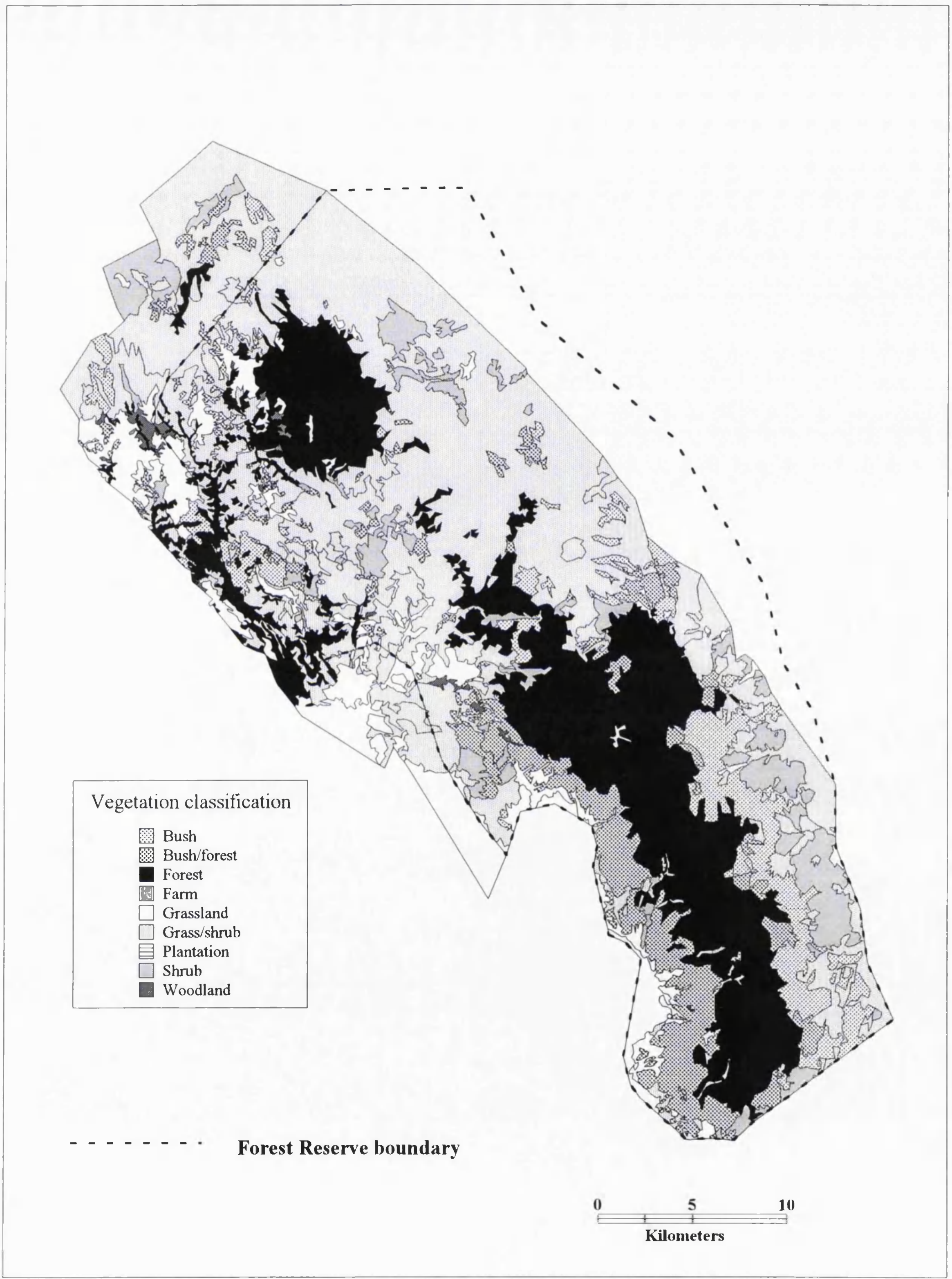


**Figure 7-3 Results of API showing vegetation cover on the Lerroki Plateau in 1993**

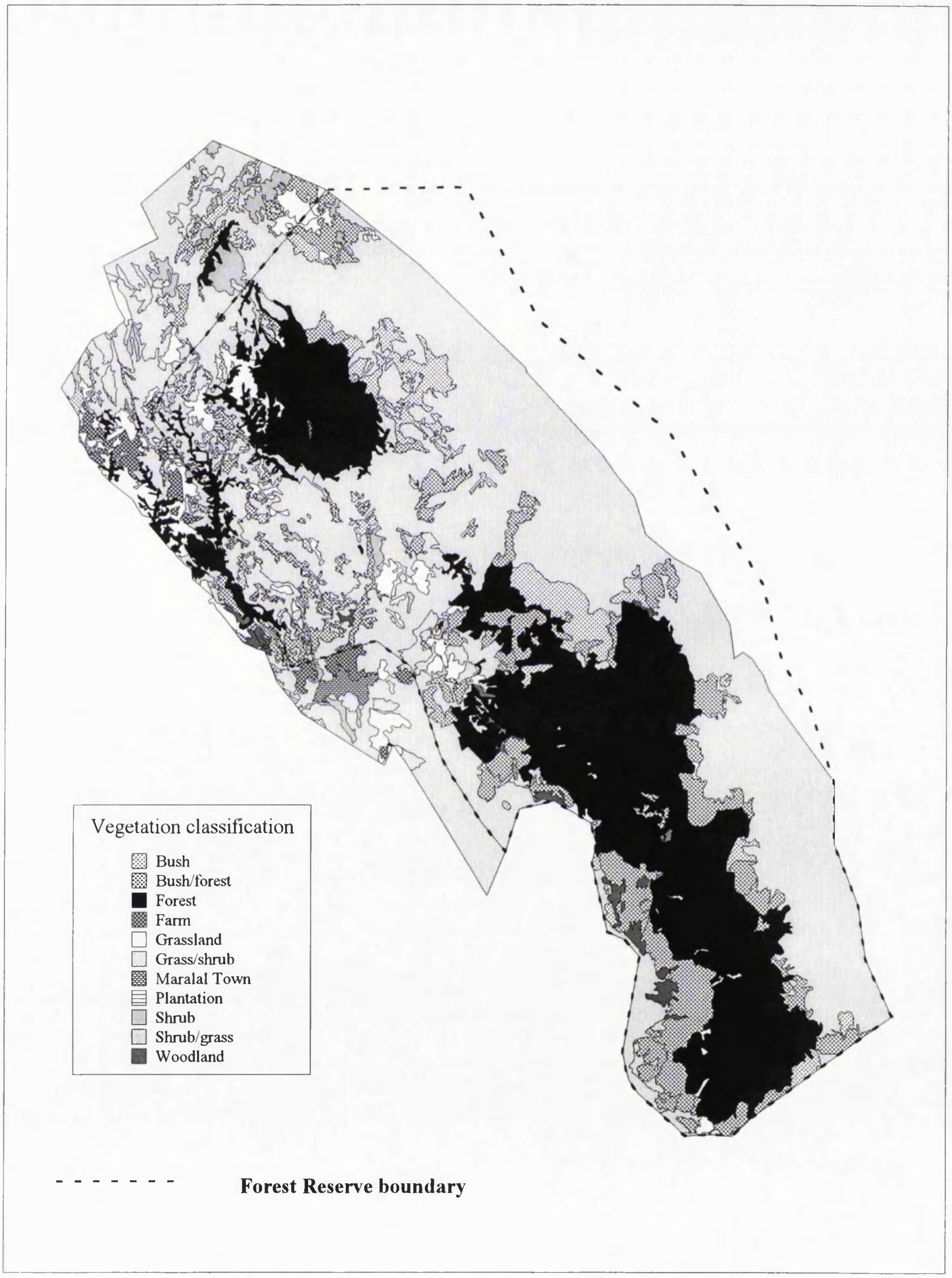


**Table 7.6** Changes in overall land use inside and outside the forest reserve

| Land-use Category | Total area of each land-use category (ha & % of total area) | | | | Net change 1963-1993 | | Area change as a percentage of total area analysed |
|---|---|---|---|---|---|---|---|
| Inside/Outside Reserve | 1963 (ha) | 1963 (%) | 1993 (ha) | 1993 (%) | ha | % | 1963-1993 |
| **Inside Reserve** | | | | | | | |
| **Bush** | 5,910 | 7.4% | 3,824 | 4.8% | - 2,086 | -35% | -2.6% |
| **Bush/Forest** | 8,316 | 10.3% | 9,820 | 12.2% | +1,504 | +18.1% | 1.9% |
| **Farm** | 0 | | 51 | 0.06% | +51 | | 0.1% |
| **Forest** | 21,946 | 27.3% | 23,937 | 29.8% | +1,991 | +9% | 2.5% |
| **Grassland** | 4,679 | 5.8% | 2,062 | 2.6% | -2,617 | -56% | -3.3% |
| **Grassland/Shrub** | 33,901 | 17.3% | 39,666 | 49.4% | +5,765 | +185% | 7.2% |
| **Plantation** | 0 | | 28 | 0.03% | +28 | | 0.0% |
| **Shrub** | 5,562 | 6.9% | 295 | 0.4% | -5,267 | -95% | -6.6% |
| **Woodland** | 271 | 0.3% | 695 | 0.8% | +424 | +157% | 0.5% |
| **Total area inside reserve** | 80,376 | 100% | 80,386 | 100% | +10 | | 0.0% |
| **Outside Reserve** | | | | | | | |
| **Bush** | 755 | 4.1% | 580 | 3.2% | -175 | -23% | -2.7% |
| **Bush/Forest** | 574 | 3.1% | 921 | 5.1% | +347 | +60.5% | 5.4% |
| **Dam** | 0 | | 5 | 0.00% | +5 | | 0.1% |
| **Farm** | 13 | 0.07% | 1,033 | 5.7% | +1,020 | +7,850% | 15.6% |
| **Forest** | 1,771 | 9.8% | 1,190 | 6.2% | -581 | -33% | -8.9% |
| **Grassland** | 4,899 | 27.1% | 2,033 | 11.3% | -2866 | -59% | -43.9% |
| **Grassland/Shrub** | 8,634 | 47.7% | 10,382 | 57.6% | +1748 | +24% | 26.8% |
| **Maralal Town** | 0 | | 343 | 1.9% | +343 | | 5.3% |
| **Plantation** | 5 | 0.0% | 72 | 0.4% | +67 | +1,340% | 1.0% |
| **Shrub** | 1,249 | 6.9% | 1,316 | 7.3% | +67 | +5% | 1.0% |
| **Trading centre** | 0 | | 5 | 0.00% | +5 | | 0.1% |
| **Woodland** | 208 | 1.1% | 157 | 0.9% | -51 | -24.6% | -0.8% |
| **Total area outside reserve** | 18,108 | 100% | 18,037 | 100% | -69 | -0.4% | -1.1% |

### 7.5.2 Change in vegetation around Ngorika, Lpartuk and Maralal

Changes in vegetation types around the three study sites both inside and outside the forest reserve are shown below in Table 7.7. Changes outside the forest reserve (the areas under most pressure from resource users) were mapped as shown in Figure 7-4, Figure 7-5 and Figure 7-6.

In interpreting the results it is important to note that there are other settlements in the areas mapped which may overlap in their sources of wild resources. For example, members of the communities at Poror and Morijo will be using wild resources from the area mapped around Ngorika, and the area around Upper Lpartuk includes the localities of Lower Lpartuk and extends into an area within 5km of Maralal itself.

Taking the results for closed canopy forest only, there are clearly different trends around the three sites:

At Ngorika, closed canopy forest cover has actually increased inside the reserve by 84ha (6% of the forested area in 1963), while outside it has declined by just 10 hectares ( a decline of 5% of the forested area in 1963).

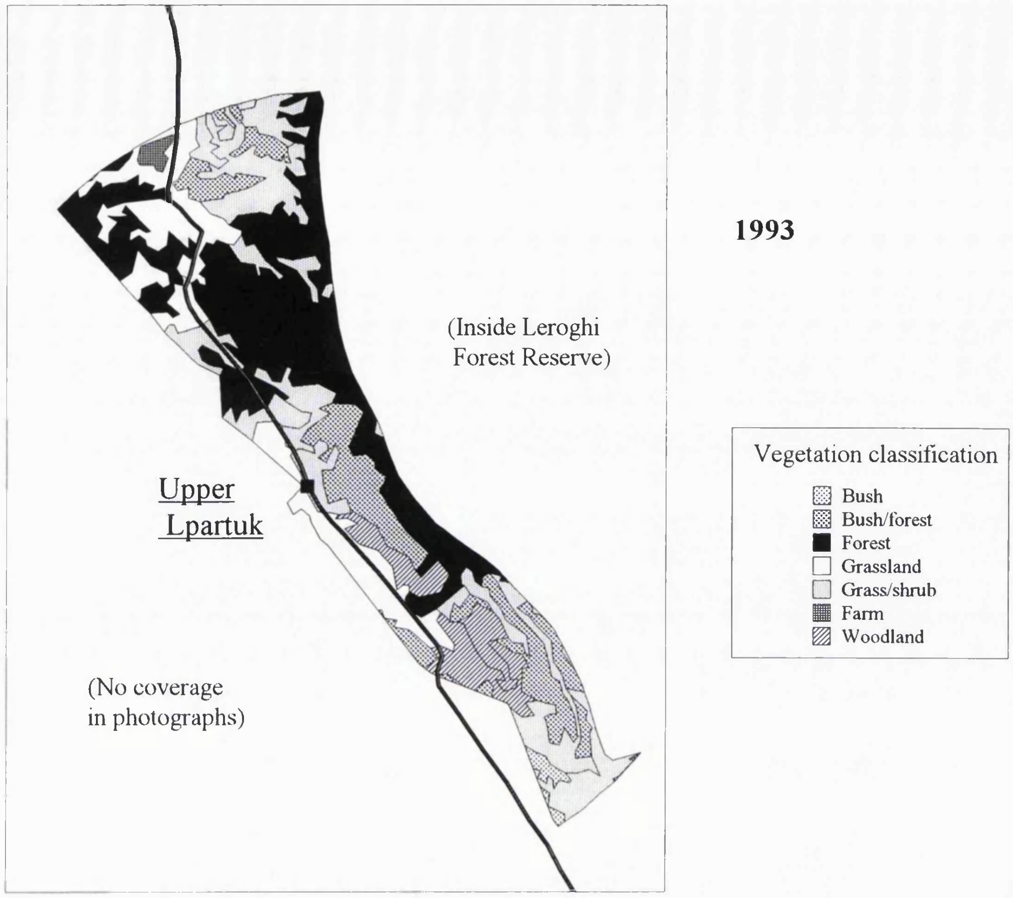
At Lpartuk, closed canopy forest cover has declined both inside and outside the reserve by 312 and 379 hectares respectively, representing a decline of 57% and 35% of the total forested area over 30 years.

At Maralal, all 532 hectares of closed canopy forest outside the reserve in 1963 had disappeared by 1993, while inside the reserve, only 47 out of 530 hectares of closed canopy forest remain, a decline of 100% and 91% in the last 30 years.

Thus, decline in closed canopy forest cover does correlate inversely with distance from Maralal both inside and outside the reserve. At Ngorika and Maralal, the decline is greater outside the reserve than inside. The opposite is true at Lpartuk.

Closer examination of the maps (Figure 7-4 and Figure 7-5) shows much of the decline in forest cover outside the reserve at Lpartuk was to the south, closest to Maralal, although there was also some clearing of forest to the north.

**Figure 7-4 Vegetation cover outside the forest reserve within a 5km radius of Upper Lpartuk, 1963 & 1993**
**(see figure 7-1 for location with respect to study area)**



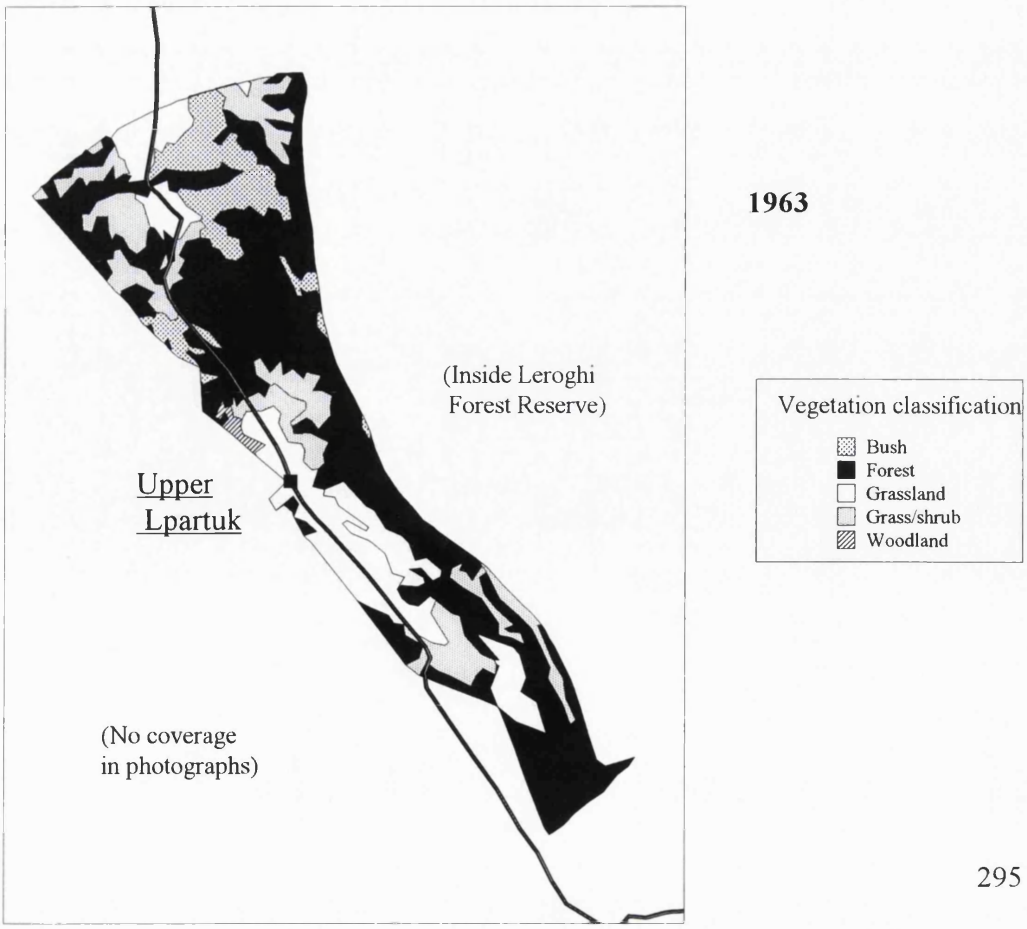
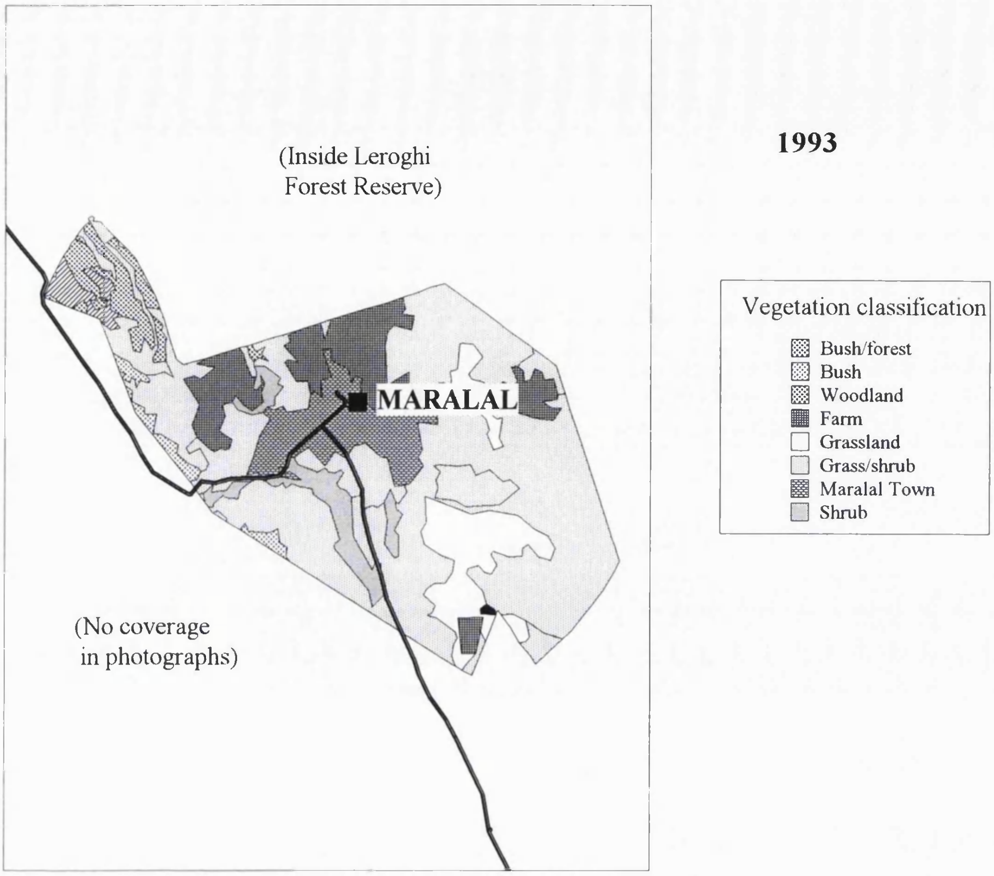



