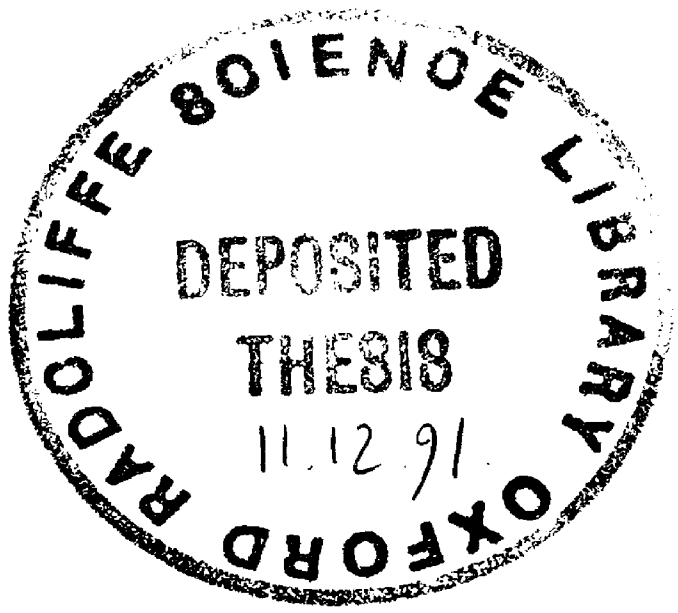
The Impact of Capital and Labour Availability on Smallholder Tree Growing in Kenya

A thesis submitted to the University of Oxford in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Peter Allen Dewees
St.John's College
Trinity Term
1991



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Abstract

Smallholder tree cultivation and management is a common form of land-use in high potential areas of Kenya. Some practices, such as the planting of trees on field boundaries are strongly rooted in customary notions of land and tree tenure. Others, such as the planting of black wattle (Acacia mearnsii) woodlots, are more recent innovations, introduced to produce commodities for domestic and export markets. This thesis explores the historic, cultural, and economic dimensions of tree growing in Kenya, using archival and ethnographic data, land-use surveys, and results from a survey of 123 households in the upper coffee/lower tea zone of Murang'a District.

The household survey was designed to explore the hypothesis that tree growing complements formal employment as a strategy for overcoming poorly operating factor markets and helps to ease land-use constraints imposed by labour migration. Tree planting is favored because of its low capital and recurrent costs and when farmers are unable to plant other more resource-intensive crops. The survey focused on households which currently maintain a black wattle woodlot and on households which operate parcels which were used for growing black wattle in 1967, but which have since been cleared and are being used for growing something else.

The survey showed that woodlot growing households operate larger parcels, are older, support fewer residents, and have more non-resident relatives than other households in the survey. Woodlot growing parcels are also at a lower altitude and are more steeply sloping than other parcels. Patterns of resource allocation suggest that woodlot growing households are more risk averse.

Logistic regression (logit) modeling explored causal relationships, suggesting woodlots are indeed more likely to be established as households age and as labour becomes scarce, and that woodlot clearance takes place when labour is more available to cultivate the holding.

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P.A.Dewees
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Introduction

Particularly since the early 1970s, enormous financial resources have been directed toward encouraging smallholders to grow trees on their farms in sub-Saharan Africa. The rationale has often been linked to a view that tree planting would reduce rapidly-increasing woodfuel scarcities. A widely-cited World Bank study, for instance, suggested that tree planting activities in Africa would have to increase *15-fold* in order to meet projected year 2000 demands for woodfuel.[1] It is also commonly argued that trees should be an integral feature of agricultural production systems, and that they can do much to increase the stability and sustainability of these systems by improving soil fertility and by providing fodder and food.

For the planner or development practitioner who must make the decision to direct limited financial and technical resources toward particular sectors, these types of arguments in favor of tree planting make good sense. From the perspective of the farmer who is expected to use his land, labour, and capital to plant trees, however, such views of the economic rationality of tree growing are seldom explicitly shared.

The underlying assumption amongst planners is that farmers are not already planting trees on their holdings or that they are somehow constrained from doing so and require external technical advice and inputs in order to encourage them to

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1. D.Anderson and R.Fishwick (1984). *Fuelwood Consumption and Deforestation in African Countries* (Staff Working Paper No.704). Washington, D.C., World Bank.

adopt these practices. Such a fallacy has ensured that aid resources continue to flow to the sector, often propping up overstaffed and underemployed agricultural or forestry extension organizations, and supporting the production of millions of tree seedlings for the benefit of those few who are able to collect and transport them from 'official' nurseries.

In Kenya for instance, a 1983 policy statement mandated the production of 200 million tree seedlings a year. This target was subsequently incorporated into the National 1984-88 Development Plan.[1] Even if unit costs for seedlings were kept low, the total cost of such an undertaking would have been enormous, particularly in the absence of any special understanding about *why* farmers should consider planting all these trees in the first place.

One would suspect that farmers in high potential areas of Kenya would at first have been confused (and then perhaps amused) by these targets. The fact is that farmers have long planted trees on their farms, often in substantial numbers and covering large areas. Indeed, the cultivation and management of trees on smallholdings is a common form of land-use in many areas of Kenya. In some regions, it has become a major feature. In others, it has assumed a peripheral or even a negligible role.

While it is often argued that population growth and agricultural intensification are incompatible with the conservation and management of tree cover, data from Kenya suggests that this is not always the case. Even in the most heavily populated areas, trees continue to be an important feature of land-use. There is also an evident *transition* in the type of tree cover which predominates as population pressures increase. Natural forest and bushland is cleared as

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1. B.Wamagunda (1988). "Effective forestry extension in support of agroforestry development," in: A.M.Kilewe, K.M.Kealey, and K.K.Kebaara (eds). (1988). *Agroforestry Development in Kenya* (Proceedings of the Second Kenya National Seminar on Agroforestry, 7-16 November, 1988). Nairobi, International Council for Research in Agroforestry. pp.147-153.

agricultural development is intensified, but replanting follows, apparently using trees which are much more productive than the forests and bush they replaced. Many farmers keep as much as 20 percent of their smallholdings under tree cover, a large proportion of this area being accounted for by planted and managed trees. Recent land-use inventories in a number of districts have indeed provided convincing evidence that trees have become an integral feature of agricultural land-use -- even in the absence of effective public sector or NGO forestry extension interventions. The results from these land-use inventories are reviewed in Chapter 1, making the case that trees are indeed an important form of land-use in Kenya.

Once this has been established, the obvious question which follows is *why* trees are so common in farming areas and why farmers have undertaken these practices. Robust markets for tree products -- such as construction poles, wattle bark (for tanning extracts), fence posts, fuelwood and charcoal -- provide some incentives for growing trees. Other land-use practices however, particularly the cultivation of more lucrative cash crops such as coffee and tea, yield much higher returns to land. Because of this, markets for tree-based products, by themselves, fail to explain the widespread interest of farmers in growing trees.

This dissertation puts forth two sets of arguments about why tree growing is such a common type of land-use in Kenya. The first set of arguments is largely based on history, culture and tradition and is tested and developed by examining the history of land and tree tenure from the pre-Colonial through the post-Independence period. The second suggests that tree growing may be an outcome when smallholders have encountered some fundamental problems in allocating labour, land and capital resources. The argument is tested in part by examining the history and development of one particular practice -- the growing of woodlots of Acacia mearnsii (black wattle) on smallholdings in Murang'a District of Kenya --

as well as by developing economic data and land-use information collected during household surveys. This dissertation, then, focuses on both the historic roots of tree growing, as well as on its economic dimensions at the household level.

The 'historic' argument is basically that tree cultivation and management by smallholders is not a new practice, but has long been a fundamental feature of farming systems in Kenya. To make this point, several of the more common contemporary tree growing practices are traced back to their origins in traditional systems of land tenure. Changing patterns of land tenure, and the wholesale reservation of large stands of forest by the Colonial Administration strengthened certain household tree planting practices, but jeopardized other widespread traditional common property forest management and reservation practices.

The 'economic' argument seeks to go beyond the role of markets, by themselves, as an incentive for smallholder tree growing and deals more broadly with trees vis-a-vis other household resource allocation opportunities. Preliminary interviews with farmers in Western Kenya suggested that tree growing might be linked to problems of labour supply. They also suggested that some of the widely held perceptions of the smallholder economy were entirely wrong. It is generally argued that there are serious problems of unemployment in Kenya, and that with a population growing at a rate of nearly 4 percent in some areas, these problems will become much worse. Farmers in Western Kenya however indicated that labour supplies were greatly *constrained* and were *constraining* their ability to use their land more productively. Tree growing was seen as a labour-conserving means of alleviating these constraints.

Particularly amongst resource-poor families, some households have the added problem of capital availability. While many types of land-use can be lucrative, some farmers are excluded from these opportunities because they are

unable to raise the required capital to invest and are unable to cover the high recurrent costs which are necessary to get the highest returns on their investment.

One outcome of these types of problems with the rural economy is the predominance of labour migration. Migration in search of wage employment in urban areas or in plantation agriculture is an attractive alternative for households with limited access to capital or to farm labour. This further complicates the labour supply picture, but provides important sources of off-farm capital for on-farm investment.

Tree growing may be an attractive land-use to those households which have problems of either capital or labour availability. Trees require low levels of capital to establish and maintain and can produce income for households which might otherwise be excluded from growing cash crops because of a lack of access to investment capital. Because labour inputs for trees are also low, they may be maintained or adopted by households which find they lack the labour power to cultivate more intensive crops.

This dissertation explores the historic dimensions of tree growing and examines the relationship between tree growing and labour and capital availability by testing the hypotheses that:

-- several contemporary tree cultivation and management practices are rooted in customary notions of land and tree tenure;

-- tree growing, as a labour conserving land use, complements formal employment as a strategy for overcoming malfunctioning factor markets and helps to ease land-use constraints imposed by labour migration; and that

-- tree growing as a land-use which requires low capital investment and recurrent costs is pursued where malfunctioning factor markets have made it problematic for farmers to plant other more capital-intensive crops.

Three types of information have been collected and form the basis for analysis and discussion. *Descriptive information*, particularly the historic record, has been used to describe the long role of trees on farms, the evolution of labour markets and land tenure systems and their impact on tree growing. *Land-use*

inventories have been used to characterize the extent to which particular tree growing strategies and other land-use practices have been adopted or maintained. *Household surveys* have been used to explore the current role of trees in the rural economy. It should be stressed at the outset that this dissertation is a multi-disciplinary effort. While there is a strong emphasis on the economics of tree growing vis-a-vis other land use choices, this thesis also reflects the view that the dynamics of land-use change can be better understood if they are placed within broader cultural and historic contexts.

Chapter 1 describes the extent of tree growing and other land-use practices on small farms in Kenya and in the study area, Murang'a District, in the Central Highlands. Chapter 2 explores how tree growing may be related to problems of labour and capital supply, and discusses the development of labour and land-use strategies in the Kikuyu agricultural economy. Chapter 3 describes the process of land-use change in Murang'a and its relationship to changing systems of land tenure from the pre-Colonial through the post-Independence period. Chapter 4 describes contemporary tree cultivation and management strategies in Murang'a District and discusses their origins and relationship to land tenure and labour use.

Chapters 5 through 8 describe a household survey and land-use study which was undertaken in the upper coffee/lower tea zone of Murang'a District and which specifically examined tree growing and resource allocation processes. Chapter 5 describes the survey design and method. Chapters 6, 7 and 8 present descriptive statistics which summarize some of the key features of the household survey.

Chapter 9 presents the results of several econometric exercises based on the results from the household survey. The chapter concludes with a brief discussion of the policy implications of this research.

As with many theses, the Appendices comprise material of peripheral importance -- not necessary for sustaining the arguments made here, but in many respects necessary background material. Appendix 1 discusses changing views of the 'woodfuel crisis' and how planners have responded to it. Appendices 2, 3 and 4 provide additional information about survey design and data analysis. Appendix 5 presents material about exports and producer and export prices for coffee, tea and wattle bark. Appendix 6 describes customary tree cultivation and management practices amongst the Kikuyu. Appendix 7 is a glossary of Kikuyu words used in this thesis. Appendix 8 discusses charcoal markets and pricing. Appendix 9 describes source material used in archival research.

Chapter 1. Tree Growing on Small Farms in Kenya

Simple observation in many high potential agricultural areas of Kenya informs the casual observer that trees -- protected, cultivated and managed trees -- have assumed an important place as one of many smallholder land-use options. It is not as if farmers have nothing else to do with their land. In high potential areas, trees are cultivated and managed in preference to cash crops like coffee and tea, which could generate far higher levels of income. The use of high quality land for tree growing poses some interesting problems for conventional views of peasant agriculture.

The rural afforestation efforts of government, aid agencies and local organizations in Kenya have seldom taken account of the extent of existing tree growing activities. Even when they have, project design and implementation has been hampered by a lack of information about why farmers have undertaken these types of activities on their own.

The Extent of Smallholder Tree Growing

Important gains in improving an understanding about the role of trees on farms in Kenya have been made with the collection of inventory information about trees in smallholder agriculture. Table 1.1 summarizes the results of a series of land-use studies carried out by the Ministry of Energy and Regional Development for three districts, showing the extent of tree protection, cultivation and management. These land-use studies, typically of areas with high population densities and heavy intensities of agricultural land-use show that planted and

Table 1.1: AGRICULTURAL LAND COVERED WITH TREES AND OTHER WOODY BIOMASS IN KAKAMEGA, KISII, AND MURANG'A DISTRICTS OF KENYA

	Area by District (in km²), and percent of agricultural land under woody biomass					
	Kakamega		Kisii		Murang'a	
Type of land-use	Area	%	Area	%	Area	%
Hedges	59.7	2.3%	118.8	6.2%	12.1	0.7%
Woodlots	70.3	2.8%	76.6	4.0%	66.1	3.7%
Windrows	33.6	1.3%	12.8	0.7%	8.7	0.5%
Bush	181.4	7.1%	90.6	4.7%	110.2	6.1%
Riparian woodland	90.4	3.5%	30.1	1.6%	56.0	3.1%
Trees in croplands	33.8	1.3%	22.6	1.2%	45.1	2.5%
Trees in grasslands	17.6	0.7%	3.1	0.2%	35.8	2.0%
Trees around the house	22.2	0.9%	4.3	0.2%	14.4	0.8%
Trees along paths	4.7	0.2%	2.2	0.1%	6.9	0.4%
Trees in bush/open woodland	43.2	1.7%	24.8	1.3%	21.3	1.2%
Total woody biomass area	556.9	21.9%	385.9	20.0%	376.6	20.8%
Total agricultural area	2548		1925		1808	
Total rural area	3111		2152		2216	
Total land area	3495		2196		2476	
1979 population density (people per km²)	294		395		261	

Source: KWDP Inventory (1985). Unpublished inventory data collected by Ecosystems Limited (Nairobi) for the Kenya Woodfuel Development Programme of the Beijer Institute and made available for further analysis.

managed trees and shrubs usually cover between 5 and 10 percent of the area of agricultural land. On average, over 20 percent of the total land area has been used for growing trees, or has otherwise been left under natural woody cover.

Although planted tree species are predominantly introduced varieties, such as Grevillea robusta, Eucalyptus sp. or Acacia mearnsii, a number of indigenous species such as Markhamia sp., Croton sp., and Sesbania sesban also feature in farmers' range of choices. Species and planting configurations are often inter-dependent. For example, in Kakamega District, Eucalpytus (and in Murang'a District, Acacia mearnsii) is almost always found planted in woodlots. These contiguous, non-linear, and usually monospecific tree management units may be extremely small, with 10 trees or so, but are more commonly around 200 m² in area.

Hedges -- contiguous, linear, and also usually monospecific tree management units -- are frequently composed of Cupressus lusitanica. They are usually planted in the first instance, but as they grow to maturity, may come to include other

species established as a result of natural regeneration. Finally, in some areas, although there is little completely untouched woodland remaining, there are large areas of natural vegetation which have been highly modified, for instance in bush/fallow systems.

The importance of tree cultivation and management as part of the farming system becomes somewhat clearer when other agricultural land-uses are considered. Table 1.2 summarizes the results of a land-use inventory for Murang'a District which shows the extent of tree protection, cultivation, and management vis-a-vis other land-uses. Although the predominance of particular crops in this district is mostly limited by characteristics of the agroclimate, the predominance of trees does not seem to be so constrained. While smallholder coffee, for instance, accounts for anywhere between 0.1 and 13 percent of the land area depending on the agro-ecological zone, woody cover (planted trees, woodlands, bushland and so on) accounts for at least 15 percent and as much as 35 percent of the total agricultural land area across all zones.

Some features of land-use described in Table 1.2 challenge certain tenets of orthodoxy. It is often argued that, in the face of growing demands for agricultural land in areas of heavy population pressure, forests are cut down, trees are depleted, soils are destroyed, and the unavoidable cycle of environmental destruction, culminating in widespread famine, is precipitated. While large areas of forests have been cleared to make way for agricultural expansion in Kenya, farmers *do* cultivate and manage trees around their farms and in their fields, thus contradicting the conventional view that they are environmentally irresponsible. Indeed, the particular care with which farmers plant and manage trees around their farms suggests that they are quite familiar with the management of their local environment.

Table 1.2: LAND USES IN MURANG'A DISTRICT

	Agroecological Zone						
	Forest/ Upper Tea Zone	Lower Tea/ Upper Coffee Zone	Lower Coffee/ Maize Zone	Middle Maize/ Estate Zone	Lower Maize Zone	New Settle- ment Zone	District Averages & Totals
Average population density per grouping (persons per km^2)	31	346	399	85	131	104	245
Average elevation (metres)	2371	1859	1502	1395	1314	1180	1685
Type of land-use	Percentages of Total Land Area Supporting each Land-Use						
Smallholder Agriculture							
Maize and maize intercrops	3.4	15.1	28.5	11.2	18.0	16.8	16.9
Smallholder coffee	0.7	11.4	13.0	0.8	0.4	0.1	7.2
Smallholder tea	2.4	12.6	0.0	0.0	0.0	0.0	3.9
Plantation Agriculture							
Sisal	0.0	0.0	2.3	5.2	2.8	7.4	2.1
Pineapple	0.0	0.1	1.4	5.2	0.0	0.0	1.2
Estate coffee	0.0	0.3	4.9	4.7	3.8	0.0	2.5
Hedges and Windrows							
Natural tree hedges	0.0	0.2	0.2	0.0	0.1	0.3	0.1
Clipped hedges	0.1	0.3	0.6	0.1	0.2	0.1	0.3
Other hedges	0.1	0.6	0.5	0.3	0.4	0.4	0.4
Planted windrows	0.1	0.5	0.4	0.1	0.0	0.1	0.3
Subtotal, HEDGES AND WINDROWS	0.3	1.6	1.7	0.5	0.7	0.9	1.2
Scattered and Isolated Tree Cover							
Fruit trees	0.0	0.0	0.6	0.2	0.1	0.0	0.2
Trees in crops	0.3	1.9	2.6	1.0	1.5	1.3	1.6
Trees around buildings	0.0	0.5	0.9	0.1	0.2	0.2	0.5
Trees in bush	0.5	0.4	1.0	1.7	3.1	1.8	1.0
Trees in open grassland	0.9	0.9	1.1	3.1	3.7	3.4	1.6
Trees in hedgerows	0.0	0.1	0.3	0.0	0.1	0.1	0.1
Subtotal, SCATTERED AND ISOLATED TREES	1.8	3.8	6.4	6.2	8.7	6.8	5.1
Orchards and Woodlots							
Orchards	0.0	0.1	0.1	0.1	0.6	1.0	0.2
Woodlots	0.8	5.9	0.9	0.1	0.0	0.0	2.1
Subtotal, ORCHARDS AND WOODLOTS	0.8	6.0	1.1	0.2	0.6	1.1	2.2
INDIGENOUS TREE COVER							
Indigenous forest	30.9	2.7	0.2	1.4	0.0	0.2	5.7
Bush or woodland	2.5	3.7	4.7	7.6	11.3	7.9	5.2
Riparian strips	2.0	1.3	2.8	3.4	7.6	3.3	2.8
Subtotal, INDIGENOUS TREE COVER	35.4	7.7	7.7	12.4	19.0	11.4	13.6
Total, PLANTED OR CULTIVATED TREES	2.9	11.4	9.2	6.8	10.0	8.8	8.5
Total, INDIGENOUS TREE COVER	35.4	7.7	7.7	12.4	19.0	11.4	13.6
Total, ALL WOODY COVER	38.3	19.1	16.9	19.2	29.0	20.2	22.1

Source: KWDP Inventory (1985).

The Rationale for Tree Planting

A number of relatively straightforward conclusions can be drawn about different tree growing strategies. It can be assumed, for instance, that farmers have planted eucalyptus woodlots in response to growing demands for construction poles.

Black wattle woodlots likely indicate that there are markets for wattle bark, charcoal and fuelwood, in addition to household demands for woodfuel.

Other tree cultivation practices, however, have little directly to do with these types of market opportunities. The predominance of hedges and windrows, for instance, is largely accounted for by extra-economic considerations, such as the need for boundary markers. Tree planting practices such as the intercropping of Sesbania sesban with maize are undertaken as part of soil improvement and management strategies. Shade trees are also highly valued.

But if the extent of *income-generating* tree planting practices is considered, the argument that they evolved as a result of "market forces" is unconvincing. There remains the question of why resource-constrained farmers are using their land for the cultivation and management of trees instead of other crops. A hectare of maize, for instance, can generate between 2 and 4 times as much income as an intensively managed 1-ha woodlot. Coffee can generate around twice as much income as maize, and tea, twice again as much.[1] Maintaining land under tree cover in the face of these alternative income-generating strategies seems something of a contradiction.

This is little more than an observation. There have been few efforts which have attempted to closely assess the impact of tree growing on the smallholder economy. Some research has focussed on social constraints, such as gender restrictions, to the growing of trees.[2] Ongugo's study in South Nyanza examined resource allocation processes and the cultivation of tobacco, maize and fuelwood and concluded that capital availability placed the greatest constraints on

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1. World Bank (1986). *Kenya: Agricultural Inputs Survey* (Volume II). Washington, D.C., World Bank. p.74.

2. N.Chavangi (1987). "Agroforestry potentials and land tenure issues in western Kenya," in: J.B.Raintree (ed.) (1987). *Land, Trees and Tenure.* (Proceedings of an International Workshop on Tenure Issues in Agroforestry). Nairobi and Madison, International Council for Research in Agroforestry and the Land Tenure Centre. pp.193-200.

smallholders' production processes, while labour was more freely available.[1] Lubega's study of the economics of agroforestry systems in dryland areas of Machakos District explored the potential economic impacts of alley cropping on maize production.[2]

Both Ongugo and Lubega analysed their data using linear programming. The first study used data collected during extensive field surveys and from interviews with farmers who were growing tobacco, fuelwood, and maize. The second used information collected in part from household interviews, but was largely based on experimental data generated on a field station, rather than on-farm. These studies are the only empirical studies of the economics of tree growing on farms in Kenya.