**Figure 7-5. Vegetation cover outside the forest reserve within a 5km radius of Maralal, 1963 & 1993**
**(see figure 7-1 for location with respect to study areas)**



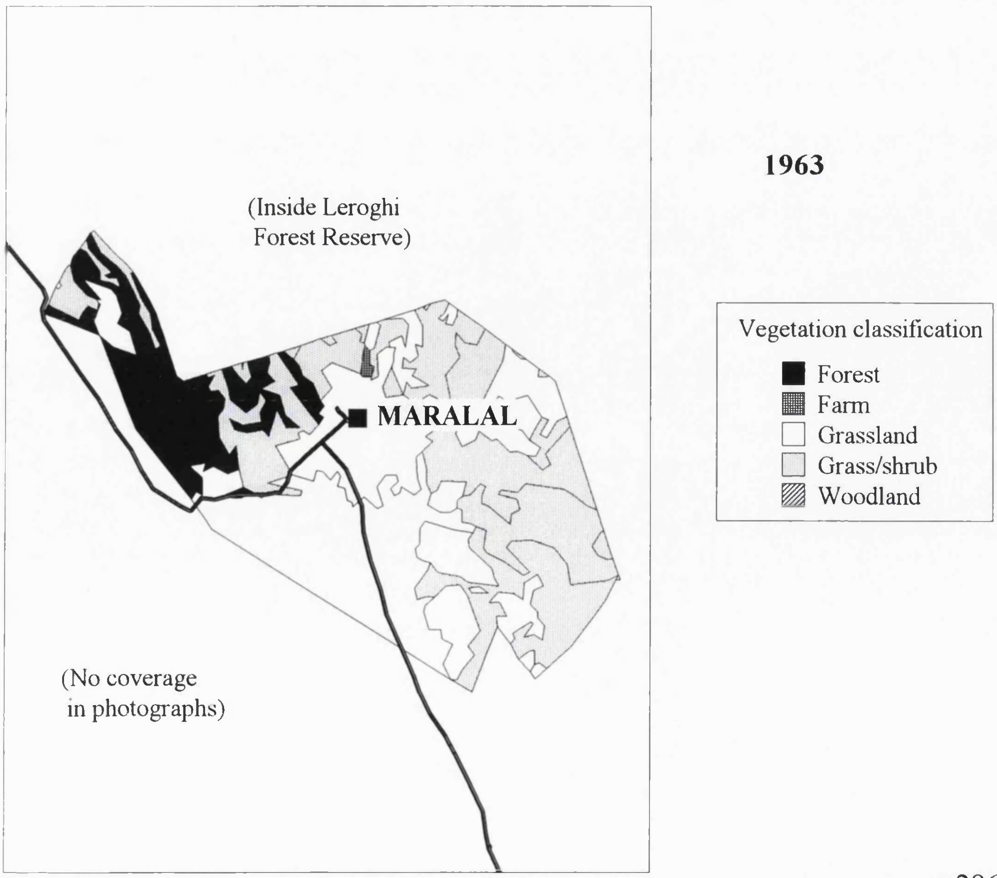
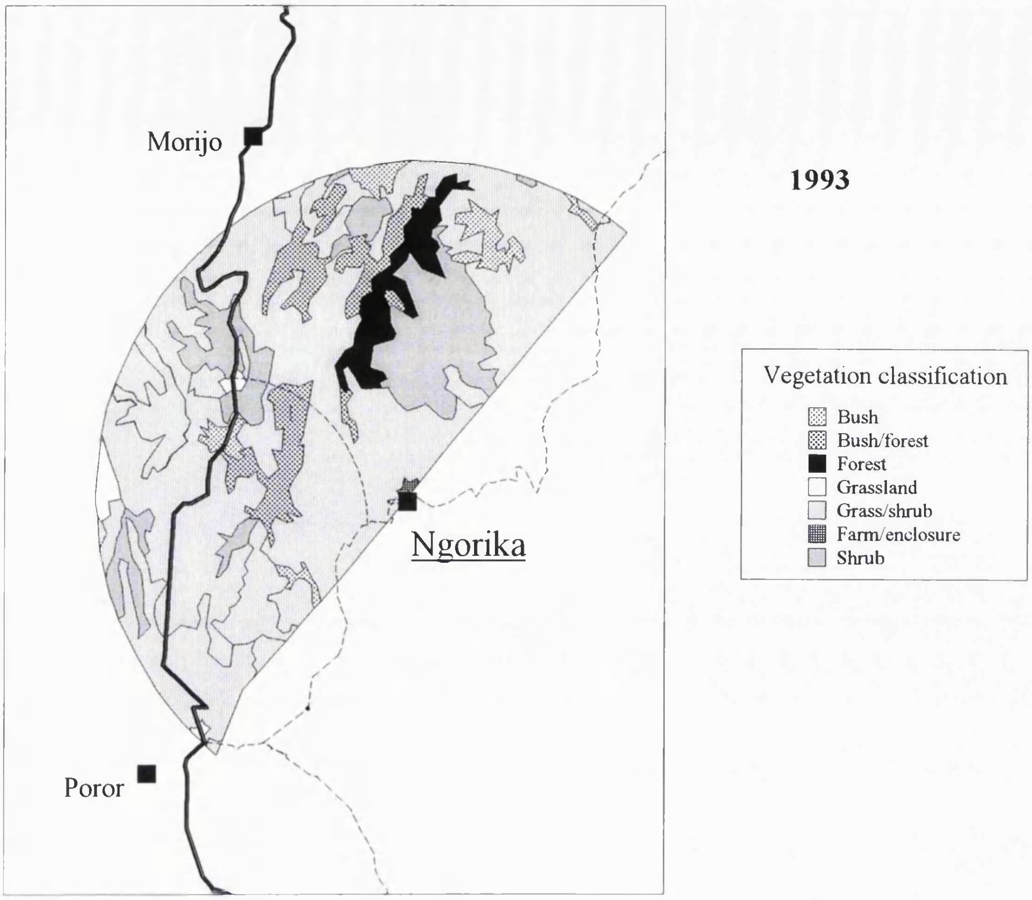



**Figure 7-6 Vegetation cover outside the forest reserve within a 5km radius of Ngorika, 1963 & 1993 (see figure 7-1 for location with respect to study area)**



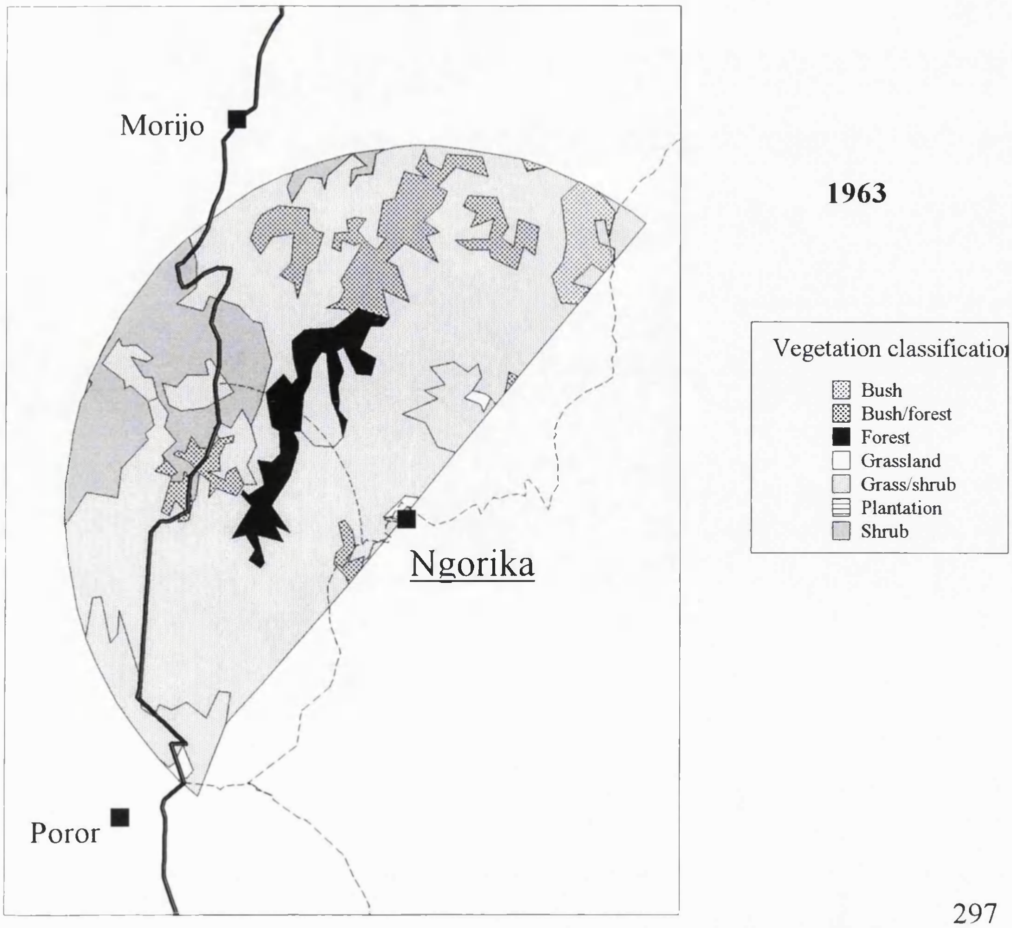



**Table 7.7** Summary of results showing changes in vegetation cover inside and outside the forest reserve at the three study sites

| Village | Vegetation type | Outside reserve | | | Inside reserve | | |
|---|---|---|---|---|---|---|---|
| | | Area in ha | | change as % of total area | Area in ha | | change as % of total area |
| **Lpartuk** | | 1963 | 1993 | | 1963 | 1993 | |
| | Bush | 197 | 17 | -9% | 570 | 125 | -14% |
| | Bush/forest | 0 | 306 | +15% | 227 | 492 | +8% |
| | Farm | 0 | 15 | +1% | 0 | 6 | 0% |
| | Forest | 1098 | 719 | -19% | 549 | 237 | -10% |
| | Grass | 389 | 329 | -3% | 154 | 71 | -3% |
| | Grass/shrub | 332 | 485 | +8% | 1496 | 2145 | +21% |
| | Shrub | 0 | 0 | 0% | 132 | 37 | -3% |
| | Woodland | 12 | 157 | +7% | 10 | 0 | 0% |
| | **Total** | **2028** | **2029** | **0%** | **3138** | **3113** | **-1%** |
| **Maralal** | Bush | 0 | 57 | +2% | 6 | 16 | 0% |
| | Bush/forest | 0 | 111 | +3% | 91 | 735 | +20% |
| | Dam | 0 | 4 | 0% | 0 | 0 | 0% |
| | Farm | 7 | 427 | +11% | 0 | 42 | +1% |
| | Forest | 533 | 0 | -15% | 530 | 47 | -15% |
| | Grass | 1681 | 322 | -37% | 526 | 197 | -10% |
| | Grass/shrub | 1431 | 2124 | +19% | 1957 | 2136 | +6% |
| | Maralal town | 0 | 343 | +9% | 0 | 0 | 0% |
| | Shrub | 0 | 170 | +5% | 46 | 5 | -1% |
| | Woodland | 1 | 96 | +3% | 43 | 36 | 0% |
| | **Total** | **3652** | **3653** | **0%** | **3199** | **3214** | **0%** |
| **Ngorika** | Bush | 99 | 141 | 1% | 37 | 58 | 0% |
| | Bush/forest | 389 | 327 | -2% | 261 | 278 | 1% |
| | Farm | 0 | 7 | 0% | 0 | 8 | 0% |
| | Forest | 200 | 190 | 0% | 1329 | 1413 | 2% |
| | Grass | 24 | 166 | 3% | 569 | 515 | -1% |
| | Grass/shrub | 3055 | 2886 | -4% | 2599 | 2489 | -2% |
| | Plantation | 0 | 0 | 0% | 0 | 0 | 0% |
| | Shrub | 570 | 639 | 2% | 0 | 1 | 0% |
| | Woodland | 0 | 0 | 0% | 17 | 0 | 0% |
| | **Total** | **4337** | **4345** | **0%** | **4813** | **4761** | **-1%** |

While there are clear differences between the study sites in terms of how closed canopy forest cover has changed and the magnitude of that change, a closer look at changes within bush and bush forest as well suggests qualitative differences in the way in which forest cover has declined in the three areas.

Overall clearance of woody vegetation (excluding shrub) is summarised in Figure 7-7 which shows the total area under woody vegetation in 1963 and 1993 for each site.

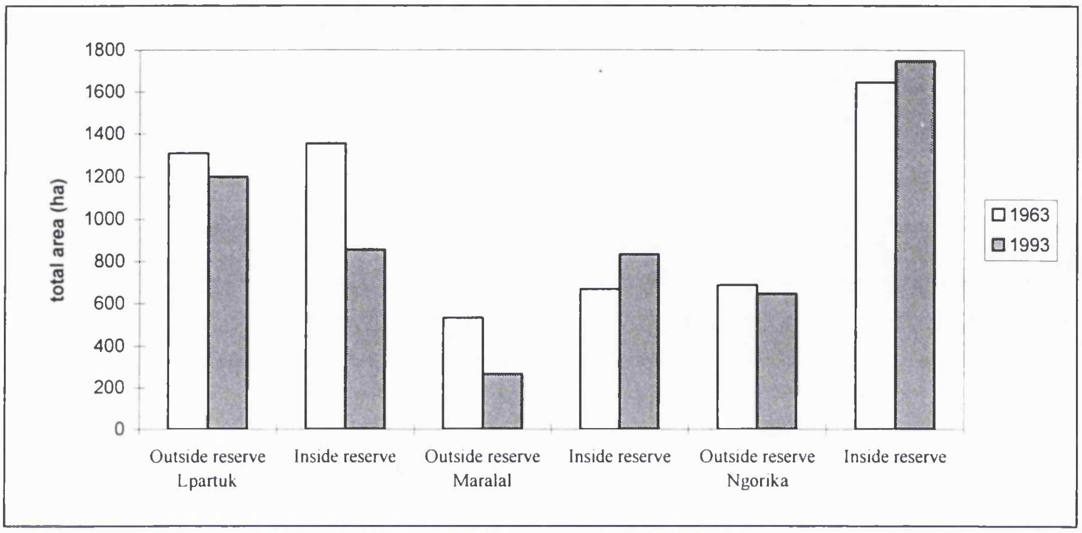



**Figure 7-7** Total woody vegetation cover (excluding shrub) inside and outside the forest reserve, 1963 and 1993

At Maralal, the decline in closed canopy forest cover inside the reserve has been more than matched by an increase in bush-forest and bush, suggesting gradual degradation of the forest, but not clearance. Outside the reserve, however, total woody cover (including forest, forest bush, bush and woodland) has declined by 50%.

At Lpartuk, inside the reserve total woody cover has declined by 492ha, a decline of 36% of the total area covered in 1963. Outside the reserve, the decline in forest and bush cover was not much greater than the increase in bush/forest and woodland cover with a total loss of 118 hectares or 8% of the total area covered in 1963.

At Ngorika, outside the reserve total woody cover has declined by just 40ha (6% of the total area covered in 1963) while inside the reserve, total woody cover has increased by 105ha (again, 6% of the total area covered in 1963).

In summary, the only overall clearance in bush and tree cover has occurred outside the reserve at Maralal and both inside and outside the reserve at Lpartuk (although outside the reserve at Lpartuk, the change is negligible given the errors associated with vegetation classification). Outside the reserve at Ngorika the changes in woody vegetation have been essentially qualitative, while inside the reserve at Ngorika and at Maralal, there appears to have been an increase in woody vegetation in this period, suggesting bush or forest encroachment.

Grassland and shrub cover has remained very stable at Ngorika both inside and outside the reserve. At Lpartuk, in contrast, there has been a slight decline in grassland and an increase in shrub. The very low values for enclosed or cultivated land in either year at Lpartuk and Ngorika is a reflection of the very small isolated nature of the farms in the village, which would not be identified in the aerial photo interpretation at this scale. The results shown in Figure 7-7, however, suggest that at there has not been much conversion of forest land or bush for cultivation at either Lpartuk or Ngorika.

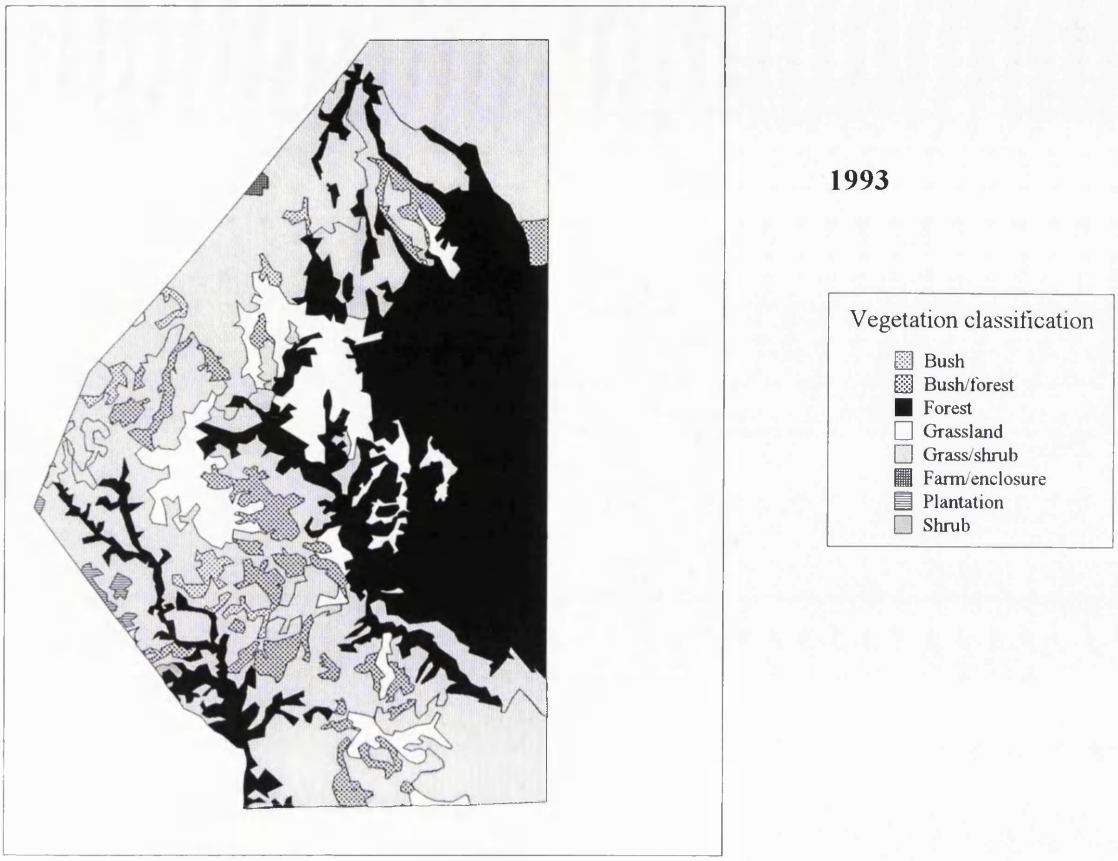
In contrast, at Maralal the area under cultivation has increased by 461 hectares in the last 30 years, 42 hectares of which are inside the official forest reserve boundary. There has been a massive decline in grassland outside the reserve, which can in part be explained by the increase in shrub grassland and shrub. However, much of this area was converted to cultivation and to the urban settlement at Maralal itself (343ha, Figure 7-5).

The potential for error due to terrain displacement and inaccurate identification of vegetation types, discussed above, remains a problem, particularly when considering a smaller area. Results should therefore be interpreted with some degree of caution. However, examination of the maps of the vegetation around each site from the two years suggests that terrain displacement may not have seriously affected the results.

### 7.5.3 Change in vegetation around Saanata

The results of the aerial photo interpretation around Saanata are shown in Figure 7-8 and summarised in Table 7.8.

**Figure 7-8 Vegetation cover within the defined area of high grazing pressure around Saanata forest, 1963 & 1993 (see Figure 7-1 for location with respect to study area)**



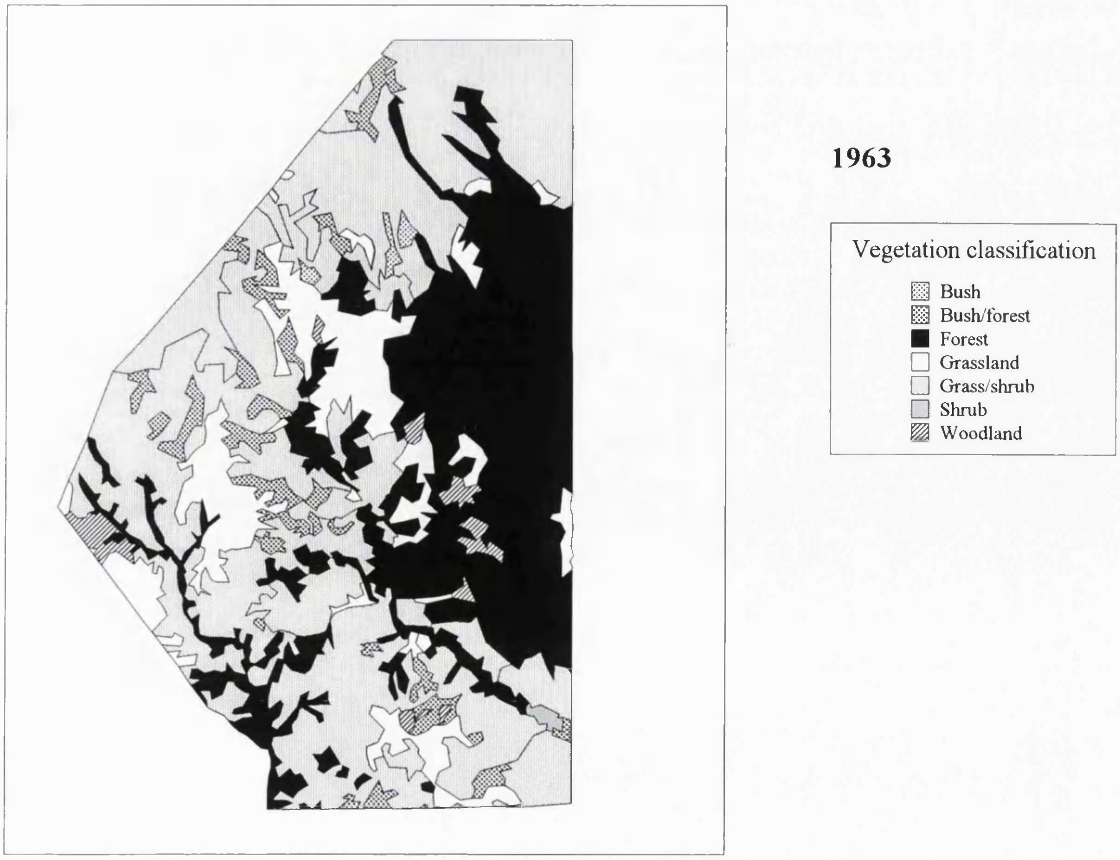



**Table 7.8** Summary of results showing changes in vegetation cover in an area of high intensity dry season grazing, 1963 - 1993

| Vegetation type | Area (ha) 1963 | Area (ha) 1993 | Change as % of mean total area |
|---|---|---|---|
| **Bush** | 34 | 102 | 0.83 |
| **Bush/forest** | 393 | 506 | 1.39 |
| **Farm** | 0 | 8 | 0.10 |
| **Forest** | 2,664 | 2,814 | 1.84 |
| **Grass** | 983 | 862 | -1.49 |
| **Grass/shrub** | 3,979 | 3,752 | -2.79 |
| **Plantation** | 0 | 28 | -0.34 |
| **Shrub** | 16 | 8 | -0.10 |
| **Woodland** | 128 | 16 | -1.37 |
| **Total area (ha)** | 8,197 | 8,096 | -1.24 |

The results show remarkable stability in vegetation cover in an area subject to high grazing pressure over the last thirty years, with a slight increase in forest and bush at the expense of grassland and shrub.

### *7.6 Discussion*

Where people are using forest resources there is often an assumption that such use is unlikely to be sustainable (Fairhead & Leach, 1994; Shepherd, 1991). The results presented in this chapter give a differentiated analysis that to some extent challenges this view and emphasises the importance of both geographical location and management regime of the forest in determining the long term sustainability of wild resource use.

#### 7.6.1 Testing hypotheses

Hypotheses were defined at the start of this chapter on the basis of the results presented and discussed in the previous four chapters. These hypotheses are now discussed in the light of the aerial photo interpretation and previous studies and where possible accepted or rejected.

**Hypothesis 1.** Cattle, in the densities present around the Leroghi Forest Reserve, do not reduce forest cover over the long term.

The results of the API support this hypothesis. Comparison of the vegetation cover from 1963 and 1993 around Saanata, an area used extensively for cattle grazing during the dry season, shows a slight increase in forest and bush cover, and a corresponding decline in grass and shrub (Table 7.8). Clearly cattle grazing has not had a negative impact on forest cover during this time period and may even be promoting forest expansion.

These results also support the results of the vegetation surveys described in chapter four of this thesis.

The role of cattle grazing in enhancing bush encroachment is well documented (Norton Griffiths, 1979; Cumming, 1982; Belsky, 1990; Huntley, 1982). The most common mechanism used to account for this relationship is the reduction in the herbaceous layer causing a reduction in frequency and severity of fire and competition for moisture and nutrients (e.g. Norton Griffiths, 1979; Lamprey, 1985). Bush encroachment provides the micro-climatic conditions favourable for the establishment of pioneer tree species leading ultimately to forest encroachment (Fairhead & Leach, 1994). However, Billé *et al.* (1983, in Coppock, 1993) propose a cyclical system in which gradual bush encroachment leads to a decline in range quality until pastoralists move elsewhere to find grazing. Released from grazing pressure, the herbaceous layer builds up and fires become more frequent and severe, gradually restoring the balance in favour of grass species over woody species. Coppock (1993) suggests such a cycle would act as a self regulatory system, the bush encroachment "providing a recovery period for abused sites through replenishment of soil fertility" (p55). However, this would depend on the pastoralists mobility and access to alternative grazing.

This relationship is well appreciated by the local Samburu and many forest managers and has important implications for forest management which will be discussed further in the final chapter.

**Hypothesis 2.** The market for construction material and other woody resources causes levels of extraction to exceed sustainable levels.

Taking closed canopy forest cover only into account, the results of the aerial photo interpretation suggest that sustainability of woody resource use in areas with relatively low population densities such as those seen around Ngorika and Lpartuk, depends on market demands more than subsistence demands. Overall, decline in closed canopy forest cover outside the forest reserve is much greater at Lpartuk than at Ngorika in spite of much higher demands for home construction materials at Ngorika over the last 40 years (chapter five).

However, this pattern is less clear if all woody vegetation is taken into account and habitat availability at the two sites is considered.

1. The decline in overall woody cover outside the reserve at Lpartuk is still greater than at Ngorika, but in both areas the total change is less than 10% of the area in 1963. With levels of vegetation classification accuracy of 90% (± 8%), these observed changes fall within the margins of error in the mapping process. Thus, change in woody vegetation cover at Lpartuk outside the reserve is essentially qualitative.

2. Degraded forest habitats were found to be the currently preferred source for marketable products (charcoal, poles and posts) at Lpartuk (chapter six). However,

there was no degraded forest bush at Lpartuk in 1963 and the area of bush and woodland around Lpartuk (209 hectares) was less than half that around Ngorika (488 hectares). These results imply that in 1963, closed canopy forest would have provided the only source of many woody materials at Lpartuk. The situation had changed considerably by 1993, when the area under bush, woodland and bush-forest at Lpartuk had increased to 481 hectares, while that at Ngorika had remained almost constant at 467 hectares. The increase in degraded bush and woodland habitats at Lpartuk could account for 79% of the overall decline in closed canopy forest and bush.

The current preference for open forest and bush at Lpartuk shown in chapter six suggests a buffer scenario evolving whereby degraded forest, 'created' through the exploitation of closed canopy forest, becomes the main source of woody products and reduces pressure on the remaining closed canopy forest. The creation of different habitat types to satisfy specific needs has been examined in detail by Fairhead & Leach (1994) within forest islands in Guinea. If degraded forests provide communities with valuable resources and can act as a buffer against further encroachments into closed canopy forests, they can provide an important link between the desire to conserve forests and the needs of the local communities. The use of buffer zones as "a type of multiple use area from where the people could obtain forest products and uses" is not a new concept (Hall & Rodgers, 1992: 5). The main concern with such areas is the need to ensure long term sustainability, i.e. to ensure that the forest is not further encroached upon.

While degradation of closed canopy forest has occurred at a greater rate at Lpartuk than at Ngorika, there has not been a significant decline in overall woody vegetation cover over the last 30 years at either site outside the forest reserve.

Demands for construction materials at Maralal have been much greater than at the other two study sites (chapter five) and the decline in both closed canopy forest cover and woody vegetation cover at Maralal has been acute. It is possible that subsistence demands for construction materials at Maralal, where the population density is much greater than at the other two sites, was high enough to cause the decline, although there is also evidence that poles and posts are transported (illegally) by lorry out of the district towards Nyaharuru to the south (District Forest Officer, *pers comm.*). The decline in woody cover around Maralal together with the fact that people at Maralal are not collecting poles and posts for sale (chapter six) has implications for woody cover at Lpartuk. Further expansion of Maralal Town will place greater demands on areas such as Lpartuk which are easily accessible and still have woody resources available. The area around Lpartuk still has over 1,000 hectares of closed canopy forest and bush forest available which, if managed sustainably, could be of great economic value. These results emphasis the importance of defining the management objectives for forested areas in the communal areas, discussed further in the following chapter.

The correlation between forest decline and the presence of an impoverished, refugee population at Maralal supports the observations made by Little & Brokensha (1987) quoted in chapter five. The results of the aerial surveys and the socio-economic and one-off resource use surveys around Maralal are clearly suggestive of a causal mechanism for decline in forest cover: a destitute population with short-term cash needs and a ready market for construction materials and other products such as charcoal (c.f. Sikana *et al.*, 1993; Sperling & Galaty, 1990). However, the results of the resource use surveys did not find any consistent difference in levels of resource use with respect to sub-household wealth. In this case, therefore, it is not possible to apportion responsibility for the decline in forest cover to any particular user group.

The comparison between the three areas has concentrated on changes in vegetation outside the forest reserve. This was due to earlier surveys which found extraction of wild resources occurred mainly outside the boundaries of the reserve in the communal lands (chapter two). Differences in changes inside and outside the reserve have important implications for forest management.

### 7.6.2 Forests and Forest Reserves: implications for management

The analysis presented in this chapter compared changes inside and outside the boundaries of the Leroghi Forest Reserve and found considerable differences between the two. Overall, closed canopy forest cover actually increased inside the reserve by almost 2,000 hectares, while outside, closed canopy forest cover declined. Taking woody vegetation overall, outside the reserve cover declined by 14%, while inside the reserve cover increased by 5%.

The same overall differences were observed at Maralal and Ngorika: outside the reserve overall woody vegetation cover declined by 50% at Maralal and by 6% at Ngorika, while inside the reserve, woody vegetation cover increased by 25% and by 6% respectively. Lpartuk provides an interesting exception to this trend, with woody cover declining more inside the reserve than outside. A number of serious fires occurred within the forest reserve close to Lpartuk during the 1980's which would account for the decline in forest and bush cover inside the reserve, according to annual reports from the District Forest Office. The fires were thought to be the result of arson attacks when a total ban on forest grazing was heavily enforced following a Presidential Decree banning forest grazing nationally in 1986 (L. Lenkaak, Forest Officer, Lerroki Division, *pers comm.* ). Whatever the cause of the fire, the build up of the herbaceous layer in the absence of cattle would have increased the severity of the fire and its effects (Norton-Griffiths, 1979; Dublin 1991).

On first consideration, taking the very different legislation governing the forest reserve and the group ranches into account, the difference in vegetation change inside and outside the reserve at Maralal and Ngorika is not surprising: The Forests Act (1966) largely prohibits use of forest resources inside the reserve, with limits enforced for select resources such as firewood and poles. However, given the limited resources available to the District Forest Office to enforce the legislation governing the forest reserve, it is interesting that the forest boundary appears to have been so effective in conserving closed canopy forest at Maralal and Ngorika.

In 1994, the Lerroki Forest Office had one vehicle at its disposal to serve the Leroghi Forest Reserve, the Ndoto Hills Reserve and Mt. Nyiro Forest Reserve. Two forest guards were permanently posted at Angata Nanyukie group ranch, but they did not have a high profile within the village and were often absent. The low frequency with which they patrolled the forest reserve was exemplified by the fact that they had never seen the exclosure plots used in this study a year after they had been constructed, despite the plots at Lorubai being placed close to one of the main paths into the main forest glade.

The District Forest Officer and the Division Forest Officer were both happy to discuss the extent to which they depended on support from the elders in controlling forest activities. 'Opening' the forest reserve to cattle at the start of the dry season and getting the cattle to leave at the start of the rains were both activities that were negotiated between the elders and the forest officers and affected by the elders. Two examples of local community involvement in forest conservation exemplify the concern of the local communities to conserve the forest within the reserve (both were confirmed to me by the District Forest Officer):

1. A logging company wanted to build a road into Saanata in 1984. They started working on the road, but when the local community saw what was happening they successfully campaigned to have the work stopped.

2. When I first started vegetation surveys in Saanata at the end of 1994, the elders from Ngorika went to the District Forest Officer to report my activities and to find out if I was really who I had said I was. I had explained the objectives of my work to the villagers when I first arrived in the area, but the Forest Officer told me they had been concerned that I wanted to expropriate land within the reserve for tourism.

The occurrence of widespread fires during the 1980's which caused the destruction of closed canopy forest inside the reserve at Lpartuk emphasises the importance of access to the forest in maintaining this relationship. The fires became frequent shortly after a Presidential Decree banning all forest grazing (which was enforced by the forest department) and became less frequent once an agreement had been reached between the local forest officers and the Samburu to allow forest grazing during drought periods (Mr Njenga, District Forest Officer & Mr Lenkaak, Division Forest Officer, *pers comm.*). The effect of these fires on closed canopy forest cover at Lpartuk exemplifies: the importance of fire as an agent of forest destruction in the area; the importance of livestock in reducing the build up of the herbaceous layer ('fire fodder'); and the importance of a strong relationship between the forest adjacent communities and the Forest Department based on mutual benefits.

### 7.6.3 Measuring change from aerial photographs

The potential sources of error at all stages in the production of a map from API have been discussed. In some cases, errors are considered marginal, such as errors due to atmospheric refraction or lens aberrations. Greater sources of error may occur in the process of boundary definition, due to tilt and topography, and in the definition of the vegetation types from the photographs. The large number of photographs involved and the limited resources available made it unfeasible to correct for tilt and terrain displacement errors, although errors due to displacement effects are likely to be random and equivalent for each set of photographs where the data is aggregated. Ground control from the photographs was carried out for the 1993 photographs and found a relatively high level of accuracy (90% ± 8%) in the identification of vegetation types. The interpretation was carried out by a single interpreter with many years of experience and it is considered that the results from the 1993 and 1963 photographs would be consistent and comparable. This is important given the qualitative nature of much of the vegetation change on the Plateau. Differences in the precise flight lines, however, make it impossible to compare precise points located on the UTM grid and thus to identify how vegetation at one precise point may have changed.

Given the difficulty of verifying the interpretation from the 1963 photographs and the scale of the photographs available, this interpretation was based on a physiognomic classification, determined by percentage canopy cover and broad physical appearance of the vegetation. No attempt was made to differentiate species.