The Study Area

The area selected for study, Murang'a District in Central Province of Kenya (Figure 1.1), is in many ways typical of the tropical highlands of East Africa. Soils in the high potential zones are deep and well-watered. Rainfall is bimodal with peaks in April and November, and totals between 900 and 2600 mm per year. The terrain is broken by an extensive system of ridges and valleys, running from east to west. The district is around 2,500 km^2 in area, and rises from the lowlands close to the town of Thika in the east, an altitude of around 1,000 metres above sea level, to the Aberdare Mountains reaching nearly 4,000 metres above sea level in the west. Population densities are closely correlated with agricultural potential, reaching very high levels in the middle zones of the district between 1,500 and 2,000 metres above sea level. Population densities range from around 50 persons

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1. P.O.Ongugo (1985). *Optimization of Fuelwood Production for Rural Development with Special Reference to Tobacco Growing Farmers (South Nyanza, Kenya)* (Unpublished MSc thesis). Helsinki, University of Helsinki.

2. A.M.Lubega (1987). *Economic Feasibility of Rural Projects in Semi-Arid Areas of Development Countries: A Case Study of Agroforestry in Kenya* (Unpublished PhD dissertation). Syracuse New York), State University of New York.

per km² in the low potential areas to over 800 people per km² in the areas of highest agricultural potential. Murang'a Town, the principal town in the District, is around 80 km by tarmac road from Nairobi.

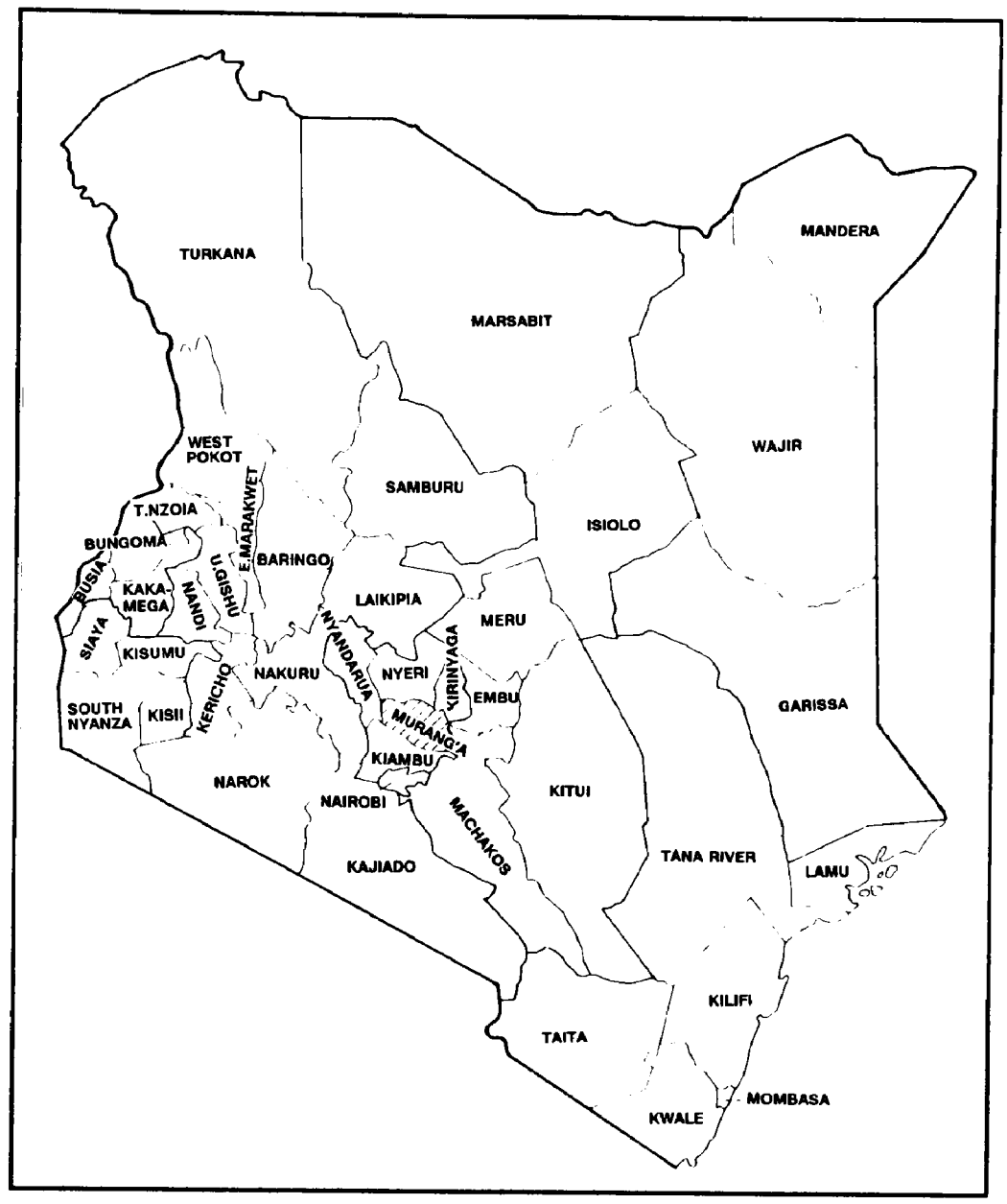


Figure 1.1: Administrative Divisions and the Location of the Study Area in Kenya

The main smallholder subsistence crops are maize and beans which are often intercropped with other crops such as bananas, sweet potatoes, English potatoes, yams, cassava, and arrowroot. In the upper zones, it becomes too cold and wet for maize and beans, and potatoes are the dominant food crop in unprotected areas. In lowland areas, dryland crops such as pigeon peas and cassava predominate. Figure 1.2 shows the principal agroecological zones in the district.

The principal smallholder cash crops are coffee and tea. These were introduced in the late 1950s and early 1960s during a period of rapid agricultural intensification around the time of Independence. Over half of Kenya's tea production is produced by smallholders; 20 percent of this comes from Murang'a District alone (totalling around 80,000 tons of green leaf annually). Processing and marketting is handled by local buying centres and factories which are managed on

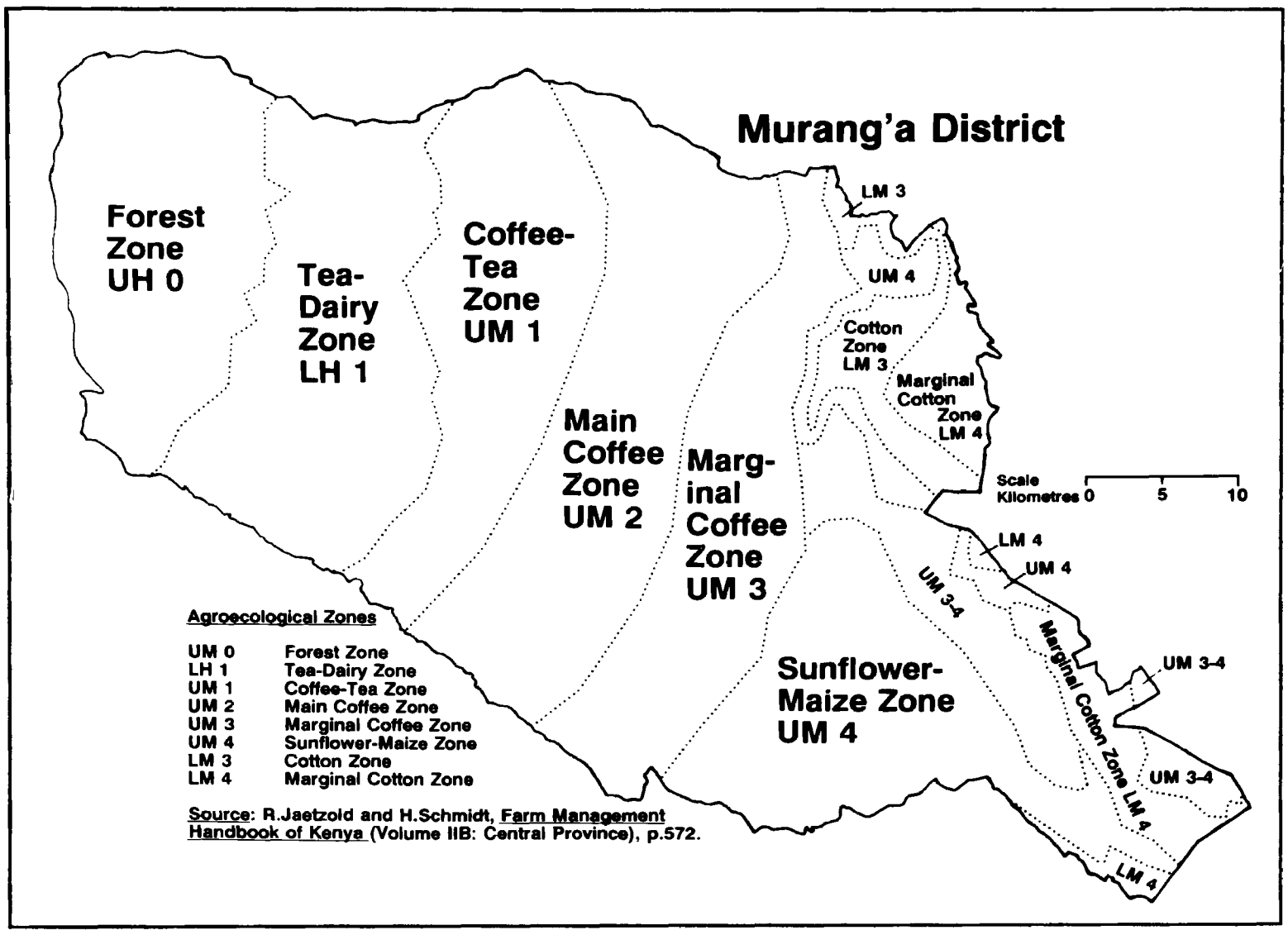


Figure 1.2: Principal Agroecological Zones, Murang'a District

a cooperative basis. The cooperatives are an extremely important source of short-term credit, providing inputs such as fertilizer and pesticides, against future crop payments. Tea predominates as a cash crop in the upper zones, while coffee is most commonly found in the middle zones. There are around 10,000 ha of smallholder tea and around 20,000 ha of smallholder coffee in the District.

Land-use inventory data was used to construct the maps in Figure 1.3, Figure 1.4, and Figure 1.5.[1] Figure 1.3 shows the extent of maize and maize intercrops in the district. Figure 1.4 and Figure 1.5 show the distribution of smallholder coffee and smallholder tea, respectively, in the district. Inventory data was calculated in terms of the number of hectares of a particular land-use per km^2.

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1. Inventory data was collected by EcoSystems, Limited (Nairobi) for the Kenya Woodfuel Development Programme of the Beijer Institute, in 1985. Raw data was made available to the Oxford Forestry Institute for further analysis and for the construction of land-use maps. Inventory data is referred to elsewhere in this thesis as, KWDP Inventory (1985).