The vegetation maps produced from the photographs can be used to show change in vegetation over the 30 year period from 1963 to 1993 over broad areas using the aggregate data. They are useful for monitoring long term changes in the vegetation where such change is fairly severe. They do not, however, show the route of this change (e.g. an increase in forest and a decrease in bush cover does not necessarily mean conversion of bush to forest) nor do they show any gradual change occurring within intermediate vegetation types (e.g. the classification for forest bush incorporates a wide range of habitat types from slightly degraded forest to heavily degraded forest). However, this can often be inferred by the nature of the vegetation types and the changes seen.

Finally, the length of period between the two sets of photographs should be long enough for more gradual processes of change to become visible: Allen and Barnes (1985) found a delay of up to 10 years before the impact of selective harvesting of trees with no replanting could be seen.

### 7.7 Conclusion

This chapter has compared the spatial distribution of changes in vegetation cover with known spatial differences in levels of specified types of resource use to test for correlations between the two types of data.

Closed canopy forest degradation correlated inversely with distance to the market at Maralal, although in the case of Maralal itself, this could be attributed to the high demands for construction material on a subsistence basis as well as market demands. Taking woody cover overall, the data suggests a qualitative change rather than an absolute clearance of woody cover at the two villages further from Maralal. However, the absolute decline at Maralal is likely to have implications for Lpartuk in the future, with ever greater demands falling on easily accessible villages with resources still easily available. The frequency with which lorries were seen collecting building posts at Lpartuk suggests this process has already begun. While there was little evidence of an absolute decline in woody cover at Lpartuk in the last thirty years, past levels of extraction have clearly caused forest degradation and the situation is likely to become worse.

The data from the aerial photographs support the conclusion of chapter four that cattle are not reducing closed canopy forest cover in the long term. The results provide further evidence that cattle may encourage forest encroachment through reduced competition from herbs for moisture and minerals and reduced frequency and severity of fires.

Finally, the forested areas inside and outside the boundaries of the forest reserve are clearly perceived differently by the local communities and the regulations governing the reserve are largely respected despite a low day to day profile of the forest department.

In the next, concluding chapter, the implications of these findings for forest management in a pastoral area such as this is discussed in detail.

# 8. Conclusions: cattle, people and dry montane forest

## 8.1 Introduction

The key findings of this study are twofold: firstly, the forest adjacent community and the Forest Department jointly ensure that the only use made of the closed canopy forest inside the Leroghi Forest Reserve is cattle grazing; and secondly, cattle have not degraded the closed canopy forest on the Lerroki Plateau over the last thirty years. Together these findings demonstrate the effectiveness with which joint forest management in semi-arid pastoral areas, based on shared objectives and mutual co-operation, can ensure the conservation of dryland closed canopy forest at the same time as providing benefits to the local pastoral community. The basis for this conclusion and its importance for forest management in dryland areas is the subject of this final chapter.

In the next section, the main findings of the study are summarised and used to test the four hypotheses presented at the start of the thesis (chapter one, p29) in turn. For each hypothesis, the findings are examined in the light of previous research and, where applicable, avenues for future research are proposed. Finally, the implications of the key findings of this study for forest management in an agro-pastoral dry montane forest are discussed.

Before testing the hypotheses, it is useful to review briefly the methods and approach taken by the thesis. Impact assessments of human and cattle activity in closed canopy forest have typically focused on single species (Hall & Bawa, 1992) and tended to avoid studying the forest as a complex whole. The reason for this has always been the difficulties associated with differentiating causal links from spurious correlations. This study used patterns of spatial variation in forest use across the plateau (inferred during the course of the study) as a natural experiment to test the impact of use on closed canopy forest cover. The study used a multi-disciplinary, comparative approach, bringing data from a number of sources to bear on the impact assessment, using a system of triangulation to distinguish genuine effects and spurious correlations. This approach was described in detail in chapter one. In summary, different lines of investigation are used to develop and test hypotheses, identifying consistent patterns in the results on which to base the interpretations. The conclusions are necessarily limited within the confines of this study.

## *8.2 Testing the hypotheses*

### 8.2.1 Hypothesis One: Closed canopy forest is a vital source of dry season grazing and water for a population of cattle disproportionate to its area.

#### *8.2.1.1 Summary of key findings*

The results presented in chapter three clearly support this hypothesis:

- Livestock grazing and watering were ranked highest of all uses made of closed canopy forest in both Lpartuk and Ngorika;
- Eighty seven percent of cattle in the area were grazing inside the forest during the height of the dry season, and 37% of the cattle counted (more than 2,200 head of cattle) came from group ranches located away from the forest boundary;
- Cattle were spending a considerable proportion of their time within closed canopy forest at the height of the dry season, browsing on tree and shrub species; and
- Informal interviews showed that forest has been used as a dry season source of grazing by the Samburu for at least 80 years and prior to that, the Laikipiak.

The availability of many forest products within other habitat types may account for the relative importance of closed canopy forest for livestock. Degraded forest-bush, bush and shrub habitats are the preferred source of firewood, poles and posts and other resources (chapter six). However, water and dry forage tends be found only within closed canopy forest during drought periods.

Faecal surveys showed cattle do not use the forest during the rainy season; elders claimed that grazing cattle constantly on herbaceous forest plants was detrimental to cattle health.

#### *8.2.1.2 Comparison with previous studies*

The importance of closed canopy forest to cattle during dry or drought periods has been well documented and a review of this literature is given in chapter three. In summary, rangeland managers have tended to ignore closed canopy forest as an important habitat for cattle on the basis that cattle are preferential grazers and there has been a subsequent pre-occupation with grassland habitats (e.g. Walker, 1980; Pratt & Gwynne, 1977). However, many researchers, particularly those interested in pastoral areas have observed the importance of closed canopy forest for cattle (e.g. Emerton, 1991; 1996; Potkanski, 1993; Struhsaker *et* al., 1989; Shepherd, 1992; Le Houérou, 1980; Bayer, 1984).

Few of these studies have attempted to quantify the intensity of closed canopy forest use by cattle (e.g. Emerton, 1991), although many have quantified the relative importance of browse to cattle during dry periods (e.g. Homewood & Hurst, 1986; Scoones, 1989; Bayer, 1990). The results of this study correspond well with the results of the latter studies.

#### *8.2.1.3 Avenues for future research*

This study did not look at cattle performance. Discussion with elders revealed a preference for removing cattle from the forest when conditions permitted because of a decline in cattle performance if allowed to stay within the forest too long. However, during less formal discussions, some elders claimed they would graze their cattle in and around the forest throughout the year when they were young, and it was only pressure from the Forest Department that made them remove their cattle after the rains these days. The faecal surveys showed that cattle did leave the forest following the rains. However, it would be interesting to assess the impact of forest grazing on cattle performance as a means of assessing the relative importance of cattle health and Forest Department rules in determining levels of forest use.

### 8.2.2 Hypothesis Two: Trampling and browsing damage to tree seedlings by cattle cause long term forest senescence, ultimately leading to reduction in closed canopy forest cover.

#### *8.2.2.1 Summary of key findings*

The results of the vegetation surveys within the forest did not support the hypothesis that cattle were having a long term effect on the forest through increasing seedling mortality (chapter four):

- There was no difference in overall plant population structure between areas of moderate cattle grazing intensity and areas where cattle are rarely, if ever, taken to graze, but which are frequented by other wild herbivores (called 'ungrazed' for the purposes of this study);
- Plant population structure at the forest edge where cattle grazing intensity was highest differed significantly with that in areas of lower grazing intensity inside the forest, with higher seedling density in the forest edge areas. These differences in seedling densities could have been due to the very different environmental conditions experienced at the forest edge (Hopkins, 1992);
- There was no evidence for cattle reducing regeneration or regenerant survival beyond expected levels of natural mortality;
- Overall density of mature trees was the same for moderately grazed and ungrazed areas; and finally
- Surveys at the forest edge found some evidence of change in species diversity. However, the differences were largely due to the presence of light demanding forest edge species, such as *Maytenus heterophylla* and *Rhus natalensis*, and not related to palatability of the indicator tree species. There was no difference in species diversity between the moderately grazed and ungrazed areas.

The results of the aerial photo interpretation (chapter seven) support the conclusion that cattle do not reduce forest cover: Data from these photographs suggest that closed canopy forest and bush cover may actually have increased under moderate grazing pressure.

Clearly, the potential impact of cattle on closed canopy forest cover will depend on cattle grazing intensities. In this area, cattle grazing intensity was estimated at a density of between 0.45 and 0.7 cattle per ha per day using the forest at the peak of the dry season in 1994 (chapter three).

#### *8.2.2.2 Comparison with previous studies*

The results of this study refute the assumption made by many studies that cattle grazing inevitably leads to forest degradation (e.g. Struhsaker *et al.*, 1989; Synnott, 1979; Stott, 1985). The conclusion that cattle did not reduce tree seedling recruitment supports the findings of the few other studies that have looked at cattle impacts within dryland forest and woodland ecosystems (e.g. Moss, 1996; Lamprey, 1985). This is perhaps not a surprising conclusion when bush encroachment due to 'overgrazing' is a well documented phenomenon and a recurrent 'problem' quoted by rangeland ecologists (e.g. Pratt & Gwynne, 1977; reviewed by Lamprey, 1985). Livestock have long been used by foresters in America to reduce competition from weeds and fire risk (e.g. Adams, 1975) and many forest managers in Kenya acknowledge the role of cattle as a positive management tool (Chenevix Trench & Luvanda, 1994). In the West African forest-savanna areas of Guinea, cattle are actively managed by farmers to promote forest vegetation. In addition to reducing inflammable dry biomass, "selectivity and manuring permit the rapid establishment of certain tree and shrub species" (Fairhead & Leach, 1994: 34).

#### *8.2.2.3 Avenues for future research*

The comparison with other studies presents a strong argument that the results of this study need not apply to the Lerroki Plateau alone. The implications of these results are very important for forest managers in dryland forest areas as well as the pastoral communities lives adjacent to dryland forests. It would, therefore, be of great interest to carry out similar studies in other dryland areas. It is also important to establish whether there exists a threshold beyond which cattle trampling and grazing begin to affect forest cover and diversity in a negative way.

### 8.2.3 Hypothesis Three: Levels of wild resource use depend on access to market and household economic status.

#### *8.2.3.1 Summary of key findings*

The results presented in chapters five and six support the hypothesis that market access affects wild resource collection:

- Frequency of marketable resource collection was significantly higher at Lpartuk that at Ngorika, the difference being entirely explained by the collection of these resources for sale; and

- Frequency of collection of non-marketable resources was equal or higher at Ngorika than at Lpartuk.

It was proposed that frequency of collection of wild products would vary with wealth, poorer households having fewer opportunities to access cash from the sale of animals or crops. Given the importance of market access in determining levels of marketable resource collection, analysis into the effects of wealth took the identity of the village into account. Seasonality was also taken into account since the effect of wealth on resource use was likely to be more acute during periods of seasonal stress. The results of this study, however, found conflicting evidence relating to the theory that wealth affected wild resource collection in this area:

- Levels of wild resource collection varied with season, with overall levels peaking from July to October;

- Partial redundancy analysis found no correlation between frequency of wild resource and estimates of wealth (neither area under cultivation, number of livestock nor the size of the sub-household at Ngorika or Lpartuk);

- Levels of marketable resource collection was higher among the poorer sub-households (defined by wealth rank) in January at the start of the dry season than among the wealthiest households, but this was true for Ngorika where the resources were not collected for sale as well as for Lpartuk;

- Overall levels of charcoal collection was very high at Loikas, a suburb of Maralal, in spite of survey bias that would tend to underestimate levels of resource collection at Maralal. Sub-household at Loikas were significantly less well off than at Lpartuk or Ngorika. However, there was no difference between levels of collection among Turkana sub-households and Samburu sub-households despite the former being significantly less well off than their Samburu counterparts in the same village.
- There were trends in the collection of charcoal and poles at Lpartuk, but the direction of the trends ere not consistent: poles were collected most frequently by the wealthiest and the poorest sub-households, whereas charcoal was collected with least frequency by these groups.

It is not possible to exclude the importance of wealth in determining levels of wild resource use on the basis of these results. The results from Lpartuk suggest that any effect that household wealth may have on the frequency with which households collected forest products may only relate to those products with high market value (cf. Godoy & Bawa, 1993). It is possible that the wealth differentials within each villages were too small for a more general effect to be visible. All households, rich and poor, were suffering the effects of the drought and subsequent failed harvest the previous year and were receiving food relief for most of the year.

#### *8.2.3.2 Comparison with previous studies*

Many studies have assumed that access to markets affect wild resource collection (e.g. Sikana *et al.*, 1993; Sperling & Galaty, 1990; Little & Brokensha, 1987). Reasons proposed for this effect include the opportunity costs involved in collecting and transporting the resources to a market (e.g. Sikana *et al.*, 1993) and the wealth status of many peri-urban communities (e.g. Sperling & Galaty, 1990; Little & Brokensha, 1987).

The importance of opportunity costs in determining wild resource use was exemplified by the higher frequencies of wild food collection at Lpartuk compared to Ngorika (levels of sub-household wealth across the two villages were very similar). It has been suggested in this study that this may have important implications for the effective management of the forests in the area. It was difficult to distinguish between the importance of wealth and market access at Maralal when comparing wild resource use, given the potential for survey biases. However, it was interesting to note that within the peri-urban community at Maralal, there was no difference evident between levels of wild resource use by the Samburu community and the poorer, almost destitute Turkana community (cf. Little & Brokensha, 1987).

The results support the observations of Sperling (1987a) that the Samburu made limited use of wild foods during drought periods, although provision of relief food to all families during periods of high nutritional stress may mitigate the reliance on wild products (Sperling, 1987a; Campbell 1987). This contrasts with the situation in other areas of sub-Saharan Africa where reliance on wild foods during drought periods has been reported as very high. (*e.g.* reviewed in Scoones *et al.,* 1992; Koppell, 1992; Dei *et al.*, 1989; Campbell 1987).

#### *8.2.3.3 Avenues for future research*

Energetic constraints appeared to play an important role in limiting overall levels of wild resource use, an affect visible across all sub-households at both Ngorika and Lpartuk. Frequency of wild resource collection was lowest during April, when all households were suffering the effects of the drought and subsequent failed harvest the previous year. And it has been suggested that access to male labour in poorer households, due to fewer demands for livestock management in the absence of household herds, could explain the higher frequency of wild resource collection among these households observed at both Ngorika and Lpartuk in January (the start of the dry season).

During a meeting at the end of the study, when some initial results of the study were discussed with a group of men and women from the villages, many women stated that they would not go out to collect resources so frequently during periods of seasonal stress because they did not have the energy to do so.

Energetic constraints will depend on seasonal labour demands and dietary intake and the importance of these factors in limiting wild resource collection, particularly in relation to different wealth indicators, such as size of harvest and livestock herds, would make an interesting future study.

### 8.2.4 Hypothesis Four: Extraction of forest resources at the household level is beyond levels of sustainability resulting in a gradual decline in closed canopy forest cover throughout the Lerroki Plateau.

#### *8.2.4.1 Summary of key findings*

Change in forest cover is not uniform across the plateau and the data are not always consistent with this hypothesis.

Outside the Leroghi Forest Reserve:

- Decline in closed canopy forest cover was greatest around Maralal, followed by Lpartuk. The decline in closed canopy forest outside the reserve at Ngorika was not significant.

- An increase in degraded forest/bush at Lpartuk could almost entirely account for the decline in closed canopy forest, suggesting a qualitative decline in closed canopy forest rather than forest clearance. There was a slight decline in all woody vegetation at Lpartuk outside the reserve but this decline was not significant. In contrast, at Maralal, all woody vegetation cover outside the Leroghi Forest Reserve declined by 50%.

- Degraded forest bush habitat was the preferred source of marketable woody resources at Lpartuk in 1994. There was no degraded forest bush within 5km of Lpartuk in 1963 (either inside or outside the reserve).

- Levels of construction over the last 40 years was highest around Maralal, followed by Ngorika and Lpartuk (chapter five).

- Levels of woody resource use in 1994 were higher at Lpartuk than at Ngorika

Inside the Leroghi Forest Reserve:

- Loss in closed canopy cover was greatest at Maralal, followed by Lpartuk. At Ngorika, closed canopy forest cover marginally increased between 1963 and 1993.

- Overall woody vegetation cover increased inside the reserve at Ngorika and Maralal, but decreased at Lpartuk. The decrease at Lpartuk has been attributed to extensive severe fires in the late 1980s.

Comparing the data from inside and outside the reserve, the results of this study support the results from the preliminary surveys and informal discussions that exploitation of forest resources is greatest outside the Leroghi Forest Reserve. The implications of this distinction in management and use of forest under different tenure is discussed in more detail below. On the basis of this distinction, the effects of overall forest use focuses on change in vegetation cover outside the reserve only.

Together the data from outside the Leroghi Forest Reserve suggest that subsistence use at Ngorika over the last 30 years has remained within sustainable levels. At Maralal, levels of use of both degraded and closed canopy forest has clearly exceeded sustainable levels, due to a combination of high subsistence and market demands for construction materials and fuel. At Lpartuk, forest resource use has clearly resulted in the degradation of closed canopy forest outside the reserve (there were no reports of serious fires outside the reserve, either by the forest officers or the local communities), but the current area of degraded bush-forest, woodland and bush remains lower than that around Ngorika. The decline in overall woody vegetation cover was negligible.

These results are suggestive of the creation of the preferred degraded bush habitat at Lpartuk (previously unavailable) from where the forest adjacent communities collect wild resources. However, the effectiveness of this buffer in protecting the closed canopy forest from further exploitation and degradation cannot be assessed without further monitoring of the area. The continuing demands for timber products for construction coming from Maralal (where woody resources are now minimal and the local communities are not active in collecting and selling construction materials) suggests continuing and increasing pressure on the forest resources at Lpartuk and other easily accessible villages.

In conclusion, the results do not support the hypothesis that levels of extraction of forest resources are universally unsustainable across the Plateau. At the relatively low densities around Ngorika and (by extension) Lpartuk, extraction of forest products for home use appears sustainable. At the higher population densities around Maralal, however, the levels of extraction of forest resources have clearly exceeded sustainable levels of use. It is proposed that this is likely to shift the pressure on woody resources elsewhere.

#### *8.2.4.2 Comparison with previous studies*

Once again, population density comes up as an ultimate cause of deforestation as found in the literature (Kummer, 1991; Allen & Barnes, 1985, Lambin, 1994). However, when the results of the API are considered together with the results of the baseline surveys and vegetation surveys, it is possible to be more specific about the proximate causes of forest degradation.

With respect to the question of *who* is using the forest, the results of this study suggest all sub-households use forest resources irrespective of household wealth, for basic subsistence needs such as fuelwood and timber for construction. Thus it is not possible in this case to apportion blame or responsibility for forest degradation on any particular group (cf. Little & Brokensha, 1987). Low per capita livestock holdings are a common feature of the majority of households, particularly around Maralal, and the opportunity for income from forest resources provided by the presence of the market at Maralal is taken up by households and individuals irrespective of relative wealth (cf. Scoones *et al.*, 1992; Koppell, 1992).

*Why* resources are being extracted can be related to geographical situation: isolated communities, far from markets, will depend on forests and other natural habitats as a source of a wide variety of commodities such as rope, household tools and furniture for which convenient (and cheap) manufactured alternatives exist for populations living close to markets (Shepherd, 1992; Fairhead & Leach, 1994; Kiwasila & Odgaard, 1992; KIFCON, 1994). On the other hand, easy access to markets can promote higher levels of extraction of those resources for which there is a local demand (Sikana *et al.*, 1993): in the case of Maralal, these marketable resources were potentially highly destructive of closed canopy forest. (Although wild honey, collected with greater frequency at Ngorika, carried a high risk of fire, since honey collectors used unprotected fire to smoke out the bees).

Forest adjacent communities use wild resources to fulfil a wide variety of functions. There was no evidence from this data that forest was being cleared for agricultural land or the expansion of Maralal Town itself (cf. Rocheleau, 1993; Cline-Cole *et al.*, 1990). Even around Maralal, where all closed canopy forest has been degraded or cleared in the last 30 years, the expansion in area under cultivation was at the expense of grassland and shrub habitats. The decline in closed canopy forest cover around Maralal may correlate with agricultural expansion, but it has not been caused by it (cf. Allen & Barnes, 1985). Thus, in answer to the question of *how* the forest has been degraded (where indeed it has been), the evidence points to both gradual degradation through woody resource use (cf. Allen & Barnes, 1985; Gilruth & Hutchinson, 1989), and fire, whether accidental (e.g. honey hunters), natural (e.g. lightning) or due to deliberate acts of arson (as suggested in the case of Lpartuk).

#### *8.2.4.3 Avenues for future research*

The ground surveys study focused on forests inside the reserves only and no data was collected from within the communal forests outside the reserve. The data from the aerial photography are highly suggestive of higher rates of extraction of woody resources outside the reserve than inside. Vegetation surveys within the forests outside the reserve are necessary to establish whether regeneration is taking place in these degraded areas to replenish the stocks extracted or whether desiccation of the open forest environment is preventing the re-establishment of tree species.

Aerial photographs are literally snapshots of one place at one time. Their comparison allows change within that time period to be assessed, but they do not allow extrapolation. They also cannot always distinguish qualitative change. Woody cover at Lpartuk has not decreased significantly over the last 30 years. However, with increasing pressure from Maralal for woody resources it is possible that the situation will change. Regular monitoring of evidence of human disturbance over a longer time period in areas known to be at high risk (i.e. easily accessible from Maralal) would determine whether rates of extraction were increasing or extending into closed canopy forest.

### *8.3 Forest Management - the broader issue*

The Lerroki Plateau covers three distinct agroecological zones and boasts a range of natural habitats, from closed canopy forests to open grassland savanna, as well as highly productive agricultural land. The opportunistic use of such a complex mosaic of resources that vary both by site and season in a sustainable manner is the challenge faced throughout dryland Africa (Rocheleau, 1993).

This study has demonstrated the importance of closed canopy forest to cattle on the Lerroki Plateau. The results challenge the assumption that cattle degrade closed canopy forest and suggest that, on the contrary, cattle grazing has potential as a positive management tool, by reducing the build up of inflammable dry biomass in the herbaceous layer.

The use of cattle as a positive management tool is not a new idea. Farmers in West Africa use "targeted cattle grazing as a way of manipulating fire to encourage forest succession" Fairhead & Leach (1994:78), and cattle grazing in plantations in Kenya has been encouraged by forest managers in the past as a way of reducing the build up of inflammable biomass in the herbaceous layer (Chenevix Trench, 1993; also Shepherd, 1992).

In the course of this study, I came to recognise that access to the Leroghi Forest Reserve for dry season cattle grazing formed the basis for a successful, informal system of forest management in the reserve, reminiscent of the Joint Forest Management (JFM) initiatives established in India in the last few decades (e.g. Poffenberger, 1994). These JFM initiatives (largely extended from the social forestry initiatives of the 1980s) tried to reconcile shared management objectives (conserving forest resources) with the very different needs and priorities of the local communities and the forest department (Western & Wright, 1994; Poffenberger, 1994). Behind these initiatives was the realisation that most forestry departments of developing countries did not have the human or the financial resources necessary to enforce regulations on forest access and the recognition of the importance of access to forests to local communities (Poffenberger, 1994; Shepherd, 1992; Dei, 1992).

In the case of the Leroghi Forest Reserve, the forest adjacent community and the local Forest Department officers both shared the desire to conserve the closed canopy forest within the reserve. However, this objective stemmed from very different needs and priorities: in the case of the pastoral Samburu, the forest ensures future access to dry season grazing; in the case of the Forest Department, the priorities are the conservation of biodiversity and the water catchment. As long as the Samburu are assured access for dry season grazing, traditional authorities within the communities are highly co-operative with officers from the Forest Department in regulating forest use. Women fear cutting live wood "in case an elder catches us" (Samburu woman at Ngorika village during a meeting on forest resource use, 14 January 1995, also Perlov, 1984) and moran are fined for entering the forest reserve with cattle when its use has not been sanctioned by the elders. Lopping of fodder species within the forest reserve is strictly prohibited. When a prohibition on forest grazing was enforced following a Presidential Decree in 1986, however, there was a radical increase in the number of arson cases and large areas of the forest were damaged (L. Lenkaak, Forest Officer, Lerroki Division, *pers comm.*). The threat of fire to the forests will always be there, particularly following a year of heavy rainfall. However, fire remains an important means for controlling bush encroachment onto important grazing areas. Encroachment of bush and forest on to grassland may ultimately be seen as a threat by the pastoralists and a controlled burning policy by the Forest Department could help prevent future conflicts.

The fact that forest grazing by cattle fulfils the shared management objectives within the Leroghi Forest Reserve is, in one sense, largely fortuitous. The needs of the local community for dry season grazing were acknowledged when the area was gazetted, but they were not included within any management strategy at that time on the part of the Forest Department (Kenya Land Commission, 1933). However, land use on the Lerroki Plateau has changed in the last 50 years, with an increasing settled population dependent on agriculture as well as pastoralism. The decline in both absolute and per capita livestock numbers has exacerbated this trend in changing land use. Pastoralists and cultivators tend to use forest in different ways (Shepherd, 1992). For example, Perlov (1984) found 'pure' Samburu pastoralists south of Maralal used less fuelwood on average than the Samburu agro-pastoralists who had access to land for cultivation.

These changes have important implications for the sustainability of forest resource use and the relevance of a management system based on pastoral priorities

Forested areas outside the forest reserve (both closed canopy forest and forest bush), have great economic potential as well as importance to the local community on a subsistence basis (chapter six). The decline in forest quality and, to a lesser extent, cover outside the Leroghi Forest Reserve (chapter seven) can be accounted for by the greater levels of extractive resource use made of the forests and degraded forest areas by the settled population for fencing, building and cooking materials, as well as the commercial value of these products (chapter six). However, the legality of this use of forest products within communal areas is a grey area. At present, although the members of the Group Ranch on the plateau have official title to the land, the ranches are entrusted to the Samburu County Council and as such are subject to the Chief's Act which prohibits tree felling without a permit. Permits are allocated by the Chief and Assistant Chief to the poorest members of the community to burn charcoal for sale (Chenevix Trench & Luvanda, 1994, also Perlov, 1984) but around Lpartuk, where pressure on marketable resources is high, elders admit that it is difficult to control unlicensed use and, recognising people's need for both cash and construction materials, tend to turn a blind eye to activities within these communal areas. The results of the multi-round surveys at Lpartuk, showing charcoal collection to be more frequent among the sub-households of medium wealth relative to the rest of the village, confirm this observation.

Without formalising management objectives, compatible with the needs of the local community, effective management of these forests outside the reserve is impossible (Oba, 1994; Shepherd, 1992). The economic potential of the forests outside the reserve and the needs of the local communities suggest that if the forest is to be conserved, the management objectives should be based on economically sustainable exploitation by the local community, rather than the protectionist approach taken inside the gazetted reserve (e.g. Western & Wright, 1994; Browder, 1992). Such an approach would need the active participation of both the users, the elders and Forest Department responsible for controlling extraction to ensure the future of the system as a whole (Shepherd, 1992). Some form of ecological monitoring would also be necessary, (as discussed above in section 8.2.4.3, Carter, 1996) to ensure levels of extraction remained within sustainable limits.

The Lerroki Forest Conservation Project began at the beginning of 1995 with the stated objectives of "working with the people from the group ranches [Lpartuk and Angata Nanyukie] to increase local awareness and participation in the effective management of woody resources in the area" (Blomley & Chenevix-Trench, 1995). The findings presented in this thesis provide a unique insight into the way the local communities use and manage those resources and highlight the need for such a project and the potential for its success.

### *8.4 Concluding remarks*

In this thesis I have attempted to present a holistic impression of the dynamics of forest-people-cattle interactions on the Lerroki Plateau. I chose a multi-disciplinary approach to investigate the dynamics of the system as a whole, drawing upon previous studies and ecological principles, and a variety of field techniques. Such an approach necessarily only scratches at the surface of a complex system and draws heavily on previous more in-depth studies of single species. However, if forest management is to have a basis in ecological principles, it is essential to extend our understanding of simple single-species interactions to complex ecological systems.

The findings of the study clearly differentiate forest-people dynamics inside and outside the gazetted forest reserve, contributing to the more general debate over the role of protected areas in conservation. Within the forest reserve, the system has been shown to be remarkably stable over the last thirty years, and I have proposed that this is in large part due to co-operative management on the part of the local communities and the Forest Department. Use of the forest within the reserve has been limited to dry season cattle grazing and the findings of this study refute the assumption that cattle have a deleterious effect on forest health. Outside the reserve, forest has been under greater pressure from the local population, proving an important source of wild resources both for household consumption and for sale. Given the importance of these forests to the local economy, a coherent management strategy for these forests is essential to ensure their long-term survival.

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# APPENDIX 1

**Livestock population estimates for Samburu District and the Lerroki Plateau, 1913 - 1993**

Livestock estimates from census and veterinary records (details of all sources are provided in the footnotes) (See also Figure 2.7 in Chapter two)

| Year | Cattle | Shoat | People (Lerroki) | Samburu No cattle per head | Lerroki Cattle | Lerroki Shoats | Lerroki No cattle per head |
|---|---|---|---|---|---|---|---|
| 1913 | 4,300[1] | 57,500[1] | | | | | |
| 1914 | 27,000[1] | 107,000[1] | | | | | |
| 1915 | 30,000[2] | 150,000[2] | 5,000[3] | 6 | | | |
| 1917 | 100,000[4] | | 10,000[4] | 10 | | | |
| 1922 | 150,000[4] | 150,000[4] | 10,000[4] | 15 | | | |
| 1923 | | | | | 15,000[4] | 4,000[4] | |
| 1924 | 100,000[4] | 130,000[4] | | | | | |
| 1925 | 102,569[5]<br>114,000[6] | | | 81.4 / stock owner[4] | | | |
| 1926 | | | 8,500[4] | | 75,000[2] | | |
| 1927 | 120,000[4] | | | | 60,000[4] | | |
| 1928 | 120-140,000[4] | 120-140,000[4] | 12,000 (6,574)[4] | 10 | 62,314[4] | 49,126[4] | 9.5 |
| 1930 | 100,000[6] | 100,000[6] | 10,000[6] | 10 | | | |
| 1931 | | | 8,956[4] | | | | |
| 1932 | 130,000[6] | | 9,286[4] | 14 | | | |
| 1933 | 119,403[6] | | 12,000[6] | 10 | | | |
| | 117,389[4] | | 9,645[4] | 12 | 38,391[4] | | |
| 1934 | 120,000[4] | | 12,000[4] | 10 | | | |
| 1935 | | | 26,000[2] | 4.6 | | | |
| 1936 | 126,000[2] | | 30,000[2] | 4.2 | | | |
| 1937 | 140,000[2] | | | | | | |
| 1938 | | | 18,816[4] | 4.4 | | | |
| 1939 | | | 31,700[2] | | 34,000[2] | | |
| 1942 | 120,000[4] | | | | | | |
| 1943 | | | 25,400[2] | 4.7 | | | |
| 1944 | | | 26,000[2] | | | | |
| 1948 | | | 18,797[6] | | 46,000[2] | | |
| 1950 | 253,850[4] | 500,000[2] | | | 61,550[4] | | |
| 1952 | 280,000[2] | | | | | | |
| 1954 | 300,000[4] | 250,000[2] | 40,000[2] | 8.6 | | | |

Continued./..

[1] Sobania 1979 calculated from taxes collected based on 1.5% of capital stock
[2] Bronner 1990
[3] Rinderpest led to 60% losses in southern areas (Sobania 1979 p 187)
[4] Sobania 1979
[5] Sobania 1979, refers to Veterinary Dept census (p 187)
[6] Sperling 1987

Livestock estimates from census and veterinary records, continued

| Year | Cattle | Shoat | People (Lerroki) | Samburu No cattle per head | Lerroki Cattle | Lerroki Shoats | Lerroki No cattle per head |
|---|---|---|---|---|---|---|---|
| 1955 | 345,000[4] | 350,000[2] | | | 61,550[4] | | |
| 1957[4] | 250,000[4]<br>350,000[2] | <br>350,000[2] | | | | | |
| 1959 | 350,000[6] | 350,000[6] | | | | | |
| 1961 | 350,000[6] | | | | | | |
| 1962 | 320,000[6] | | 56,539[6] | 5.7 | | | |
| | 250,000[2] | 250,000[2] | 50,000[2] | 5 | | | |
| 1966 | 450,000[2] | 300,000[2] | 56,512[6] | 8.0 | | | |
| 1967 | 575,000[2] | 350,000[2] | | | | | |
| 1968 | 633,000[2] | 350,000[2] | | | | | |
| 1969 | 420,000[2] | 250,000[2] | 69,519[7] | 6.0 | | | |
| 1971 | 300,000[6] | 250,000[6] | 70,000[2] | 4.3 | | | |
| 1977 | 241,120[6] | 435,120[6] | | | | | |
| 1978 | 221,205[6] | 237,110[6] | | | 68,691[8] | 72,130[8] | |
| 1979 | | | 76,908[7] | 2.9 | | | |
| 1980 | 127,260[6] | 148,948[6] | | | | | |
| | 116,700[2] | 134,000[2] | | | | | |
| 1982 | 109,094[6] | 172,890[6] | | | | | |
| 1983 | 158,674[6] | 287,054[6] | 87,857 | 1.8 | 54,171[9] | 49,794 | |
| 1984 | 117,483[6] | | | | 25,569[10] | 77,218[11] | |
| 1985[12] | 90,500 | 236,000 | | | | | |
| 1987[13] | 155,000 | 516,000 | | | | | |
| 1989[13] | 167,757 | 552,444 | 108,884[7] | 1.5 | | | |
| 1990[13] | 177,821 | 642,237 | | | | | |
| 1991[13] | 189,000 | 623,624 | | | | | |
| 1992[13] | 113,414 | 532,805 | | | | | |
| 1993[13] | 120,200 | 438,300 | | | | | |

[7] RoK official population census
[8] District Livestock Development Office, census for Range/Ranch planning
[9] District Livestock Development Office
[10] District Livestock Development Office estimate of 60% cattle loss due to drought on Lerroki
[11] District Livestock Development Office estimate of 25% shoat loss due to drought on Lerroki
[12] Last official District Livestock census
[13] District Livestock Development Office estimate based on 1985 census. 1992 drought led to estimated 40% cattle mortality and c. 25% shoat mortality

Livestock Estimates from Aerial Survey (unadjusted data)

| Year (month) | Cattle (SE) | Shoat (SE) | People (Lerroki) | Samburu Cattle/ Person | Lerroki Cattle (SE)[14] | Lerroki Shoats (SE) | Lerroki Cattle/ Person |
|---|---|---|---|---|---|---|---|
| 1968[15] (Aug) | 448,261 (57,479) | 318,453 (73,337) | 69,519[16] (29,853) | 6.4 | 117,725 (25,296) | 34,071 (10,336) | 3.9 |
| 1977[17] (Aug) | 177,657 (47,148) | 293,048 (60,759) | | | | | |
| 1977[18] (Oct) | 222,465 (60,151) | 358,731 (65,214) | | | 108,292 (12,030) | 48,593 (15,816) | |
| 1981[17] (Feb) | 105,247 (47,148) | 198,835 (29,727) | 76,908 (34,753) | 1.4 | | | |
| 1987[19] (Oct) | 146,041 (19,881) | 460,280 (48,199) | | | 35,277 (2,757) | 88,790 (7,721) | 0.7 |
| 1990[19] (Oct) | 168,088 (26,229) | 409,745 (58,177) | 108,884 (49,560) | 1.5 | 65,537 (3,505) | 99,256 (7,774) | 1.3 |
| 1992[19] (Oct) | 117,395 (17,307) | 430,948 (37,837) | | | 50,146 (2,703) | 104,361 (5,461) | |
| 1993[19] (Sept) | 116,523 (22,193) | 549,579 (103,704) | | | 41,075 (4,732) | 110,036 (21,168) | |

14 S.E calculated as population S.E /√n, where n=no of observations in Lerroki sample

15 Watson 1972

16 RoK Population census 1969

17 Peden 1984, from KREMU count, data unadjusted for observer's biases

18 Raw data from DRSRS

# APPENDIX 2

**Plant species found in and around the Leroghi Forest Reserve, Samburu District, Kenya**

**Appendix 2a.** Plant Species Found In Leroghi Forest Reserve, Samburu District, Kenya, Sorted by botanical species name

**Appendix 2b.** Plant Species Found In Leroghi Forest Reserve, Samburu District, Kenya, Sorted by vernacular name

**Appendix 2c.** Species used in the course of the household surveys. Table shows percent of total count of plants recorded for each resource use category.