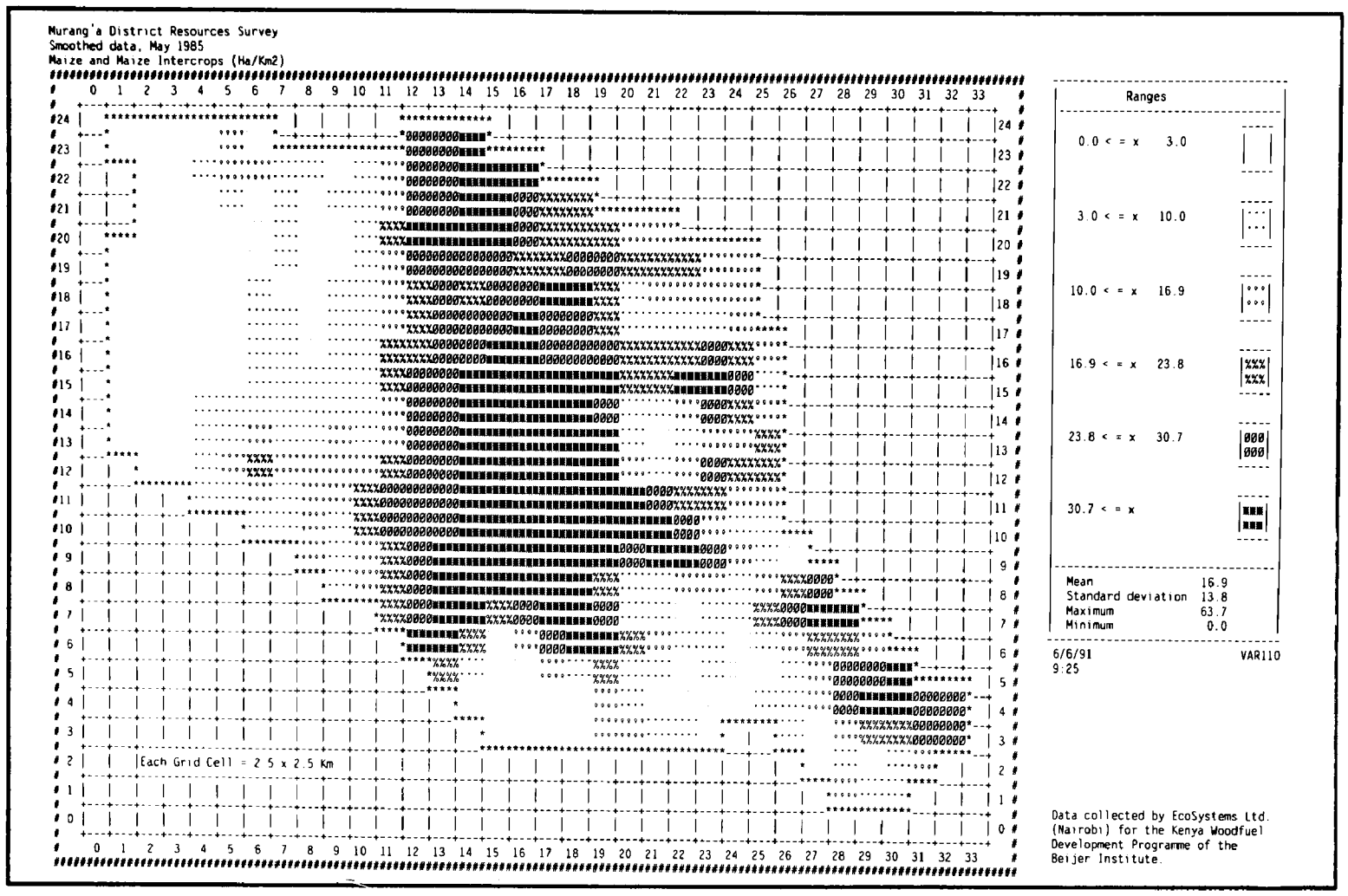


Figure 1.3: Distribution of Maize and its Intercrops, Murang'a District

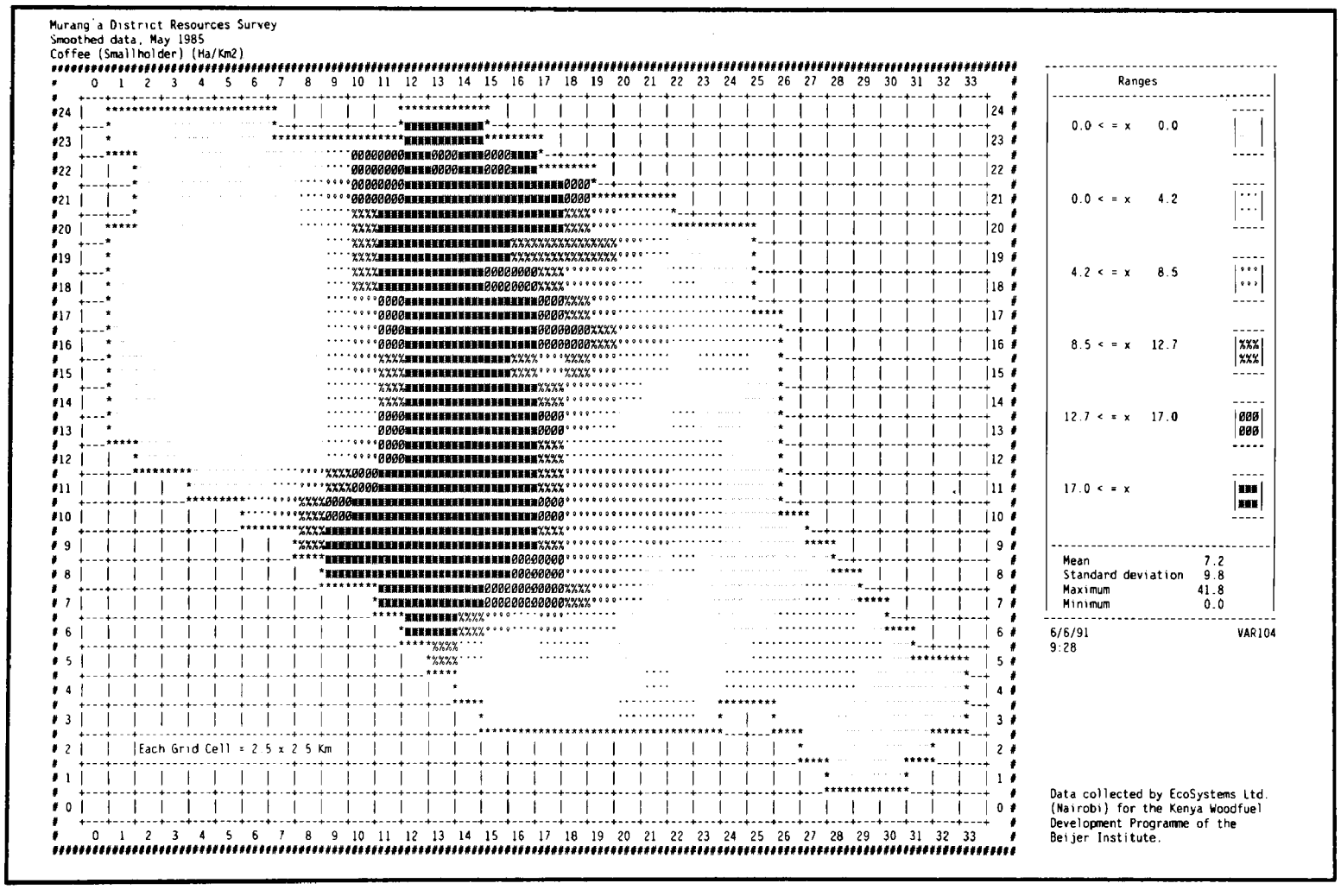


Figure 1.4: Distribution of Smallholder Coffee, Murang'a District

This is equivalent to the percentage of land under each particular land-use, and these are the units which were used to define the shading in the maps.

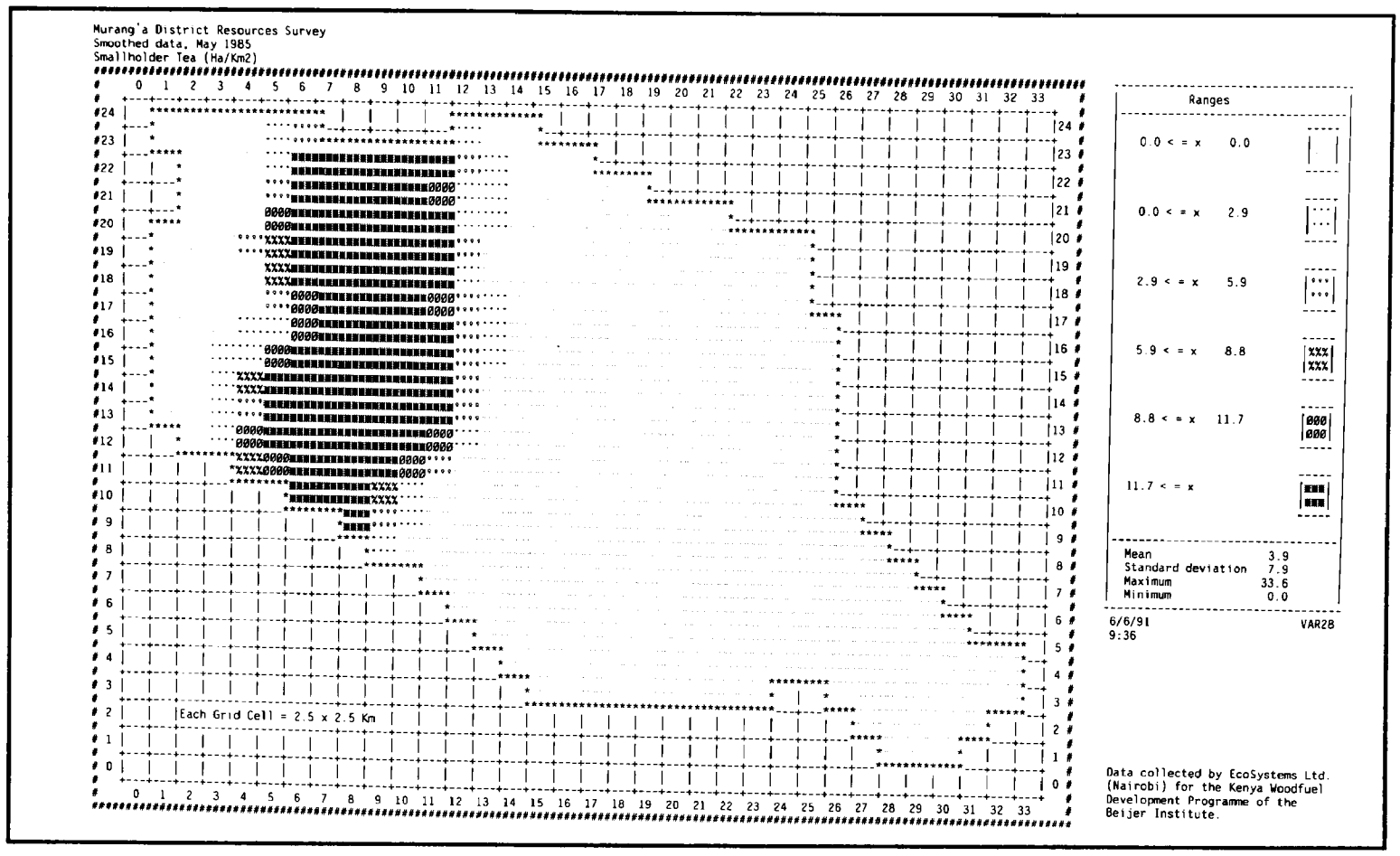


Figure 1.5: Distribution of Smallholder Tea, Murang'a District

Important sources of local employment are coffee, sisal and pineapple plantations in the lower zones of the District. These are variously owned by cooperatives, by individuals, and by companies, and comprise around 15,000 ha.

With a number of exceptions, most of the land in the district is privately owned. Murang'a District is the area of longest settlement for the Kikuyu and in many respects is viewed as the Kikuyu homeland. A complex system of customary land tenure was superseded by a system of private tenure in the early 1960s. Tenure to a relatively small portion of the District is held by the County Council and by the Government as Forest Reserves and as part of a National Park.

Selection of Tree Cultivation and Management Practices

Types of woody cover

There is a range of on-farm tree cultivation and management strategies in Murang'a District.[1] The extent of some of these land-uses is summarized in

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1. In addition to the typologies discussed here, see also the typologies in, J.B.H.Kuyper and P.N.Bradley (1985). *Woodfuel and Agroforestry in Kisii District* (mimeo). Nairobi, Beijer Institute. p.15.

Table 1.2. Trees and woody cover comprise:

-- Windrows. Rows of trees one or more stems deep, usually planted as one species, but sometimes planted with multiple species.