Appendix 2a. Plant Species Found In Leroghi Forest Reserve, Samburu District, Kenya, Sorted by botanical species name
(compiled by Mwangangi, Kamau & Miringu, Kenya Indigenous Forest Conservation Project, NMK & L. Lelesiit, Ngorika village, Angata Nanyukie Group Ranch )

| Botanical Name | Vernacular Name | Family |
|---|---|---|
| *Abutilon longicuspe* A.Rich | Sulubei | Malvaceae |
| *Abutilon mauritianum* | Sulubei | Malvaceae |
| *Acacia gerardii* | Rankau | Mimosaceae |
| *Acacia nilotica* | Lkiloriti | Mimosaceae |
| *Acacia nubica* | Ndepe | Mimosaceae |
| *Acacia* sp. *(horrida/arabica)* | Lmunyimunyi | Mimosaceae |
| *Acalypha* sp | Ngomodot/Siaiti | Euphorbiaceae |
| *Achyranthes aspera* | Lbatapata/Mbatapata/ Segeet | Amaranthaceae |
| *Achyrospermum schimperi (*Hochst.) Perkins | Saali | Labiatae |
| *Acokanthera fresiorum* | Morijei | Apocynaceae |
| *Acokanthera schimperi* | Morijoi | Apocynaceae |
| *Adiantum capillus-veneris* L. | Mboroiyeyo | Adiataceae |
| *Adiantum thalictroides* Schlectend. | Mboroi | Andiantaceae |
| *Agrocharis incognita* (Norman) Heywood & Jury | Losariani | Umbelliferae |
| *Amaranthus graecizans* | Nterere | Amaranthaceae |
| *Apodytes dimidiata* | Njenaiyok | Icacinaceae |
| *Asparagus aethiopicus* var. *aethiopicus* | Ngoimei | Liliaceae |
| *Asparagus setaceus* | Lomei | Liliaceae |
| *Asparagus* sp | Lomeei/Ngoimeei | Liliaceae |
| *Asplenium aethiopicum* | Mboroyeiyo | Aspliniaceae |
| *Asplenium erectum Willd* var. *usambarense*(Hieron.) Schelpe | Mboroio | Aspliniaceae |
| *Asplenium thecifovum* | | Aspliniaceae |
| *Auphorbia tirucalli* | Loilei | Euphorbiaceae |
| *Basela alba* | Lemudog | Basellaceae |
| *Bothriocline fusca* (S.Moore) M Gilbert | Uvanja | Compositae |
| *Buddleia polystachya* Fres. | Musungash | Loganiaceae |
| *Cadia purpurea* | Lkigeriyai | Papilionaceae |
| *Calanthe sylvatica* | Lordenyai/Mbororeiyo | Orchidaceae |
| *Calodendrum capense* | Lkarantei | Rutaceae |
| *Canthium lactescens* | Lgumi | Rubiaceae |
| *Canthium* sp | Masei | Rubiaceae |
| *Carduus kikuyorum* R.E. Fries. | | Compositae |
| *Carex* sp | Loperiai | Cyperaceae |
| *Carissa edulis* | Lamuriai | Apocynaceae |
| *Cassipourea malosana* (Bak.) Alston | Mashakudu | Rhiphoraceae |
| *Ceropegia* sp | Ilei | Asclepiadaceae |
| *Chionanthus mildnraedii* (Gilg & Schell.) Stern | Loliodoi | Oleaceae |

| Botanical Name | Vernacular Name | Family |
|---|---|---|
| *Cissampelos pereira* | Lagit | Menisperaceae |
| *Clausena anisata* | Matasia | Rutaceae |
| *Clematis brachiata* Thunb. | Lgisit | Ranunculaceae |
| *Clerodendrum myricoides* | Lmakutikuti | Verbenaceae |
| *Clutia abyssinica* | Lokildia | Euphorbiaceae |
| *Commelina benghalensis* | Neiteteyai/Naiteteyai | Commelinaceae |
| *Conyza steudelii* Sch. Bipiex A.Rich | Kuvanja | Compositae |
| *Crassocephalum montuosum* (S.Moore) Milne-Redh | | Compositae |
| *Crassula granvikii* Mildbr. | Ndiati | Crassulaceae |
| *Croton alienus* | Lakiridagai | Euphorbiaceae |
| *Croton dichogamus* | Lakirdingai | Euphorbiaceae |
| *Cuscuta kilimanjari* Oliv. | | Convolvulaceae |
| *Cussonia holstii* | Lboloriyo | Euphorbiaceae |
| *Cyathula uncinulata* (Schrad.) Schinz | Lorepilipi | Amaranthaceae |
| *Cynoglossum coeruleum Johnstonii* var. *Keniensis* | Lorepilepi | Boraginaceae |
| *Cyperus* sp | Lorian | Cyperaceae |
| *Cyphostemma adenocaule* | Lordo | Vittaceae |
| *Cyphostemma kilimandscharicum* (Gilg) Descoings | Lordo | Vitaceae |
| *Dichocephala integrifolia* (L.f.) O. Kuntze | Ikicheeni | Compositae |
| *Dicliptera laxata* C.B.Cl. | Segeet | Acanthaceae |
| *Dicliptera maculata* Nees | Segeet II | Acanthaceae |
| *Digitaria* sp | Ntalagwani | Gramineae |
| *Dodonaea augustifolia* | Lketerai | Sapindaceae |
| *Dombeya burgessiae* | Purukwai | Sterculiaceae |
| *Dovyalis abyssinica* (A.Rich) Warb. | Moroo | Flacourtiaceae |
| *Dovyalis macrocalyx* | Lmoroo | Flacourtiaceae |
| *Dregea abyssinica* (Hochst.) K.Schum. | Lgaraboi | Asclepiadaceae |
| *Droguetia iners* (Forsk.) Schweinf. | Namejgosowan/Ngawili | Urticaceae |
| *Drymaria cordata* (L.) Roem & Schultes | Siget. | Caryophyllaceae |
| *Ekebergia capensis* Sparrm. | Songoroi | Meliaceae |
| *Elaeodendron buchananii* | Emachakudu | Celastraceae |
| *Eleusine indica* | Sosi | Gramineae |
| *Erythrina abyssinica* | Lolponyi | Papilionaceae |
| *Erythrina burtii* Bak.f. | Loponi | Papilponaceae |
| *Erythrococca bengensis* | Loiyapaseg | Euphorbiaceae |
| *Ethulia* sp | Lukwanja | Compositae |
| *Ethulia veronoides* | Uvanja | Compositae |
| *Euclea divinorum* | Lchingei/Lkinyai | Ebenaceae |
| *Euphorbia candalabrum* | Sirai | Euphorbiaceae |
| *Euphorbia schimperiana* Scheepe | Lakole | Euphorbiaceae |
| *Ficus thinningii* | Sepei | Moraceae |
| *Flacourtia* sp | Ladat | Flacourtiaceae |
| *Galinsoga parviflora* | Lbangi | Compositae |

| **Botanical Name** | **Vernacular Name** | **Family** |
|---|---|---|
| *Galium aparinoides* Forsk | Lorepiredi | Rubiaceae |
| *Geranium arabicum* Forsk. | Masai/Noitti | Geraniaceae |
| *Gerbera viridifolia* (DC.) Sch. Bip | Dawalokop | Compositae |
| *Girardinia diversifolia* (Link) Friis | | Urticaceae |
| *Gloriosa superba* | Lekagok Sakutari | Liliaceae |
| *Glycine whytei* | Dakat/Lolmontoi | Papilionaceae |
| *Gramineae* | Laraa | Gramineae |
| *Grewia similis* | Irii | Tiliaceae |
| *Grewia villosa Willd* | Lporokwai | Tiliaceae |
| *Haemanthus* sp | Ngaramirami | Amaryllidaceae |
| *Hibiscus cannabinus* | Loigoriomwonyi | Malvaceae |
| *Hibiscus fuscus* Garcke | Lokumeki | Malvaceae |
| *Hibiscus ludwigii* E. & Z. | Sulubei | Malvaceae |
| *Histiopteris incisa* | | Dennstaedtiaceae |
| *Hyparrhenia* sp | Lokojitong'u | Gramineae |
| *Hypoestis verticillaris* | Segeet | Acanthaceae |
| *Impatiens meriensis* | Ndiati | Balsaminaceae |
| *Impatiens sp.* (Sterile) | Mparicharagi | Balsaminaceae |
| *Indigofera sp.* Poor | Imiim | Papilionaceae |
| *Ipomoea kituiensis* | Lolkitenyi | Convolvulaceae |
| *Ipomoea sp.* (sterile) | Ligiruii | Convolvulaceae |
| *Isoglossa gregorii* (S.Moore) Lindau | Segeet III | Acanthaceae |
| *Jasminum abyssinicum* | Larachi | Oleaceae |
| *Jasminum fluminense* | Lmingis | Oleaceae |
| *Juniperus procera* | Ltarakwai | Cupressaceae |
| *Justicia exiqua* | Segeet | Acanthaceae |
| *Justicia extensa* | Segeet | Acanthaceae |
| *Justicia striata* (Klotzsch.) Bullock | Segeet | Acanthaceae |
| *Kalanchoe densiflora* | Lebelishoi/Mbasiliki | Crassulaceae |
| *Kyllinga* sp | Loperiai | Cyperaceae |
| *Lagenaria abyssinica* (Hook.f.) C. Jeffrey) | Moomoi | Cucurbitaceae |
| *Launea cornuta* (O & H.) C. Jeffr. | Larodar | Compositae |
| *leaf vegetable* | Managu | |
| *Lepidotrichilia volkensii* | Songoroi | Meliaceae |
| *Leucas calostachys* Oliv. | Lmichomi | Labiatae |
| *Leucas martinicensis* | Solubei/Bibii/Larubat | Labiatae |
| *Leucas urticifolia* R.Br. var. Urticifolia | Bibii | Labiatae |
| *Lippia javanica* (Burm.f.) Spreng. | Sinoni | Verbenaceae |
| *Lippia ukambensis* | Sunoni | Verbenaceae |
| *Loranthus* sp | Loldanyai | Loranthaceae |
| *Loranthus* sp | Lotunenei | Loranthaceae |
| *Loxogramona lanceolata* | | Polypodiaceae |
| *Maerua* sp. | Lamalogi | Capparaceae |

| **Botanical Name** | **Vernacular Name** | **Family** |
|---|---|---|
| *Maerua* sp. (Sterile) | Loitakine | Capparaceae |
| *Maytenus heterophylla* | Sagomai | Celastraceae |
| *Maytenus undata* (Thunb.) Blakelock | Saramunai (lodoganaioi) | Celastraceae |
| *Microglossa pyrifolia* (Lam.) O.Ktze | | Compositae |
| *Momordica foetida* | Momoi | Cucurbitaceae |
| *Momordica friesiorum* (Harms) C. Jeffrey | Sepeita/Momoi | Cucurbitaceae |
| *Myrsine africana* | Seketet | Myrsinaceae |
| *Mystroxylon aethiopicum* | Lordonganaiyoi | Celastraceae |
| *Notonia hildebrandtii* Vatke (sterile) | Ngaramarami | Compositae |
| *Nuxia congesta* | Musungash | Loganiaceae |
| *Ocimum kilimandscharicum* | Lemuran | Labiatae |
| *Ocimum* sp | Lkarialemunyi | Labiatae |
| *Oldenlandia* sp | Loiyapasasei | Rubiaceae |
| *Oldenlandia* sp | Segeet | Rubiaceae |
| *Olea capensis* | Loliontoi | Oleaceae |
| *Olea europeana* ssp *africana* | Lngeriyei | Oleaceae |
| *Olinia rochetiana* | Lkirenyi | Oliniaceae |
| *Olinia usambarensis* | Ngilenyi | Oliniaceae |
| *Oplismenus hirtellus* | Larraa/Lkujita | Gramineae |
| *Orthosiphon rubicundus* | Lchimcheeni | Labiatae |
| *Osyridocarpus schimperanus* (A.Rich) A.DC. | Loitunengi | Santalaceae |
| *Osyris compressa* | Losesiai | Santalaceae |
| *Oxyanthus speciosus* | Lkaukawa | Rubiaceae |
| *Paspalum* sp | Laraa | Gramineae |
| *Pavetta abyssinica* Fresen | Musungash | Rubiaceae |
| *Pelargonium whytei* Bak. | Masikirai | Geraniaceae |
| *Pennisetum clandestinum* | Lobobo | Gramineae |
| *Pennisetum megophylla* | Lopekendongoi | Gramineae |
| *Pennisetum* sp | Lepikindongoi | Gramineae |
| *Peperomia abyssinica* | Mbarichalagi | Piperaceae |
| *Peperonia stuhlmannii* C.DC. | | Piperaceae |
| *Peponium* sp | Lkirau | Cucurbitaceae |
| *Peponium vogelii* | Raragi | Cucurbitaceae |
| *Phytolacca dodecandra* L'Herit | | Phytolaccaceae |
| *Pilea johnstonii* Oliv. | | Urticaceae |
| *Pistacia aethiopica* | Lokilepoi | Anacardiaceae |
| *Plantago palmata* | Kichaga | Plantaginaceae |
| *Plectranthus barbatus* | Saali | Labiatae |
| *Plectranthus kamerunensis* Gurke | Saali | Labiatae |
| *Plectranthus* sp | Sumuriyai/Lchiceen | Labiatae |
| *Plectranthus sylvestris* | Saali | Labiatae |
| *Pleopeltis macrocarpa* | | Polypodiaceae |
| *Podocarpus gracilior* Pilger | Piripirinti | Podocarpaceae |

| Botanical Name | Vernacular Name | Family |
|---|---|---|
| *Pouzolzia parasitica* (Forsk.) Schweinf. | Ngomodot | Urticaceae |
| *Prunus africana* (Hook.f.) Kalkm. | Malan | Rosaceae |
| *Psiadia arabica* | Labai | Compositae |
| *Psychotria sp* | Lmasei | Rubiaceae |
| *Pteris cretica* L. | Mborolo | Adiantaceae |
| *Pteris dentata* Forsk. | Lgwetiti | Adiataceae |
| *Rhamnus prinoides* L'Herit | Lkijil/Ngingiri | Rhamnaceae |
| *Rhamnus staddo* | Lkokulai | Rhamnaceae |
| *Rhoicissus tridentata* | Lkilenyai | Vittaceae |
| *Rhus natalensis* | Misigiyoi | Anacardiaceae |
| *Rhynchosia usambarensis Taub.* ssp. *inelegans* Verdc. | Lebebek/Dakat | Papilionaceae |
| *root vegetable* | Loropij | |
| *Rubus* (sterile) | Kalamule | Rosaceae |
| *Salvia nilotica* Jacq. | Leturot | Labiatae |
| *Sanicula elata* D.Don | | Umbelliferae |
| *Satureja biflora* (D.Don.) Briq. | Leselemede | Labiatae |
| *Schefflera abyssinica* | Lkianatei | Araliaceae |
| *Schefflera volkensii* Harms | Lkinantei | Araliaceae |
| *Schimperella aberdarense* Norman | | Umbellifera |
| *Schrebela alata* | Likikauwa | Olacaceae |
| *Scutia myrtina* | Sanaguri | Rhamnaceae |
| *Secamone* sp. | Sinantei | Asclepiadaceae |
| *Sena didymobotrya* | Senetoi | |
| *Senecio syringifolia* O.Hoffm. | Lekelden | Compositae |
| *Sericocompsis* sp. | Ntorokwan | Amaranthaceae |
| *Solanum aculeatissimum* Jacq. | Ntulelei | Solanaceae |
| *Solanum gigantum* | Ntulele | Solanaceae |
| *Solanum incanum* L. | Ntulelei | Solanaceae |
| *Solanum mauense* Bitter | | Solanaceae |
| *Solanum* sp | Ntulele | Solanaceae |
| *Solanum* sp | Lekuru | Solanaceae |
| *Solanum terminale* Forsk | Ikeniorok | Solanaceae |
| *Sphaeranthus* sp | Loturot | Compositae |
| *Sphaeranthus* sp. | Loiyapasei | Compositae |
| *Spilanthes mauritiana* | Nasigoyo/Ndiati | Compositae |
| *Sporobolus* sp | Laraa | Gramineae |
| *Sporobolus* sp | Lperesi | Gramineae |
| *Stephania abyssinica* (A.Rich) Walp.var. *abyssinica* | Lagit | Menispermaceae |
| *Tarenna graveolens* | Lmasei | Rubiaceae |
| *Teclea nobilis* Del. | Lgilai | Rutaceae |
| *Thalictrum rhynchocarpum* Dall & A.Rich | Laisarian | Ranunculaceae |
| *Themeda triandra* | Lperesiuasi | Gramineae |
| *Toddalia asiatica* | Paramunyo | Rutaceae |

| Botanical Name | Vernacular Name | Family |
|---|---|---|
| *Trichocladus ellipticus* ssp. *malosanus* | Lpalagilagi | Hamamelidaceae |
| *Trimeria grandifolia* | Ledaat | Flacourtiaceae |
| *Tylophora lugardae* Bullock. (First Record) | Lagit | Asclepiadaceae |
| *Tylophora sylvatica* Decne | Idagat | Asclepiadaceae |
| *Urera hypselodendron* | Ngomodot | Celastraceae |
| *Urtica massaica* | Sapai | Urticaceae |
| *Vangueria infausta* Burch. ssp. *rotundata* (Robyns) Verdc. | Lugomii | Rubiaceae |
| *Vernonia auriculifera* | Lekidapdapat | Compositae |
| *Vernonia brachycalyx* | Marigeroi | Compositae |
| *Vernonia galamensis* (Cass.) Less. | | Compositae |
| *Vernonia lasiopus* O.Hoffm | | Compositae |
| *Vernonia* sp (climber) | Lmarigeroi | Compositae |
| *Vernonia* sp (shrub) | Lekildapat | Compositae |
| *Vigna* sp | Lagit | Papilionaceae |
| *Viscum tuberculatum* | Naldanyai | Loranthaceae |
| *Xymalos monospora* | Lkukut | Monimiaceae |
| *Zanthoxylum gillettii* | Loisugi | Rutaceae |
| *Zehneria scabra* | Moomoi/Lgilaui | Cucurbitaceae |
| | Larampushi | |
| | Nyopit | |
| | Mpopongi | |
| | Rechen | |
| | Kerenulei | |
| | Lmelikori | |
| | Lmenangi | |
| | Lolpiyaiyo | |
| | Loneneni | |
| | Longorno | |
| | Mgongo | |
| | Lmonguntan | |
| | Lolopinyi | |