-- Hedges. Rows of shrubs which function as fences or which mark farm boundaries. Also usually planted with one species, but sometimes planted with multiple species. Sometimes they are managed for multiple outputs.

-- Orchards. Fruit trees planted at regular intervals in fields.

-- Woodlots. Groups of trees planted in close stands, usually of the same species, as small as 0.1 ha but sometimes as large as 10 ha.

-- Other trees in fields.

-- Trees around houses. Individual trees or small groups of trees planted close to houses.

-- Natural vegetation. Riparian woodland, closed forest, fallow bush, trees in grassland, and so on. Trees not closely integrated with the farming system.

Although these typologies suggest there are discrete patterns of tree planting and management, in practice, there is a considerable amount of overlap between land-use strategies: windrows may function as hedges; orchards may be interplanted with other trees; trees around the house may be planted and managed as small woodlots, and so on.

Woodlots occupy the largest area of land of any particular type of on-farm tree cultivation and management practice. By comparison, other practices, such as the planting of trees on boundaries, are widespread, but in aggregate, occupy relatively small areas. Woodlots, however, occupy a considerable land area in some parts of the district, comprising as much as 30 percent of some holdings in the upper coffee/lower tea zone.

One of the arguments in favor of the adoption of many tree planting practices (such as the planting of scattered trees in fields and on field boundaries) is that they do not compete with crops or with other land-uses. Woodlots, however, are quite different. They often occupy considerable areas of land which could be used for many other crops.

One of the objectives of this research is to explore how patterns of household resource allocation are different when land is used for tree planting. When trees are consciously planted and managed on discrete blocks of land, the potential for competition between land-uses becomes greater, and observable changes in patterns of resource-use become clearer. Consequently, much of this research has focussed specifically on the role of woodlots in the rural economy. In fact, woodlots are not a new agricultural innovation in Murang'a District and have a long and interesting history.[1]

The extent of woodlots in Murang'a District

Earlier land-use studies suggested that the area of woodlots in Murang'a was substantial. In 1985, the Kenya Rangeland Ecological Monitoring Unit (KREMU) estimated that there were over 20,000 ha of woodlots in Murang'a.[2] The estimate was unrealistically high, and was probably accounted for by sampling errors. Inventory data developed by the Kenya Woodfuel Development Programme in 1985 (referred to in Table 1.2) placed the estimate at between 5,500 ha and 6,610 ha.[3]

Neither study disaggregated the types of woodlots by species. The four dominant woodlot species are Acacia mearnsii (Black Wattle), Eucalyptus saligna, E.grandis, and Grevillea robusta. Of these, A.mearnsii is by far the most dominant. Grevillea is found primarily in the middle and lower zones, and Eucalyptus is, by comparison, relatively uncommon in all zones. Based on the frequency with which other woodlots were encountered during fieldwork, it is estimated that between 80 and 90 percent of the woodlots in the district are of A.mearnsii.

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1. See for instance, M.P.Cowen (1978). *Capital and Household Production: The Case of Wattle in Kenya's Central Province, 1903-1964.* (unpublished PhD dissertation). Cambridge, University of Cambridge.

2. C.H.K.Muchoki (1985). *Land Use in Murang'a District* (Technical Report No.120). Nairobi, Kenya Rangeland Ecological Monitoring Unit. p.11.

3. KWDP Inventory (1985).

The KWDP area estimate is consistent with earlier estimates of the area under wattle. The last comprehensive inventory of wattle, carried out in 1969, indicated that there were around 12,950 ha of wattle woodlots in the district.[1] Considering that much of this has been cleared and is now planted under tea and other crops, and that other species of woodlots comprise relatively small areas, the area currently under wattle must be close to the KWDP estimate of between 5,000 and 6,000 ha.

The heaviest woodlot coverage is found in the middle and upper zones of Murang'a District. Using inventory data collected in 1985, a map showing woodlot distribution has been generated and is shown in Figure 1.6. Comparing this map with the land-use maps in Figure 1.3, Figure 1.4 and Figure 1.5, woodlots are found to be most common in areas where smallholder tea and coffee predominate.

This distribution of land-uses through Murang'a indeed poses a number of interesting questions about the rationale for the large-scale planting of trees by smallholders in these zones. Wattle accounts for substantial areas of the district -- areas which could be made much more productive if land was used for cash crops such as coffee and tea. What specific features of the household economy have accounted for the interest of smallholders in tree growing? How do these smallholders differ from others in patterns of labour allocation, land holding, and capital use?

Relationships between tree growing and smallholder resource allocation processes are central to this study. Cultural bases for these processes continue to have a particularly strong hold over the rural economy. Chapter 2 examines the development of labour and capital markets in Murang'a, with a particularly strong

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1. Department of Agriculture (1969). *Fort Hall District Annual Report*. Nairobi, Department of Agriculture (Republic of Kenya). This inventory estimated that there were around 10,000 growers of wattle bark in Murang'a.

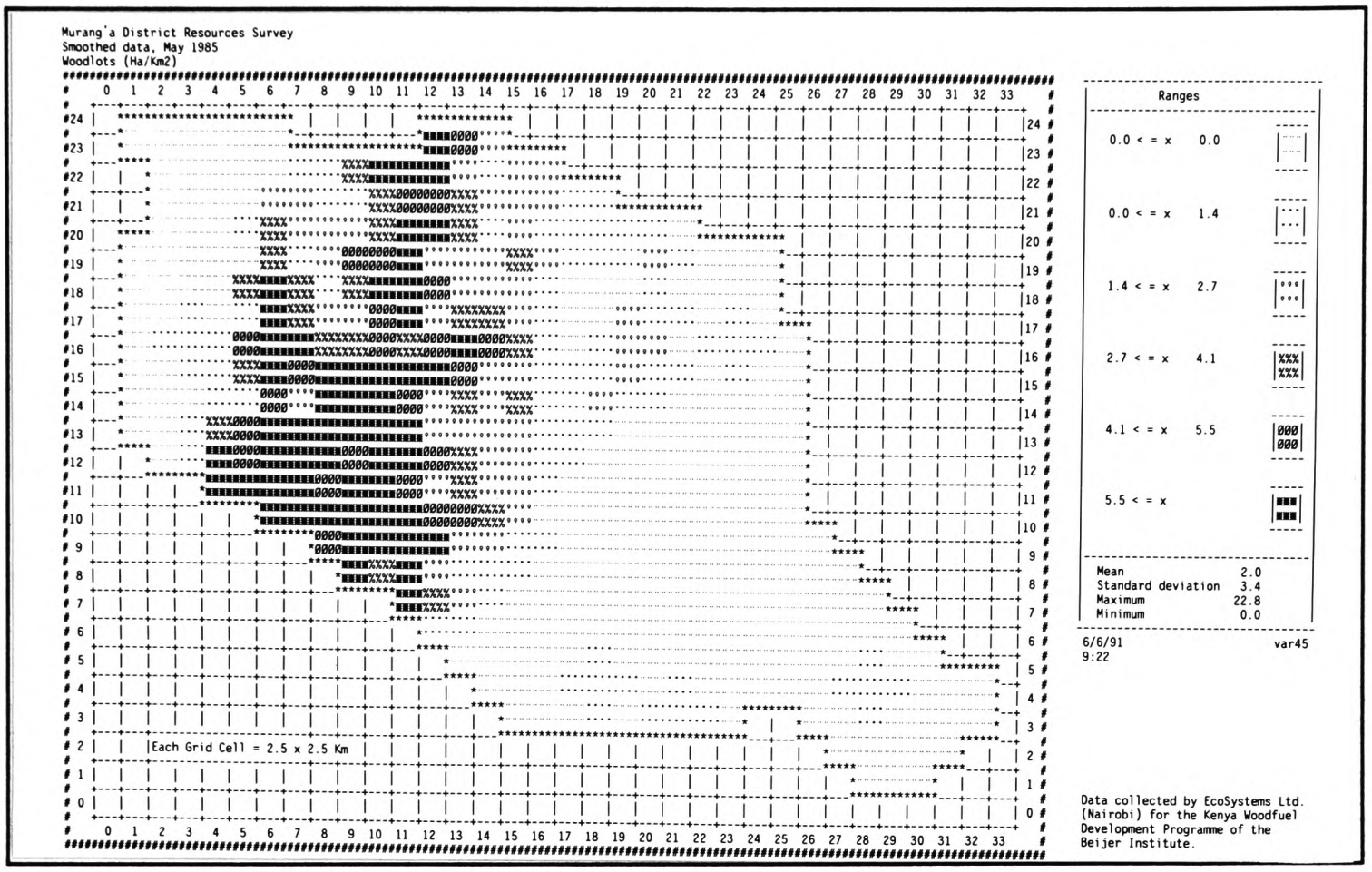


Figure 1.6: Distribution of Smallholder Woodlots, Murang'a District

emphasis on how labour and capital allocation processes evolved from the pre-Colonial through the post-Independence period. The objective is partly to identify how long-term structural problems have affected the supply of rural labour and continue to affect the agricultural economy. Labour and capital allocation processes are in many ways related to questions about the use of and access to land. Chapter 3 describes how systems of land tenure in Kikuyu areas of Kenya developed and evolved over the same period.

The objective in presenting material in Chapters 2 and 3 is to provide a longer term view of the rural economy by describing the processes which affected how patterns of labour, land and capital allocation emerged. While neither of these chapters address the question of tree growing on smallholdings in much detail, the background they provide is essential for understanding how several tree cultivation and management practices assumed such a dominant role in the rural economy during the Colonial period, and following Independence.

Chapter 2. Dynamics of Rural Capital and Labour Supply

A number of features of the rural economy are of particular relevance with regard to farmer tree growing. These are related primarily to the development of labour, capital and land-use strategies within the Kikuyu agricultural economy. This and subsequent chapters are intended to make the case that some of the more common tree planting practices -- particularly boundary plantings and the establishment of woodlots -- are partly an outcome of long-term historical processes and are closely related to customary systems of land tenure and to patterns of smallholder labour organization.

Labour-use in Smallholder Agriculture

Labour transactions in the traditional economy

Labour transactions in the pre-Colonial Kikuyu economy were largely a function of kinship ties and responsibilities within the *mbari* (sub-clan).[1] One of the chief obligations of a man to his wife (or wives) was to provide her with fields for cultivation, which meant he had the task of clearing the bush and of hoeing it with the *mũnyago* (digging stick) to make it ready for the harrow.[2] Subsequent cultivation and harvesting responsibilities rested with the man's wife, but if it was needed, particularly during times of illness or incapacitation, additional labour

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1. A glossary of the Kikuyu words used in this thesis is included in Appendix 7. The *mũhĩrĩga* (clan) was the largest form of political organization. There were nine clans, each descended from one of the nine daughters of the ancestral parents of the Kikuyu. The *mbari*, or sub-clan, was a more important unit of social organization. Members of the *mbari* lived for the most part on their own land unit.

2. L.S.B.Leakey (1977). *The Southern Kikuyu before 1903*. London, Academic Press. p.863.



Figure 2.1: Senior and Junior Warrior Grades (Murang'a District, 1903)

could be drawn from the man's other wives. She would be expected to give assistance in return when it was needed and when she was able.[1] Communal *ngwatio* labour was organized if a household had insufficient labour to carry out an agricultural task. *Ngwatio* groups of 3 to 10 women, not necessarily related, would work from day to day on each others plots.[2] Contemporary derivatives of *ngwatio* continue to be widely practiced.

The only system which bore any resemblance to wage labour *per se* was the *wĩra* work party. When labour was needed to complete a large task, such as digging or weeding, as many as 80 people would be enlisted for assistance by the individual concerned. He or she was obligated to provide beer, at least, and often provided food as well.[3]

Significant changes in labour-use were brought about in Kikuyu areas between 1900 and 1910 as the boundaries of the forest were fixed by the Colonial Administration and as the pace of the alienation of lands for European settlement accelerated. It wasn't so much that the Kikuyu *lost* land (although they clearly had), but that the process of alienation effectively limited further expansion through forest clearance. In many areas, the man's labour task of land clearance and

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1. *Ibid.*, p.865.