Appendix 2b. Plant Species Found In Leroghi Forest Reserve, Samburu District, Kenya, Sorted by vernacular name
(compiled by Mwangangi, Kamau & Miringu, Kenya Indigenous Forest Conservation Project, NMK & L. Lelesiit, Ngorika village, Angata Nanyukie Group Ranch )

| Vernacular Name | Botanical Name | Family | Plant type |
|---|---|---|---|
| Bibii | *Leucas martinicensis* R.Br. | Labiatae | herb |
| Bibii | *Leucas urticifolia* R.Br. var. *Urticifolia* | Labiatae | herb |
| Dakat | *Glycine whytei* | Papilionaceae | climber |
| Dakat | *Rhynchosia usambarensis* Taub. var. *usambarensis* | Papilionaceae | herb |
| Dawalokop | *Gerbera viridifolia* (DC.) Sch. Bip | Compositae | herb |
| Emachakudu | *Elaeodendron buchananii* | Celastraceae | tree |
| Idagat | *Tylophora sylvatica* Decne | Asclepiadaceae | herb |
| Ikeniorok | *Solanum terminale* Forsk | Solanaceae | herb |
| Ilei | *Ceropegia* sp | Asclepiadaceae | climber |
| Imiim | *Indigofera* sp. Poor | Papilionaceae | herb |
| Irii | *Grewia similis* | Tiliaceae | shrub |
| Kerenule | *Rubus* (sterile) | Rosaceae | shrub |
| Kichaga | *Plantago palmata* | Plantaginaceae | herb |
| Kuvanja | *Conyza steudelii* Sch. Bipiex A.Rich | Compositae | herb |
| Labai | *Psiadia arabica* | Compositae | shrub |
| Ladat | *Flacourtia* sp | Flacourtiaceae | shrub |
| Lagit | *Cissampelos pereira* | Menispermaceae | climber |
| Lagit | *Stepharnia abyssinica* (A.Rich) Walp.*var. abyssinica* | Menispermaceae | climber |
| Lagit | *Tylophora lugardae* Bullock. (First Record) | Asclepiadaceae | herb |
| Lagit | *Vigna* spp | Papilionaceae | herb |
| Laisarian | *Thalictrum rhynchocarpum* Dall & A.Rich | Ranunculaceae | herb |
| Lakirdingai | *Croton dichogamus* | Euphorbiaceae | shrub |
| Lakiridagai | *Croton alienus* | Euphorbiaceae | shrub |
| Lakole | *Euphorbia schimperiana* Scheepe | Euphorbiaceae | herb |
| Lamalogi | *Maerua* sp. | Capparaceae | |
| Lamuriai | *Carissa edulis* | Apocynaceae | shrub |
| Laraa | *Gramineae* | Gramineae | grass |
| Laraa | *Oplismenus hirtellus* | Gramineae | grass |
| Laraa | *Paspalum* sp | Gramineae | grass |
| Laraa | *Sporobolus* sp | Gramineae | grass |
| Larachi | *Jasminum abyssinicum* | Oleaceae | climber |
| Larampushi | | | |
| Larganyai | *Carissa edulis* | Apocynaceae | tree |
| Larodar | *Launea cornuta* (O & H.) C. Jeffr. | Compositae | herb |
| Larubat | *Leucas martinicensis* R.Br. | Labiatae | herb |
| Lbangi | *Galinsoga parviflora* | Compositae | herb |
| Lbatapata | *Achyranthes aspera* | Amaranthaceae | herb |

| Vernacular Name | Botanical Name | Family | Plant type |
|---|---|---|---|
| Lboloriyo | *Cussonia holstii* | Euphorbiaceae | tree |
| Lchicheen | *Pletranthus sylvestris* Guerke | Labiatae | shrub |
| Lchimcheeni | *Orthosiphon rubicundus* | Labiatae | herb |
| Lchingei | *Euclea divinorum* | Ebenaceae | tree |
| Lebebek | *Rhynchosia usambarensis* Taub. ssp. *inelegans* Verdc. | Papilionaceae | herb |
| Lebelishoi | *Kalanchoe densiflora* | Crassulaceae | herb |
| Ledaat | *Trimeria grandifolia* | Flacourtiaceae | shrub |
| Lekagok Sakutari | *Gloriosa superba* | Liliaceae | herb |
| Lekelden | *Senecio syringifolia* O.Hoffm. | Compositae | climber |
| Lekidapat | *Vernonia auriculifera* | Compositae | shrub |
| Lekildapat | *Vernonia* sp (shrub) | Compositae | shrub |
| Lekuru | *Solanum* sp | Solanaceae | |
| Lemudog | *Basela alba* | Basellaceae | climber |
| Lemuran | *Ocimum kilimandscharicum* | Labiatae | herb |
| Lepikindongoi | *Pennisetum* sp | Gramineae | grass |
| Leseremende | *Satureja biflora* (D.Don.) Briq. | Labiatae | herb |
| Leturot | *Salvia nilotica* Jacq. | Labiatae | herb |
| Lgalaui | *Zehneria scabra* (Linn) Sond. | Cucurbitaceae | climber |
| Lgaraboi | *Dregea abyssinica* (Hochst.) K.Schum. | Asclepiadaceae | climber |
| Lgilai | *Teclea nobilis* Del. | Rutaceae | tree |
| Lgisit | *Clematis brachiata* Thunb. | Ranunculaceae | shrub |
| Lgumi | *Canthium lactescens* | Rubiaceae | tree |
| Lgwetiti | *Pteris dentata* Forsk. | Adiataceae | pteridophyte |
| Ligiruii | *Ipomoea* sp. (sterile) | Convolvulaceae | climber |
| Likarialemun | *Ocimum* sp | Labiatae | herb |
| Likikauwa | *Schrebela alata* | Olacaceae | tree |
| Lkakauwa | *Oxyanthus speciosus* | Rubiaceae | tree |
| Lkarantei | *Calodendrum capense* | Rutaceae | tree |
| Lketerai | *Dodonaea augustifolia* | Sapindaceae | shrub |
| Lkicheeni | *Dichocephala integrifolia* (L.f.) O. Kuntze | Compositae | herb |
| Lkigeriyai | *Cadia purpurea* | Papilionaceae | tree |
| Lkijil | *Rhamnus prinoides* L'Herit | Rhamnaceae | shrub |
| Lkilenyai | *Rhoicissus tridentata* | Vittaceae | climber |
| Lkiloriti | *Acacia nilotica* | Mimosaceae | tree |
| Lkinantei | *Schefflera volkensii* Harms | Araliaceae | tree |
| Lkinantei/Lkianate | *Schefflera abyssinica* | Araliaceae | tree |
| Lkinyai/Lkinyei | *Euclea divinorum* | Ebenaceae | tree |
| Lkirau | *Peponium* sp | Concurbitaceae | tree |
| Lkirenyi | *Olinia usambarensis* | Oliniaceae | tree |
| Lkirenyi | *Olinia rochetiana* | Oliniaceae | tree |
| Lkokulai | *Rhamnus staddo* | Rhamnaceae | shrub |
| Lkujita | *Oplismenus hirtellus* | Gramineae | grass |
| Lkukut | *Xymalos monospora* Warb. | Monimiaceae | tree |

| Vernacular Name | Botanical Name | Family | Plant type |
|---|---|---|---|
| Lmakutikuti | *Clerodendrum myricoides* | Verbenaceae | tree |
| Lmarigeroi | *Vernonia* sp (climber) | Compositae | climber |
| Lmarigeroi | *Vernonia brachycalyx* | Compositae | shrub |
| Lmasei | *Psychotria* sp | Rubiaceae | shrub |
| Lmasei | *Tarenna graveolens* | Rubiaceae | tree |
| Lmelikori | | | |
| Lmenangi | | | |
| Lmichomi | *Leucas calostachys* Oliv. | Labiatae | herb |
| Lmingis | *Jasminum fluminense* | Oleaceae | tree |
| Lmoroo | *Dovyalis macrocalyx* | Flacourtiaceae | shrub |
| Lmunyimunyi | *Acacia* sp. *(horrida/arabica)* | Mimosaceae | tree |
| Lngeriyei | *Olea europeana* ssp *africana* | Oleaceae | tree |
| Lobobo | *Pennisetum clandestinum* | Gramineae | grass |
| Loigoriomwonyi | *Hibiscus cannabinus* | Malvaceae | herb |
| Loilei | *Auphorbia tirucalli* | Euphorbiaceae | climber |
| Loisugi | *Zanthoxylum gillettii* | Rutaceae | tree |
| Loitakine | *Maerua* sp. (Sterile) | Capparaceae | shrub |
| Loitunengi | *Osyridocarpus schimperanus* (A.Rich) A.DC. | Santalaceae | shrub |
| Loiyapasasei | *Oldenlandia* sp | Rubiaceae | herb |
| Loiyapaseg | *Erythrococca bengensis* | Euphorbiaceae | shrub |
| Loiyapasei | *Sphaeranthus* sp. | Compositae | herb |
| Lokildia | *Clutia abyssinica* | Euphorbiaceae | shrub |
| Lokilepoi | *Pistacia aethiopica* | Anacardiaceae | shrub |
| Lokojitong'u | *Hyparrhenia* sp | Gramineae | grass |
| Lokumeki | *Hibiscus fuscus* Garcke | Malvaceae | shrub |
| Loldanyai | *Loranthus* sp | Loranthaceae | herb |
| Loliodoi | *Chionanthus mildnraedii* (Gilg & Schell.) Stern | Oleaceae | tree |
| Loliontoi | *Olea capensis* | Oleaceae | tree |
| Lolkitenyi | *Ipomoea kituiensis* | Convolvulaceae | shrub |
| Lolmontoi | *Glycine whytei* | Papilionaceae | climber |
| Lolpiyaiyo | | | |
| Lolponyi | *Erythrina abyssinica* | Papilionaceae | tree |
| Lolponyi/loponyi | *Erythrina burtii* Bak.f. | Papilponaceae | tree |
| Lomei | *Asparagus setaceus* | Liliaceae | climber |
| Lomei | *Asparagus* sp | Liliaceae | climber |
| Loneneni | | | |
| Longorno | | | |
| Lopekendongoi | *Pennisetum megophylla* | Gramineae | grass |
| Loperiai | *Carex* sp | Cyperaceae | sedge |
| Loperiai | *Kyllinga* sp | Cyperaceae | sedge |
| Lordenyai | *Calanthe sylvatica* | Orchidaceae | orchid |
| Lordo | *Cyphostemma kilimandscharicum* (Gilg) Descoings | Vitaceae | climber |
| Lordo | *Cyphostemma adenocaule* | Vittaceae | shrub |

| Vernacular Name | Botanical Name | Family | Plant type |
|---|---|---|---|
| Lordonganaiyoi | *Mystroxylon aethiopicum* | Celastraceae | tree |
| Lorepilepi | *Galium aparinoides* Forssk | Rubiaceae | climber |
| Lorepilepi | *Cyathula uncinulata* (Schrad.) Schinz | Amaranthaceae | herb |
| Lorepilepi | *Cynoglossum coeruleum* Johnstonii *var. Keniensis* | Boraginaceae | herb |
| Lorian | *Cyperus* sp | Cyperaceae | sedge |
| Loropij | root vegetable | | |
| Losariani | *Agrocharis incognita* (Norman) Heywood & Jury | Umbelliferae | herb |
| Losesiai | *Osyris compressa* | Santalaceae | shrub |
| Lotunenei | *Loranthus* sp | Loranthaceae | herb |
| Loturot | *Sphaeranthus* sp | Compositae | herb |
| Lpalagilagi | *Trichocladus ellipticus* ssp. *malosanus* | Hamamelidaceae | tree |
| Lperesi | *Sporobolus* sp | Gramineae | grass |
| Lperesiuasi | *Themeda triandra* | Gramineae | grass |
| Lporokwai | *Grewia villosa* Willd | Tiliaceae | shrub |
| Ltarakwai | *Juniperus procera* | Cupressaceae | tree |
| Lugomii | *Vangueria infausta* Burch. ssp. *rotundata* (Robyns) Verdc. | Rubiaceae | shrub |
| Lukwanja | *Ethulia* sp | Compositae | herb |
| Malan | *Prunus africana* (Hook.f.) Kalkm. | Rosaceae | tree |
| Managu | leaf vegetable | | herb |
| Masai | *Geranium arabicum* Forsk. | Geraniaceae | herb |
| Masei | *Canthium* sp | Rubiaceae | shrub |
| Mashakudu | *Cassipourea malosana* (Bak.) Alston | Rhiphoraceae | tree |
| Masikirai | *Pelargonium whytei* Bak. | Geraniaceae | herb |
| Matasia | *Clausena anisata* | Rutaceae | shrub |
| Mbarichalagi | *Peperomia abyssinica* | Piperaceae | herb |
| Mbasiliki | *Kalanchoe densiflora* | Crassulaceae | herb |
| Mboroi | *Adiantum thalictroides* Schlectend. | Andiantaceae | pteridophyte |
| Mboroiyo | *Adiantum capillus-veneris* L. | Adiataceae | pteridophyte |
| Mborolo | *Pteris cretica* L. | Adiantaceae | pteridophyte |
| Mbororeiyo | *Calanthe sylvatica* | Orchidaceae | orchid |
| Mbororeiyo | *Asplenium aethiopicum* | Aspliniaceae | pteridophyte |
| Mboroyeiyo | *Asplenium aethiopicum* | Aspliniaceae | pteridophyte |
| Mboroyo | *Asplenium erectum* Willd var. *usambarense*(Hieron.) Schelpe | Aspliniaceae | pteridophyte |
| Mgongo | | | |
| Misigiyoi | *Rhus natalensis* | Anacardiaceae | shrub |
| Momoi | *Lagenaria abyssinica* (Hook.f.) C. Jeffrey | Cucurbitaceae | climber |
| Momoi | *Momordica foetida* | Cucurbitaceae | climber |
| Momoi | *Mormodica friesiorum* | Cucurbitaceae | climber |
| Momoi | *Zehneria scabra* | Cucurbitaceae | climber |
| Morijoi | *Acokanthera fresiorum* | Apocynaceae | shrub |
| Morijoi | *Acokanthera schimperi* | Apocynaceae | tree |
| Moroo | *Dovyalis abyssinica* (A.Rich) Warb. | Flacourtiaceae | shrub |

| Vernacular Name | Botanical Name | Family | Plant type |
|---|---|---|---|
| Mparicharagi | *Impatiens* sp. (Sterile) | Balsaminaceae | herb |
| Mpopongi | | | |
| Musungash | *Pavetta abyssinica* Fresen. | Rubiaceae | herb |
| Musungash | *Buddleia polystachya* Fres. | Loganiaceae | shrub |
| Musungash | *Nuxia congesta* Fres. | Loganiaceae | tree |
| Naldanyai | *Viscum tuberculatum* | Loranthaceae | parasitic |
| Namejgosowan | *Droguetia iners* (Forsk.) Schweinf. | Urticaceae | herb |
| Nasigoyo | *Spilanthes mauritiana* | Compositae | herb |
| Ndepe | *Acacia nubica* | Mimosaceae | tree |
| Ndiati | *Impatiens meriensis* | Balsaminaceae | herb |
| Ndiati | *Spilanthes mauritiana* (Pers.) DC. | Compositae | herb |
| Ndiati | *Crassula granvikii* Mildbr. | Crassulaceae | herb |
| Neiteteyai/Naiteteya i | *Commelina benghalensis* | Commelinaceae | herb |
| Ngaramarami | *Notonia hildebrandtii* Vatke (sterile) | Compositae | herb |
| Ngaramirami | *Haemanthus* sp | Amaryllidaceae | herb |
| Ngawili | *Droguetica iners* (Forssk.) Schweinf. | Urticaceae | herb |
| Ngingiri | *Rhamnus prinoides* L'Herit | Rhamnaceae | shrub |
| Ngoimei | *Asparagus aethiopicus* var. *aethiopicus* | Liliaceae | climber |
| Ngoimei | *Asparagus* sp | Liliaceae | climber |
| Ngomodot | *Urera hypselodendron* | Celastraceae | climber |
| Ngomodot | *Acalypha* sp | Malvaceae | herb |
| Ngomodot | *Pouzolzia parasitica* (Forsk.) Schweinf. | Urticaceae | herb |
| Njenaiyok | *Apodytes dimidiata* | Icacinaceae | tree |
| Noitti | *Geranium arabicum* Forsk. | Geraniaceae | herb |
| Ntalagwani | *Digitaria* sp | Gramineae | grass |
| Nterere | *Amaranthus graecizans* | Amaranthaceae | herb |
| Ntorokwan | *Sericocompsis* sp. | Amaranthaceae | tree |
| Ntulele | *Solanum aculeatissimum* Jacq. | Solanaceae | herb |
| Ntulele | *Solanum gigantum* | Solanaceae | herb |
| Ntulele | *Solanum incanum* L. | Solanaceae | herb |
| Ntulele | *Solanum* sp | Solanaceae | herb |
| Nyopit | | | |
| Paramunyo | *Toddalia asiatica* | Rutaceae | tree |
| Piripirinti | *Podocarpus gracilior* Pilger | Podocarpaceae | tree |
| Purukwai | *Dombeya burgessiae* | Sterculiaceae | tree |
| Rankau | *Acacia gerardii* | Mimosaceae | tree |
| Raragi | *Peponium vogelii* | Cucurbitaceae | shrub |
| Rechen | | | |
| Saali | *Achyrospermum schimperi* (Hochst.) Perkins | Labiatae | herb |
| Saali | *Plectranthus barbatus* | Labiatae | herb |
| Saali | *Plectranthus kamerunensis* Gurke | Labiatae | herb |
| Saali | *Plectranthus sylvestris* | Labiatae | shrub |
| Sagomai | *Maytenus heterophylla* | Celastraceae | shrub |

| Vernacular Name | Botanical Name | Family | Plant type |
|---|---|---|---|
| Sananguri | *Scutia myrtina* | Rhamnaceae | shrub |
| Sapai | *Urtica massaica* | Urticaceae | herb |
| Saramunai (lodoganaidi) | *Maytenus undata* (Thunb.) Blakelock | Celastraceae | tree |
| Segeet | *Dicliptera laxata* C.B.Cl. | Acanthaceae | herb |
| Segeet | *Dicliptera maculata* Nees | Acanthaceae | herb |
| Segeet | *Hypoestis verticillaris* | Acanthaceae | herb |
| Segeet | *Isoglossa gregorii* (S.Moore) Lindau | Acanthaceae | herb |
| Segeet | *Justicia exiqua* | Acanthaceae | herb |
| Segeet | *Justicia extensa* | Acanthaceae | herb |
| Segeet | *Justicia striata* (Klotzsch.) Bullock | Acanthaceae | herb |
| Segeet | *Achyranthes aspera* | Amaranthaceae | herb |
| Segeet | *Drymaria cordata* (L.) Roem & Schultes | Caryophyllaceae | herb |
| Segeet | *Oldenlandia* sp | Rubiaceae | herb |
| Seketet | *Myrsine africana* | Myrsinaceae | shrub |
| Senetoi | *Sena didymobotrya* | | shrub |
| Sepei | *Ficus thinningii* | Moraceae | tree |
| Sepeita | *Momordica friesiorum* (Harms) C. Jeffrey | Cucurbitaceae | climber |
| Siaiti | *Acalypha* sp | Malvaceae | herb |
| Sinantei | *Secamone* sp. | Asclepiadaceae | climber |
| Sirai | *Euphorbia candalabrum* | Euphorbiaceae | tree |
| Songoroi | *Ekebergia capensis* Sparrm. | Meliaceae | tree |
| Songoroi | *Lepidotrichilia volkensii* | Meliaceae | tree |
| Sosi | *Eleusine indica* | Gramineae | grass |
| Sulubei | *Leucas martinicensis* | Labiatae | herb |
| Sulubei | *Abutilon longicuspe* A.Rich | Malvaceae | shrub |
| Sulubei | *Abutilon mauritianum* | Malvaceae | shrub |
| Sulubei | *Hibiscus ludwigii* E. & Z. | Malvaceae | shrub |
| Sumuriyai | *Plectranthus* sp | Labiatae | herb |
| Sunoni | *Lippia javanica* (Burm.f.) Spreng. | Verbenaceae | shrub |
| Sunoni | *Lippia ukambensis* | Verbenaceae | shrub |
| Uvanja | *Bothriocline fusca* (S.Moore) M Gilbert | Compositae | herb |
| Uvanja | *Ethulia veronoides* | Compositae | herb |

Appendix 2c. Species named in the course of the household surveys. Table shows percent of total count of plants recorded for each resource use category.