2. M.P.Cowen and F.Murage (undated). *Notes on Agricultural Wage Labour In Kenya Locations*. Nairobi, Institute for Development Studies (University of Nairobi). p.39.

3. *Ibid.*, p.39ff.

hoeing was no longer as significant as it had been simply because expansion had been stopped. These limits clearly disrupted traditional agricultural practices. The chief forest offenses registered by the Forest Department in 1909 were for "making new gardens and enlarging old ones" in the newly reserved forests.[1]

The coming of the European basically put an end to the otherwise frequent conflicts with the Maasai and made the warrior age-grades redundant. One of the impacts of this change was that young men who would have formerly become warriors were no longer clearly needed, and formed a new group with no clear task in the social structure.

The emergence of the migrant and wage labour economy

The migrant labour economy developed subsequent to these events. The first "hut taxes"[2] and the later Poll Tax[3] were partly intended to coerce Africans, who would not otherwise have sought wage employment, to find jobs working in plantation agriculture or in urban areas in order to enable them to pay their taxes.[4] The movement to European plantations and urban areas was largely because opportunities for wage employment in smallholder agriculture were nearly non-existent at the time. The rapidly-expanding white settler economy was vitally dependent on these labour supplies for agricultural expansion and development.

The development of wage labour markets to meet labour demands in smallholder agriculture dates from 1910 to 1920. Mission schools tended to produce educated Africans who became traders, teachers and artisans. This class

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1. FD 1909/10, p.8.

2. *East Africa Hut Tax Ordinance*, 1903.

3. *Native Hut and Poll Tax Ordinance*, 1910.

4. G.Kitching (1980). *Class and Economic Change in Kenya*. New Haven, Yale University Press. p.153; R.M.A.van Zwanenberg (1975). *Colonial Capitalism and Labour in Kenya 1919-1939*. Nairobi, East African Literature Bureau. pp.76-103; S.Stichter (1982). *Migrant Labour in Kenya: Capitalism and African Response, 1895-1975*. Harlow (Essex), Longman. pp.34-35.

of peasant elite introduced crops such as English potatoes and wheat which were far more labour-intensive than traditional maize, millet, and bean crops. At the same time, they were involved in managing their businesses and other concerns and were less able to spend time working on the farm.

Amongst these households then, household labour was not fully able to meet the growing demands for labour imposed by new crops. *Ngwatio* labour, which was normally only used infrequently and in times of dire need, was similarly inadequate. *Wĩra* work groups could no longer be easily convened because of the mission-educated elite's adopted strictures against beer drinking.

Labour markets developed primarily because existing forms of labour organization -- household labour, *ngwatio*, and *wĩra* work parties -- were not sufficient for satisfying new agricultural labour demands. In the place of customary forms of labour use which relied on kinship ties and on community obligation, the peasant elite instead developed a reliance on wage labouring participants in the growing cash economy. Gender-specific patterns of labour use in the peasant economy were evident as well in these new labour markets. Men would be hired to carry out heavy digging and women would be paid for planting, weeding and harvesting. Consequently, demands for waged labour in the Reserves expanded greatly in the early 1930s; even then, plantation agriculture competed with smallholder agriculture for labour supplies. Both became more or less dependent on migrant labour to meet their growing demands.[1]

Labour migration and landlessness

The alienation of land for European settler agriculture, in addition to closing the frontier to further peasant agricultural expansion, dispossessed a large population of their land. Nearly 30,000 ha of high potential agricultural land in

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1. Cowen and Murage (undated). p.40 ff.

Kikuyu areas had been alienated for European cultivation by the mid-1930s. Advocates of European settlement argued that this land did not actually belong to the Kikuyu in the first place, but that they had replaced its earlier inhabitants, the Ndorobo, "by a process which consisted...partly of adoption and absorption, partly of payment, and largely of force and chicanery"[1] and that the rights of individual Kikuyu in these areas had never amounted to full ownership. Over a relatively short period of time, a large number of Africans found themselves living with no land use or tenancy rights.

Most were left with few options. The most likely option for many in this new class of landless was to "squat" on European farms. Reported as early as 1904, squatting allowed Africans to cultivate plots on European farms in exchange for a fixed amount of labour.[2]

Squatting was not dissimilar from the customary practice amongst the Kikuyu of land borrowing -- the *ahoi* system -- which allowed individuals to cultivate underutilized land in return for gifts to the person who held hereditary cultivation rights. Tenancy under the *ahoi* system was not definitely assured, as land could be redeemed by the original rightholder if it was needed. The process of European alienation, the closure of the forests to agricultural expansion, and consequent increasing land scarcity brought about the wholesale cancellation of many *ahoi* agreements and created a new landless class amongst the Kikuyu. Many former *ahoi* settled on European farms as squatters.

In 1918, the Administration introduced the Resident Native Labourers Ordinance which legislated that squatters had to be contracted as labourers,

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1. Government of the United Kingdom (1934b). *Kenya Land Commission: Summary of Conclusions Reached by His Majesty's Government*. Cmd.4580. p.93.

2. Government of the United Kingdom (1955). *East Africa Royal Commission, 1953-1955: Report*. Cmd.9475. p.163.

obligating them to provide 180 days of labour per year for a small wage and for the right to live and cultivate plots on European farms. Later changes prohibited squatters from keeping stock, limited cultivation to two acres per family, and increased the labour requirement to 270 days per year.[1]

A move to evict squatters from European farms, and to force them to the Reserves, gathered momentum in the mid-1940s as their numbers burgeoned. By then, most squatters had lost any cultivation rights they may have had as *ahoi* or as rightholders in the Reserves.[2] Their eviction from settler farms created a huge class of landless unemployed, and their absorption into the Reserves created enormous problems.

During the villagization programme of the Emergency and subsequently during the land consolidation process in the early 1960s it was assumed that the landless, or near landless, could provide wage employment for smallholder agriculture. The relationship between agricultural employee and employer had little traditional precedent in Kikuyu areas, although reciprocal labour arrangements were (and remain) relatively common; the very small formal labour markets in smallholder areas were clearly not able to absorb this new mass of the unemployed. The absence of this market, and the fact that the landless had formerly been employed in settler agriculture only reinforced the predominance of the migrant labour economy.

Even now, rural agriculture can support only a small wage labour market. Fewer than 10 percent of smallholder labour inputs are provided by hired labour.

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1. T.Kanogo (1987). *Squatters and the Roots of Mau Mau*. Nairobi, James Currey. p.97.

2. The squatter's position was made even more difficult by influential agriculturalists like Colin Maher who argued that squatters should not even be allowed to cultivate maize on European farms because it "provides unnecessary starchy food and little else." Maher (who in the same breath, concluded that "the African is unreliable, dilatory, and rarely understands the meaning of an honest day's work") was commenting on how squatter labour productivity could be increased by limiting time spent on subsistence crop production. C.Maher (1942). "African labour on the farm in Kenya Colony", *East African Agricultural Journal* (April). p.233.

Of these hired labourers, between 50 and 75 percent are landless or near-landless.[1] In a survey of labour requirements for the tea industry in Embu District for instance, over 90 percent of tea pluckers did not operate holdings of their own, but plucked tea primarily on holdings of relatives.[2]

Labour, crops and gender

Labour-use and cropping patterns were closely linked to culturally-defined norms of social responsibility. Land clearance and the first digging of the soil was the responsibility of a man to his wife. Most other labour tasks were the responsibility of women. Women's crops were generally labour intensive seasonal ones (*irio cia ĩmera* -- "sprouting foods") such as cereals and legumes, while men's crops were generally labour extensive perennial crops (*irio cia menja* -- "digging foods") such as yams, taro, cassava, and bananas. Men's crops were also more commonly used as famine foods.[3] This gender link with specific types of land-use has important implications for contemporary patterns of labour utilization, and may account in part for a predominance of subsistence crops in areas where male labour migration has skewed the labour supply.

Most of the Colonial Government's labour ordinances, and particularly the system of taxation, were gender-specific and resulted primarily in *male* labour migration. Much of the legislation was drafted under the assumption that there was idle male labour in the reserves though some conceded that the encouragement of African men to seek wage employment would pose serious problems for the women

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1. P.Collier and D.Lal (1986). *Labour and Poverty in Kenya, 1900-1980.* Oxford, Clarendon Press. p.121.

2. Technoserve, Inc. (1987). *Analysis of Tea Pluckers and Labour Requirements in the Smallholder Tea Sector* (mimeo). Nairobi, Technoserve. p.30.

3. J.M.Fisher (undated). *Reports on the Kikuyu.* (unpublished manuscript). See also KNA DC/FH3/1. p.183-184.

and children who remained by increasing their labour load.[1]



Figure 2.2: Women and Children Collecting Fuelwood from the Nyandarua Forests, around 1905

With the emergence and development of the market economy, and the relatively higher wages which could be earned in cities and on plantations, gender related patterns of labour-use and distribution became entrenched. In Murang'a District, the transition in gender-specific patterns of rural labour availability seems to have taken place between 1924 and 1948. The 1924 census for the district reported a ratio of women to men in the "working age range" of 0.89 to 1.[2] The 1948 census, however reported the ratio had increased to around 1.4 to 1.[3]

Labour migration, gender-specific patterns of labour availability, and strong crop/gender associations (i.e.women's crops were annual crops and men's crops were perennial crops and famine foods) meant that less labour was available for the cultivation of perennial crops because of male labour migration. Although black wattle had been introduced into Murang'a much earlier, the developing labour supply picture in the late 1920s did much to make it popular. Wattle was a perennial tree crop and it filled a particular niche: it required little labour and

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1. J.W.Arthur (1920). "Memorandum on labour circulars", in: Colony and Protectorate of Kenya (1920). *Despatch to the Governor of the East Africa Protectorate relating to Native Labour, and Papers connected therewith*. Nairobi, Government Printer.

2. KNA DC/FH6/1. *History of Fort Hall from 1898-1944.*

3. KNA DC/FH5/1. January 1950. Fort Hall District, Kenya. *A Preliminary Examination of Land and Population Problems.*

could be planted on holdings when men sought wage employment off the farm. It also filled the role of a perennial crop as a famine food as it could be harvested to generate income when it was needed most. Fisher noted that by the early 1950s, men were usually the ones who would make the decision to plant wattle on a holding, although women were in no way prevented or discouraged from doing so.[1] The wattle economy is discussed in greater detail in Chapter 4.

Labour migration in contemporary Kenya

Labour migration continues to be a dominant feature of the rural economy, even to the extent of placing heavy constraints on smallholder agriculture. The Integrated Rural Surveys (particularly IRS1) found that nationally, 20 percent of landowners of smallholdings both lived away from the holding and were not in charge of day-to-day decisions about its operation.[2] Men remain the main participants in the migrant labour economy. Interregional variations in the ratio of men to women of working age (between the ages of 20 and 40) indicate the extent to which migrant labour has become a feature of the rural economy.[3] For instance, in Siaya District, a heavily populated area of moderate agricultural potential, the 1979 census indicated that there were 1.84 times as many women in the "working age range" as men. By contrast, in Kericho District, an area dominated by large-scale tea plantations, there were around 0.90 times as many women as men in the same age range. In Murang'a, the ratio was 1.29 women per man in the working age range.

Even if men have chosen not to seek employment out of their area, they

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1. She also reported that men were usually responsible for felling wattle while women were responsible for stripping the bark, though it was not unusual to see women felling trees as well. Fisher (undated). pp.231 and 241.

2. Republic of Kenya (1977). *Integrated Rural Survey I, 1974-75.* Nairobi, Central Bureau of Statistics.

3. B.Wasow (1981). "The working age sex ratio and job search migration in Kenya", *Journal of Developing Areas*. 15:435-444.

may not be willing to work on their smallholding, preferring wage employment in local businesses or engagement in their consultative roles as elders in the community. In some areas, children, formerly an abundant source of labour, are not widely available to work on farms because they are in school.

One outcome of all this movement has been that it has contributed to the development of labour constraints in smallholder agriculture. The observation is hardly new. Clayton, in his analysis of the economics of the farm plans which were being introduced in high potential areas of Kenya following the land consolidation programme in the early 1960s, pointed out that even when land might be abundant, labour could be "... a critically restrictive factor, in a hand-labour farm economy, when it is associated with high labour-demanding cash crops."[1]

Where land endowments per household are large or where the family operates several parcels which are widely dispersed as a result of inheritance or purchase, the supervision of hired labour to farm the entire holding efficiently can be problematic. In these cases, the real cost of hired labour (because of its relative inefficiency due to a lack of supervision) may be so high as to encourage the development of labour-extensive types of cultivation.

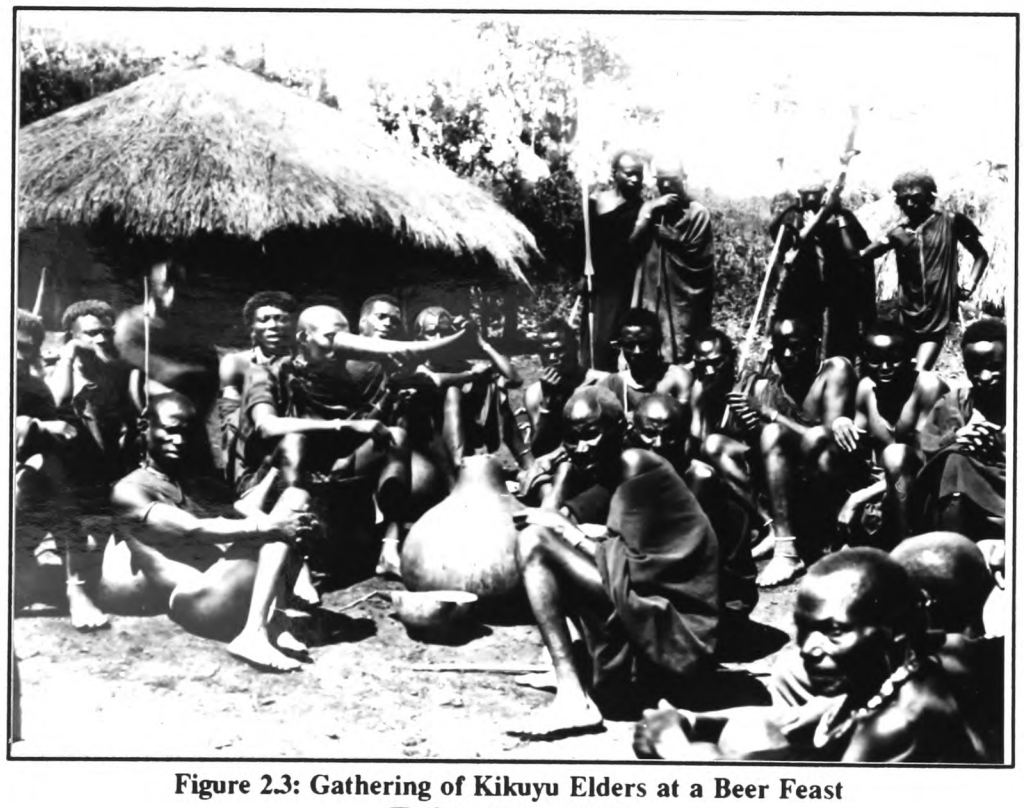


Figure 2.3: Gathering of Kikuyu Elders at a Beer Feast (Tuthu village, 1908)

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1. E.S.Clayton (1961). "Economic and technical optima in peasant agriculture", *Journal of Agricultural Economics*. 14(3):337-347.

Alternative labour strategies

In the face of these kinds of constraints, modified traditional labour-use strategies have emerged as mechanisms for dealing with seasonal shortages or for more effectively utilizing available resources. The participation of women in rural associations in Murang'a District has provided a number of important alternatives to the conventional approach toward labour utilization.[1] Women's collective participation in labour activities, similar to *ngwatio* labour, is undertaken for income generation, to provide labour during periods of peak demand, or to otherwise ease labour constraints. In Weithaga location for instance, women's associations work as groups in seasonal wage employment for, say, a morning a week -- weeding, mulching, picking coffee, or carrying out other tasks. Income from collective employment would be used to support the group's activities, or could be tapped through a revolving credit fund.[2] During illness, women's group members can be called on to work on the ill member's farm and could expect such support in return in the future if needed. This long tradition of mutual-aid is firmly rooted in traditional systems of labour organization.

Capital Transactions in Smallholder Agriculture

Traditional capital transactions

In pre-Colonial Kenya, capital accumulation primarily involved the accumulation of livestock. Cattle, sheep and goats were clearly important for their direct uses, such as for milk, meat and skins, but also had exchange value. Livestock could be exchanged for food crops, for land, for utilitarian objects such as spears, hoes, baskets, and shields, and formed the basis for bridewealth.[3]

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1. B.P.Thomas (1988). "Household strategies for adaptation and change: Participation in Kenyan rural women's associations", *Africa*. 58(4):401-421.

2. *Ibid.*, p.409.

3. See particularly the discussion in, Kitching (1980). p.200 ff.

Information about traditional credit arrangements amongst the Kikuyu is extremely sparse. Probably the most widespread arrangement involved the redeemable sale of land for the generation of capital. Redeemable land sales were initiated by the seller, and were generally undertaken to obtain livestock to pay bridewealth or to pay compensation for death or injury. The purchaser (*mūguri*; pl.*aguri*) of the land had full cultivation and building rights, in exchange for the agreed upon livestock. The seller's land would be returned on repayment of an equivalent number of livestock to the *mūguri* at either party's request.[1]

Informal credit arrangements

Until the mid-1950s, there were few formal mechanisms for channeling capital into the smallholder agricultural sector; informal credit mechanisms played an important role during this period. The 1950 *Report of Committee on Agricultural Credit for Africans*, recognized the growing need for an effective means of channeling capital into African areas, but argued that to do so to individual farmers would introduce the risk that they could become "hopelessly indebted."

> "(W)e must state emphatically the dangers inherent in any attempt to make credit available in an agricultural community at that stage of development which the African has reached today... We would be doing the country a permanent disservice were we to advocate the introduction of a widespread scheme of agricultural credit which would result in agriculturalists living permanently in advance of their income and under the continual fear of foreclosure."[2]

The introduction of any scheme of credit to individual African farmers would, at the time, have been particularly problematic. Land could only be taken as security in very limited cases where customary tenure rights were particularly secure, and instead, security had to be that of "personal character".

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1. A.J.F.Simmance (1961). "Land redemption among the Fort Hall Kikuyu", *Journal of African Law*. 5(2):75-81. If the purchaser did not cultivate the land in question, the original number of livestock *plus any natural increase* would be required for redemption. In practice, this seldom happened because if the seller discovered that the *mūguri* was not cultivating the land, he would quickly ask members of his *mbari* to redeem it in order to avoid having to pay the enormous natural interest which would accrue on the loan.

2. Colony and Protectorate of Kenya (1950). *Report of Committee on Agricultural Credit for Africans*. Nairobi, Government Printer. p.1.

Even had a mechanism existed for channeling capital to smallholder agriculture, controls and regulations had a dampening effect on individuals who might have wanted to do so. No debt, for instance, could be incurred by an African from a non-African in excess of £10 unless permission to become indebted had been granted by a Provincial or District Commissioner.[1]

These restrictions did not eliminate the demand for credit. Rather, they channeled demand into informal credit systems which flourished long after Independence. The widespread adoption of smallholder coffee, for instance, was financed for the most part by alternative capital generating strategies. In 1964, the Agriculture Department reported that there were more than 235,000 registered growers of coffee, accounting for around 50,000 ha. At the same time, however, only 8,000 publicly-financed small-scale loans had been granted. Even assuming that all these loans had supported coffee establishment, the total area of small-holder coffee established with credit was clearly quite small.[2]

A number of informal credit mechanisms developed in the absence of formal lending arrangements: kinship credit, merchant credit, moneylending, mutual savings societies, and the redeemable sale of crops or capital assets. Some of these mechanisms bore a resemblance to customary practices associated with obligations to kinship groups and clans. Others were relatively new innovations, introduced as response to changing economic conditions and to the emergence of the cash economy.

Kinship credit often takes the form of small loans which are made for farm purchases or for school fees or other expenses. There may be no implicit understanding that these loans must be paid back at some rate of interest or over

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1. Government of the United Kingdom (1955). pp.72 and 96.

2. J.D.Von Pischke (1977). *The Political Economy of Farm Credit in Kenya* (unpublished PhD dissertation). Glasgow, University of Glasgow. p.236.

a particular time period -- or at all -- but there is the understanding that the creditor may freely ask for a similar loan sometime in the future, in return.

Merchant credit is relatively common as well.[1] The amount of credit outstanding amongst surveyed shopkeepers in Nyeri and Machakos Districts was reported to be around 15 percent of average monthly sales. Moneylending by merchants and others, by comparison to other types of informal credit, appears to be relatively uncommon, and is largely limited to the Asian community.

Mutual savings and credit activities play an important role in some areas for generating investment capital. These activities are generally a feature of rural women's associations (although they may involve men as well) and may complement other group ventures such as communal labour activities.[2] Monthly contributions to the society would be pooled, and then given to a different member every month. In two locations of Murang'a District, around 50 such associations each raise and distribute around the equivalent of US$ 500 per year.[3] In aggregate, the sums become quite substantial.

Redeemable sales as credit

One type of informal credit is the redeemable sale of crops or other assets. Amongst its traditional antecedents was the practice of the redeemable land sale to a *mũguri*. Sales may be redeemable when the seller has the option of rendering the transaction reversible. The reversible aspect gives these transactions a

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1. M.E.Harper, *The Development of a Cost-Effective Extension Service for Small Business: A Kenya Experiment*, cited by, Von Pischke (1977). pp.224-225.

2. The operation of mutual savings societies has been widely reported. See for instance, B.P.Thomas (1985). *Politics, Participation and Poverty: development through self-help in Kenya*. Boulder (Colorado), Westview Press; B.P.Thomas (1988). "Household strategies for adaptation and change: Participation in Kenyan rural women's associations", *Africa*. 58(4):401-421.; Von Pischke (1977); K.Little (1973). *African Women in Towns*. London, Cambridge University Press; and, C.Geertz (1962). "The rotating credit association: a 'middle rung' in development", *Economic Development and Cultural Change*. 10(2):241-263.

3. 1990 dollars. Thomas (1988). pp.408-409.

"future" element, in addition to their "spot" characteristic.[1] These types of transactions appear to be relatively uncommon where marketing arrangements are well-established and where crop sales occur regularly, but appear with greater frequency for commodities which are irregularly sold.

Trees are sometimes sold under this type of arrangement. It has been reported in Murang'a District with regard to the sale of wattle trees.[2] A number of informants have confirmed that the practice is occasionally found amongst growers of wattle and eucalyptus. Under this type of arrangements, payment at current market prices would be advanced against standing trees when they were young, giving the buyer the right to harvest them whenever he wished -- usually 7 or 8 years later. The seller could buy back the standing trees at any time, at current market prices for an agreed upon product mix (in the case of wattle, for charcoal, bark, building poles, fence posts, or any combination).