| Botanical Name | Vernacular Name | Plant type | Firewood | Wild food | Medicine | Fodder /vet | poles & posts | weapons | rope | charcoal | timber | other wood | honey | thatch | other gen | Total | Cumulative % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Juniperus procera | Ltarakwai | tree | 47% | 0% | 0% | 0% | 99% | 1% | 0% | 5% | 100% | 23% | 85% | 89% | 30% | 30% | 30% |
| Olea europeana ssp africana | Lngeriyei | tree | 45% | 0% | 4% | 24% | 0% | 73% | 0% | 67% | 0% | 7% | 8% | 1% | 39% | 22% | 52% |
| Carissa edulis | Lamuriai/ Larganyai | shrub | 0% | 62% | 19% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 13% | 65% |
| Rhus natalensis | Misigiyoi | shrub | 1% | 10% | 14% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 4% | 69% |
| Maytenus heterophylla | Sagomai | shrub | 3% | 0% | 1% | 29% | 0% | 3% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 4% | 73% |
| Rhamnus staddo | Lkokulai | shrub | 1% | 0% | 6% | 27% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 6% | 3% | 76% |
| Ceropegia sp | Ilei | climber | 0% | 0% | 0% | 0% | 0% | 0% | 52% | 0% | 0% | 0% | 0% | 0% | 0% | 3% | 79% |
| Myrsine africana | Seketet | shrub | 0% | 0% | 13% | 9% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 3% | 81% |
| Toddalia asiatica | Paramunyo | shrub | 0% | 0% | 14% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 2% | 83% |
| Cissampelos pereira/ Vigna spp/ Stepharnia abyssinica/ Tylophora lugardae | Lagit | climber | 0% | 0% | 0% | 0% | 0% | 0% | 25% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 85% |
| Amaranthus graecizans | Nterere | herb | 0% | 8% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 86% |
| Euclea divinorum | Lchingei/ Lkinyei | tree | 1% | 0% | 3% | 0% | 1% | 0% | 0% | 17% | 0% | 2% | 0% | 0% | 0% | 1% | 87% |
| Teclea nobilis Del. | Lgilai | tree | 0% | 0% | 0% | 1% | 0% | 17% | 0% | 9% | 0% | 2% | 0% | 0% | 15% | 1% | 88% |
| Rhynchosia usambarensis | Lebebek | herb | 0% | 6% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 89% |

| Botanical Name | Vernacular Name | Plant type | Firewood | Wild food | Medicine | Fodder /vet | poles & posts | weapons | rope | charcoal | timber | other wood | honey | thatch | other gen | Total | Cumulative % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dombeya burgessiae | Purukwai | tree | 0% | 0% | 0% | 0% | 0% | 1% | 16% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 90% |
| Mormodica friesiorum | Moomoi | climber | 0% | 4% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 91% |
| Secamone sp. | Sinantei | climber | 0% | 0% | 4% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 92% |
| Cussonia holstii | Lboloriyo | tree | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 35% | 0% | 0% | 0% | 1% | 92% |
| Clerodendrum myricoides | Lmakutikuti | tree | 0% | 0% | 4% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 93% |
| leaf vegetable | Managu | | 0% | 4% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 94% |
| Trimeria grandifolia | Ledaat | shrub | 0% | 0% | 3% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 94% |
| Lippia javanica/L. ukambensis | Sinoni | shrub | 0% | 0% | 1% | 0% | 0% | 3% | 0% | 0% | 0% | 0% | 0% | 4% | 0% | 0% | 95% |
| Dovyalis abyssinica/ Dovyalis macrocalyx | Moroo | shrub | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 95% |
| Croton alienus/ Croton dichogamus | Lkardingai | shrub | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 95% |
| Grewia similis | Irii | shrub | 0% | 1% | 0% | 3% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 96% |
| Dodonaea augustifolia | Lketerai | shrub | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 96% |
| Satureja biflora | Leselemede | herb | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 96% |
| Oxyanthus speciosus | Lkaukawa | shrub | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 97% |
| Podocarpus gracilior | Piripirinti | tree | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 15% | 0% | 0% | 3% | 0% | 97% |

| Botanical Name | Vernacular Name | Plant type | Firewood | Wild food | Medicine | Fodder /vet | poles & posts | weapons | rope | charcoal | timber | other wood | honey | thatch | other gen | Total | Cumulative % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rhamnus prinoides | Lkijil | shrub | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 97% |
| Psiadia arabica | Labai | shrub | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 6% | 0% | 0% | 97% |
| Zanthoxylum gillettii | Loisugi | tree | 0% | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 97% |
| Trichocladus ellipticus ssp. malosanus | Lpalagilagi | tree | 0% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 3% | 0% | 0% | 0% | 0% | 98% |
| Acacia gerardii | Rankau | tree | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 98% |
| Lepidotrichilia volkensii/ Ekbergia capensis | Songoroi | tree | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 8% | 0% | 0% | 0% | 0% | 98% |
| Peponium vogelii | Raragi | shrub | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 98% |
| | Larampushi | | 0% | 0% | 0% | 0% | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 98% |
| Olinia rochetiana | Lkirenyi | tree | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 98% |
| root vegetable | Loropij | | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 98% |
| Osyris compressa | Losesiai | shrub | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |
| Senecio syringifolia | Lekelden | climber | 0% | 0% | 0% | 0% | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |
| Solanum sp | Ntulele | herb | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 3% | 0% | 99% |
| | Nyopit | | 0% | 0% | 0% | 0% | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |
| Abutilon longicuspe/ Abutilon mauritianum/ Hibiscus ludwigii/ Leucas martinicensis | Sulubei | shrub | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |

| Botanical Name | Vernacular Name | Plant type | Firewood | Wild food | Medicine | Fodder /vet | poles & posts | weapons | rope | charcoal | timber | other wood | honey | thatch | other gen | Total | Cumulative % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acacia sp. (horrida/ arabica) | Lmunyi-munyi | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |
| Olea capensis | Loliontoi | tree | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 8% | 0% | 0% | 0% | 99% |
| Maerua sp. | Lotakine | shrub | 0% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |
| Acokanthera fresiorum/ Acokanthera schimperi | Morijei | tree | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |
| | Mpopongi | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |
| Apodytes dimidiata | Njenaiyok | tree | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |
| | Rechen | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 3% | 0% | 0% | 0% | 0% | 99% |
| Rubus sp. | Lkaramule | shrub | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |
| | Lolopinyi | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |
| Maerua sp. | Lamalogi | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 99% |
| Solanum sp | Lekuru | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| Acacia nilotica | Lkiloriti | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| | Lmelikori | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| | Lmenangi | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| | Lolpiyaiyo | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| | Loneneni | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| | Longorno | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| | Mgongo | | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| Sericocompsis sp. | Ntorokwan | tree | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| Urtica massaica | Sapai | herb | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 100% |

| Botanical Name | Vernacular Name | Plant type | Firewood | Wild food | Medicine | Fodder /vet | poles & posts | weapons | rope | charcoal | timber | other wood | honey | thatch | other gen | Total | Cumulative % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Euphorbia candalabrum | Sirai | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| Viscum tuberculatum | Naldanyai | parasitic | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| Carex sp/ Kyllinga sp. | Loperiai | sedge | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 3% | 0% | 100% |
| | Lmonguntan | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| Achyranthes aspera/ Dicliptera laxata/ Dicliptera maculata/D rymaria cordata/ Hypoestis verticillaris/ Isoglossa gregorii/ Justicia exiqua/ Justicia extensa/ Justicia striata/ Oldenlandia sp | Segeet | herb | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| Loranthus sp | Lotunenei | herb | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| Acacia nubica | Ndepe | tree | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% |
| | | | **100%** | **100%** | **99%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | |
| **Total count of use** | | | **1092** | **553** | **509** | **245** | **317** | **158** | **178** | **58** | **19** | **60** | **10** | **134** | **31** | **3364** | |
| **Total number of plants (named in vernacular)** | | | **15** | **18** | **36** | **11** | **2** | **9** | **8** | **5** | **1** | **10** | **3** | **5** | **7** | **71** | |

# APPENDIX 3

**Questionnaires and forms for baseline and multiround surveys**

**SAMPLE BASELINE QUESTIONNAIRE**

## BASIC HOUSEHOLD INFORMATION

Household No: __________ Date:__________________
Interviewer: ______________ Interpreter:____________________
Rank: ____________ Village/Group Ranch: ___________

---

**RESPONDENT:**

Gender M / F Approx Age: _____Tribe: _______________

How long here?

Original home:

Position in household:

HEAD OF HOUSEHOLD

*(If not the above)*: Gender M / F Approx Age: ____ Tribe: ___________

*IF MALE*, Does he live and work here? Y / N Comment..

*IF FEMALE*, Is she: Married Widowed Divorced Unmarried Co-wife

OTHERS LIVING IN THE HOUSEHOLD:

Gender M / F Age: ___ Gender M / F Age ____
Gender M / F Age: ___ Gender M / F Age ____
Gender M / F Age: ___ Gender M / F Age ____
Gender M / F Age: ___ Gender M / F Age ____
Gender M / F Age: ___ Gender M / F Age ____

Any family members employed elsewhere? Y / N As what?

---

## SHAMBA

Do you cultivate land? Y / N *If yes*, for how long?: _______

Area under cultivation:___________ Owned Communal

Area under fodder:______________ Owned Communal

Non relatives hired to work on farm?

Household No:__________

Crops for home consumption:
1. ______________________
2. ______________________
3. ______________________
4. ______________________

Any of these also sold: 1 2 3 4

Crops grown for sale:
1. ______________________
2. ______________________
3. ___________________
4. ______________________

How long does your harvest last *(month it runs out)*?: Crop | month

What do you do when it runs out?
(Probe for possible sources of income/protein, ie hunting etc)

---

## LIVESTOCK

CATTLE Y / N
Milk for Sale Y / N
Do you have enough milk for home consumption? All year / Wet season only/Other....
No of milk cows (*Ngiteng na lepo*): _____ No of calves (*Lachau*): _____
No of unmilked cows (*Ngiteng nime lepo*): ____ No of heifers (*Nauwa*): _____
Breeds: LOCAL ______CROSS______GRADE______

CATTLE (*Ngishu*) Sale Y / N
*If yes:* Where sold?
When did you last sell a cattle (*Ngishu*)? : Why?
When did you last buy a cattle (*Ngishu*)?:
Sale of hides / other products?
No of Castrated bulls (*Lmongo*): No of uncastrated bulls (*Laigoni*):
Breeds: LOCAL ______CROSS______GRADE______

Household No:___________

GOATS/SHEEP Y / N Number: G_____ ; S_____

Sale of shoats: Y / N

*If yes*: Where sold?

Sale of hides / other products?

When did you last sell a shoat? Why?

CHICKENS Y / N Number

*If yes*: Eggs for home consumption / sale HC / S

Meat for home consumption / sale HC / S

OTHER ANIMALS:

---

**FUEL NEEDS**

FIRE WOOD:

How often do you collect fire wood (No of headloads per week)?:

How many people go from H/H?:

Where do you collect fire wood? Farm Communal forest Govt forest Other .....

*(Probe for forest if necessary)*

Is there enough dry wood available in these forests?

How is the situation compared with the past?

How far into the forest do you have to go to collect firewood?

(Forest edge / Up to 100m / Up to 0.5km / Up to 1km / Up to 2km / More than 2 km)

Do people sometimes cut live wood to supply firewood?

What proportion of your fire wood is collected from Govt forest?:

(None / Quarter / Half / Three-quarters / All)

What proportion of your fire wood is collected from Communal forest?:

(None / Quarter / Half / Three-quarters / All)

Do you buy fire wood? Y / N From who?

Suspected source of bought wood:

No of head loads per week/month (specify)

Do you sell fire wood? Y / N When?

Where?

No of head loads per week/month (specify)

Household No:___________

Preferred species for fire wood:
Source of preferred species?
Main species used now? As Above / Other.....
*If different from above*, why?

CHARCOAL: Y / N
*If yes*:
Bought? Y / N Where does it come from?
How often *(No of debes/sacks etc)*?
Home-made? Y / N From where?
Sale? Y / N Where?
How much?
Preferred species for charcoal?
Main species used now? As Above / Other.....
*If different from above,* why?

Do other people make charcoal in the forests? Y / N
How often do they burn? *(eg every week / every 2 weeks / once a month)*
Do they need to get authorization? Y / N From who?
Do they get authorization? Y / N

---

**<u>HOME TIMBER NEEDS</u>**

No of structures:___________

Walls: Cement Brick Mud Wood Other
Roof: Mabate Thatch Bark Iron Other
*For mud/wood buildings:*
When was this house built:
Preferred species for walls:
Species used:
*(Rank if more than one used)* Young tree / Mature tree
Live / Dead standing / Dead fallen
Source:

Household No:___________

Preferred species for roofing timber:
This house? - Species used
*(Rank as above)* Young tree / Mature tree
Live / Dead standing / Dead fallen
Source:

Do you need to get authorization for building posts? Y / N
*If yes:* From who? Did you?

*Where roofing is cedar bark*:
Source: Govt forest / Communal forest
Preferred tree type *(rank)*: Young tree / Mature tree
Live / Dead standing / Dead fallen
No of trees needed for this roof:
Frequency of replacing roofing:

FENCING Y / N
When was fence built?
Preferred species for fencing:
Timber for this fence? - Species
Timber/posts/branches?
Young tree / Mature tree
Live / Dead standing / Dead fallen
Source:
Frequency of replacement:
Do you need to get authorization? Y / N From who?
Did you? Y / N

Household No: _

## COMMERCIAL INDIGENOUS TIMBER USE

Do people come from outside the Group ranch to take indigenous timber or posts from forest? Y / N

Which forest: Govt / Communal

Which species?

Live / Dead standing / Dead fallen

Who? *(ie from where? form of transport? independent individuals/companies?)*

Do they take cut timber /posts?

Is it for sale / home use *(rank if both)*

Where sold?

Do they need to get authorization? Y / N From who?

Do they get authorization? Y / N

Do you extract timber from natural forest for sale? Y / N

Species:

Preferred timber *(rank)*: Young tree / Mature tree
Live / Dead standing / Dead fallen

Source:

Where sold?

Do you need to get authorization? Y / N From who?

Do you get authorization?

---

## MEDICINES

Are there any herbalists living around here who go to the forest to collect plants for medicine?

Last year which type of medicines did you use more: bought / forest?

Why?

## INCOME

*To follow questions on forest use*

What are your main sources of income?
1.____________________
2. _________________________
3. _________________________
4. _________________________

Household No:___________

## OTHER USE OF FOREST AND FOREST PRODUCTS

*Ask respondent to select cards showing any use made by him/her or anyone else in household*

| D A Y S | Use | When/how often/why (dry/wet season; G/C)............................. | HC/ S | | Species | G / C *Rank if both* | | Rank im | in |
|---|---|---|---|---|---|---|---|---|---|
| | Wild foods | dry/wet | H | S | | G | C | | |
| | Wild honey | when | H | S | | G | C | | |
| | Honey hives | when, how many etc | H | S | | G | C | | |
| | Fishing | when | H | S | | G | C | | |
| | Fire wood | already covered | H | S | | G | C | | |
| | Hunting | when, how | H | S | | G | C | | |
| | Charcoal | already covered | H | S | | G | C | | |
| | Medicine - hu | | H | S | | G | C | | |
| | Medicine -ls | | H | S | | G | C | | |
| | Grazing cattle | when - govt/comm, freq | | | | G | C | | |
| | Grazing shoat | when - govt/comm, freq | | | | G | C | | |
| | Cultural | when | H | S | | G | C | | |
| | Fodder | when - govt/comm,freq | H | S | | G | C | | |
| | Water | when - govt/comm, freq | | | | G | C | | |
| | Timber | covered | H | S | | G | C | | |
| | Poles & posts | when | H | S | | G | C | | |
| | Rope | when | H | S | | G | C | | |
| | Hhold tools | when, what | H | S | | G | C | | |
| | Mats/basket | when, what | H | S | | G | C | | |
| | Sand/minerals | when | H | S | | G | C | | |
| | Carving | when, what | H | S | | G | C | | |
| | Thatch | when | H | S | | G | C | | |
| | Weapons | what | H | S | | G | C | | |

How long does it take to walk from here to the edge of the Comm forest ............../ Govt Forest...........?

*For cattle and shoat grazing put freq and timing of use of Comm forest in first column and Govt forest in main column and of Communal forest in Species column*

**SAMPL LIVESTOCK SURVEY FORM**

**HH Number______________.**

| | | | | |
|---|---|---|---|---|
| **Cattle** | Number staying around manyatta | | | |
| | Number staying elsewhere | | | |
| | Number sold since last survey | | Why sold? | |
| | Number bought since last survey | | | |
| | Number died by disease since last survey | | | |
| | Number slaughtered since last survey | | | |
| | Number in milk | | | |
| | | | | |
| **Shoats** | Number staying around Manyatta | | | |
| | Number staying elsewhere | | | |
| | Number sold since last survey | | Why sold? | |
| | Number bought since last survey | | | |
| | Number died by disease since last survey | | | |
| | Number slaughtered since last survey | | | |
| | Number in milk | | | |

**SAMPLE MULTIROND WILD RESOURCE USE SUREY**

Household No:______

*Ask respondent to select cards showing any use made by him/her or anyone else in household*

| Date | Use Category | Species | Veg. type | HC/ S | | Source | c/g | m/f |
|---|---|---|---|---|---|---|---|---|
| | | | | H | S | | | |
| | | | | H | S | | | |
| | | | | H | S | | | |
| | | | | H | S | | | |
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| | | | | H | S | | | |

# Appendix 4. Summary of GLIM4 analysis

### *Why GLIM?*

GLIM4 was used to carry out multiple analysis of variance, analysis of co-variance and multiple regression on data from the baseline survey and the plant size distribution data. Conventional statistical packages which carry out these parametric tests assume that the independent variable is normally distributed. In the case of the livestock holdings data and the plant size distribution data, however, they were highly skewed to the left, approximating a Poisson or log-linear distribution.

Poisson data can be transformed to approximate a normal linear distribution by log-transformation. However, this operation has the effect of reducing the error variance, thereby increasing the probability of rejecting a null-hypothesis incorrectly. GLIM4 uses a maximum likelihood model which estimates the best fit of the transformed data without changing the distribution of the error function (Crawley 1993). The distribution of the data is defined by the "link function" which links the original error distribution with the transformed data. Data which has a Poisson distribution is defined by a "log link".

Transforming the data allows a linear model to be applied, whereby the transformed response variable is the linear sum of the effects of one or more explanatory variables and factors. The fit of the model is determined by comparing the predicted values with the transformed values of the response variable, y. The error variance, however, is calculated by comparing the original untransformed data with the fitted value, where the fitted value is calculated by applying the inverse of the link function to the value predicted by the linear model.

The advantages of GLIM for these analyses were, therefore, threefold:

1. it allows both continuous and nominal independent variables to be tested within the same analysis;
2. it allows the use of powerful parametric statistical tests on data which is not normally distributed by transforming the data without altering the error distribution of the original data; and
3. it allows rigorous simplification of complexes of multiple interacting factors to identify which among the many possible determinants are the ones which best define the distribution of the data (Crawley, 1993).

An excellent description of GLIM4, its approach and use in analysis of ecological data is given in Crawley (1993).

### *Overdispersion*

Where count data fit a Poisson distribution exactly, the mean is equal to the variance which is equal to unity. Thus, the error sum of squares should be equal to the degrees of freedom. In ecological data the error variance is often greater than unity due to overdispersion (usually a sign that not all explanatory variables are available). Overdispersion increases the error sum of squares, since the probability of an event occurring is random. This can result in explanatory variables having a significant effect on the model incorrectly. When the error variance is much greater than the degrees of freedom, scaling down the sample sizes has the effect of increasing the standard errors (since standard errors are proportional to $1/\sqrt{n}$) and reducing the risk of rejecting a null hypothesis incorrectly (Crawley 1993). This procedure was necessary with all analyses of both livestock and plant size distribution data.

# APPENDIX 5

**A sample of the pictures of resource use categories used in the course of both the baseline and multi-round surveys**


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