Several entrepreneurs in Kiambu District have attempted to further refine this type of sale. A number of agreements have been made with wattle producers that they will continue to maintain their woodlots in exchange for agreed upon annual payments from the entrepreneurs. In most cases, annual payments have eliminated the redeemable feature of the sale. The entrepreneurs had hoped that higher charcoal prices would make their investment worthwhile. The outcome of their initiative is unclear.

When options for the development of formal credit mechanisms were being considered in the early 1950s, trees were recognized as a possible form of security against loans. Wattle bark prices reached historic highs between 1948 and 1952, prompting a local committee in Fort Hall (Murang'a) District to note that "in high

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1. Von Pischke (1977). p.220.

2. *Ibid.*

wattle areas a man's potential profit from the sale of his wattle bark could be considered to guarantee his loan."[1]

Formal credit mechanisms

Formal mechanisms for channeling credit to smallholders are a recent phenomenon in Kenya mostly dating from the mid- to late 1960s. While the expansion of smallholder coffee from the late 1950s was accomplished with limited access to formal credit, the expansion of smallholder tea until 1968 and the adoption of improved grades of dairy cattle was extensively supported by formal credit mechanisms.[2] Even in the absence of credit, self-financing capabilities appear to be quite high; the average number of new tea growers between 1970 and 1973 (after smallholder credit for tea expansion was abandoned) was twice what it had been between 1965 and 1967 when formal sectoral lending to smallholders was at a peak.[3]

The primary source of credit for smallholders is through agricultural marketing and processing cooperatives. Farmers are allowed to buy inputs against future sales of their crops to the cooperative. There are few mechanisms for channeling credit specifically to support labour activities.

Commercial lending for smallholder agriculture is at an historic low. The gap between the ceiling rates which commercial banks are allowed to charge for loans, and the rate at which they are able to obtain capital from the Central Bank has been steadily decreasing. This has caused a shift in most commercial banks'

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1. Colony and Protectorate of Kenya (1950). p.29. In a memorandum to the Committee, the Fort Hall District Commissioner F.A.Loyd noted that he had been advised by a committee of Africans in Fort Hall that livestock could also form an important form of security. Both of these suggestions were very likely derived from the established concept of the redeemable sale of land to *aguri*.

2. Von Pischke (1977). p.235.

3. Part of this was due to the change in tea planting practices between 1967 and 1970 from the more costly method of stump propagation to the relatively inexpensive method of vegetative propagation. It allowed farmers to plant far greater areas of tea with lower capital outlays.

lending portfolios away from agriculture and towards urban and industrial investment. Lending portfolios in agriculture have shifted away from smallholder agriculture in favor of larger-scale agro-industrial investments.

Smallholder Responses to Constrained Labour and Capital Supplies

Historical and cultural processes have greatly contributed to the evolution and functioning of labour and capital markets in Kenya. Current patterns of labour migration owe much to the institutionalization of labour and wage processes. Restrictive legislation against smallholder credit encouraged a strong reliance on derivatives of traditional credit mechanisms and on self-financing.

Where population pressures are low and labour is consequently relatively scarce, it could be expected that the production of crops which would benefit from mechanization, primarily food crops, would predominate. Similarly, smaller holdings would be used to specialize in labour-intensive crops which yield high returns -- predominantly cash crops. Commodity specialization in Kenya however is the reverse. Larger holdings are used primarily for growing labour-intensive cash crops, and smaller holdings are used for land-intensive food crops which yield low returns to both land and labour.[1]

Patterns of labour-use like these are in part a function of risk management. It is a risk averting strategy for the household to grow at least some food crops, since this eliminates exposure to the risk that cash crops will fail to generate enough income to purchase food crops. The combination of uncertain price and uncertain availability makes subsistence cultivation a rational choice for those with little land, even though it reduces returns to household labour. The other difficulty is that labour-intensive cash crops generally have long gestation periods. Coffee usually takes 4 years to yield, while tea is not fully mature for 11 years.

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1. Republic of Kenya (1977), cited by, Collier and Lal (1986). p.133.

Labour-intensive crops pose serious problems for smallholder cash flow because of this deferred consumption, as well as because of heavy investment and recurrent costs.

These types of constraints could partly be overcome if there were financial resources available for smallholders to expand their area under cultivation either through purchase or tenancy, if capital were available to hire additional labour, and if smallholder labour markets operated in a way which could allow households to specialize in labour-intensive crops. These types of allocation processes have been problematic in Kenya. Only around a tenth of smallholder labour inputs are supplied by the market, and the efficiency of hired labour compared with household labour is quite low. Tenancy and land sales are almost entirely absent; IRS1 indicated that the total area of rented smallholder farming land accounted for less than 1 percent of all smallholder farming land. Access to credit is restricted to a small minority of smallholders.[1]

This last point is of special significance. Credit is largely available only to higher income smallholders. The lack of access to smallholder credit accounts in part for the focus on food crop production on the smallest holdings: farmers are unable to afford the heavy investment costs in say, coffee or tea, much less the high recurrent costs for fertilizers and other inputs.

These problems with resource allocation processes have had the most profound impact on those with the most atypical land/labour ratios. As Collier and Lal suggest:

> "... The near-landless, poor through their limited land endowments, have their poverty compounded by atypically low returns to labour... (They) are caught between the contractual inefficiencies of factor markets and the low returns at the margin to cultivation of their own holdings... The alternatives to cultivating mainly food crops with a very high input of labour per hectare are low wages due to contract-dependent inefficiency labouring for other smallholders, low wages due to monopsony power labouring on the estates, low wages in the informal sector due to competition from the young dependents of employees in the formal sector, or migration to dry land

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1. *Ibid.* p.119.

> areas. It is of course because none of the alternatives are attractive that such smallholders decide to use their labour on their own holdings, and hence why such widely differing factor proportions are observed."[1]

This difficult situation can be overcome if there are alternatives to the prevailing pattern of land and labour use. One of the most attractive alternatives for those without access to credit or capital is urban wage employment. Because off-farm income is usually generated by household members who live elsewhere, and because of the inefficiency and difficulty of supervising hired labour to replace household labour, this strategy may be problematic because of the labour constraints it can introduce.

Tree Growing and Factor Markets

Given this background, several ideas about why farmers adopt different tree growing practices can be introduced. Tree cultivation and management requires far less labour than other types of crop production. Where there are markets for different types of tree products -- in Kenya these include building timbers, charcoal, bark (for tanning extracts), fence posts, pulpwood (for the paper mill at Webuye), and fuelwood -- returns to labour can be quite high. A Senior Agricultural Officer in Central Province noted, in the early 1940s, that the labour-extensive nature of black wattle largely accounted for its rapid adoption as a cash crop. People had found out that wattle trees

> "... grow quickly while they are sleeping, so that it is an easy way to get money. They plant the wattle, tend it for a year or so, then go away to Nairobi and find work for some years and know when they return that their 'bank' has grown to be worth many shillings without the owner doing much work."[2]

Early modelling of optimal resource allocation strategies in Central Province clearly indicated that labour constraints could have a significant impact on

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1. *Ibid.* p.255.

2. KNA AGR/4/343, 10 April 1941. *Wattle, General* 1937 to 1957. "Should Black Wattle Trees be grown in Kikuyu Country?" Drafted as an article by the Senior Agricultural Officer for Central Province, at the request of the Director of Agriculture, for publication in the swahili language newspaper, *Baraza*.

land-use.[1] More recently, Ongugo confirmed that tree growing would give relatively higher returns to labour than most other cash cropping activities,[2] and a number of other studies have suggested that tree growing in agroforestry systems could increase the household's returns to labour-use *even in the absence of markets for tree products.*[3]

Investments required for tree growing can be quite small, and primarily consist of labour for site preparation and planting. Seedlings can be grown by households in small, on-farm nurseries, for very low labour costs for seed collection and bed preparation. In Kisii District, it has been reported that most farmers plant trees every two or three years, and that 65 percent of their seedling stock comes from either their own tree nurseries or from their neighbor's. Another 10 percent of seedling stock is bought in local markets. The balance -- 25 percent -- is obtained from "official" Forest Department nurseries.[4]

Seedlings for cash crops such as tea or coffee can be quite costly and beyond the reach of the poorest farmers. In addition to sometimes large investment costs, there are usually heavy recurrent costs for fertilizers and fungicides for cash crops. While income from alternative investments may be much higher, cash constraints and the failure of rural credit markets virtually exclude poorer farmers from participation. To grow trees as a cash crop requires neither these heavy investment or recurrent costs.

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1. Clayton (1961). p.340 and p.345.

2. Ongugo (1985). p.i.

3. See particularly, World Bank (1988). *Kenya: Forestry Subsector Review*. Washington, D.C., World Bank. (Annex II, Appendix 4). The argument is that nitrogen fixation of trees like Sesbania sesban could increase yields of maize at a lower labour cost, giving higher returns to labour for food crops.

4. Kuyper and Bradley (1985). p.20.

Finally, trees can provide a flexible source of household income in the absence of alternative sources of capital because they can be harvested when they are most needed -- to provide school fees, dowry, to purchase food in times of scarcity, and for other basic needs. The timing of harvesting is quite flexible: when cash is most needed, when the markets are right, or when labour is freed up from other farming activities. For households which consume most of their marginal output, or which otherwise have too little capital to pursue alternative savings strategies, tree cultivation and management provides a sort of on-farm revolving savings/credit mechanism which can be withdrawn as capital is needed.

An understanding of these kinds of processes is extremely limited. Some theoretical work has been carried out on resource allocation processes amongst smallholder tree growers,[1] but there have been few empirical studies of factor relationships and tree growing.

Summary

Labour supply problems in smallholder agriculture in Kenya are a long-standing result of labour and taxation legislation and of policies which were developed to ensure an adequate supply of labour for plantation agriculture in pre-Independent Kenya. Entrenched patterns of labour migration, one outcome of these policies, have been gender specific and have limited the household's access to male farm labour. The problem of labour supply has been made more difficult because there have been few mechanisms for encouraging the development of labour markets for smallholder agriculture when household labour is inadequate.

Credit is constrained, and is primarily available for the application of farm inputs like fertilizers and fungicides, rather than for labour inputs. The absence

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1. See particularly, C.S.Binkley and J.Perez-Garcia (1988). *The Application of Household Production Models to Smallholder Forestry in Developing Countries* (discussion draft). Washington, D.C., World Bank.

of formal credit mechanisms has meant that smallholders have relied on informal mechanisms such as kinship credit, savings groups, and other strategies, to provide capital for on-farm investment.

The problem of access to capital, which could also be alleviated if family members seek wage employment in urban areas or on plantations, tends to exacerbate rather than to improve the smallholder labour supply situation. One outcome of this situation has been that labour extensive crops have been favored in some areas over more lucrative labour intensive crops. These include food crops such as maize and potatoes, but also perennial crops such as fodder grass.

Linked with this problem of labour supply are gender-specific patterns of labour use. Limited access to male farm labour may have resulted in the predominance in some areas of annual food crops, instead of perennial (and often cash) crops. Seasonal crops were traditionally women's crops while perennials were men's crops. Perennials had the characteristic of being labour extensive and were, typically, famine foods which were only harvested in times of need.

Black wattle first became popular as a smallholder tree crop in the late 1920s at a time when there were emerging labour supply problems in Murang'a. Wattle was favored as a cash crop particularly when male labour migrated elsewhere in search of wage employment. It filled a similar role as other perennial men's crops in that it took little labour to cultivate and had the characteristic of other famine foods in that it could be harvested to generate income when the household was most in need.

Compared with most other crops, the capital costs of wattle woodlot establishment are also quite low. Household labour can be used to prepare a new woodlot site. Establishment practices vary, but largely consist of burning old wattle branches on the new woodlot site, causing prolific seeding and regeneration. The

application of costly inputs to wattle is virtually unheard of.

When households have capital and labour supply constraints then, wattle may have advantages over other crops and land-uses. Tree growing, however, requires land. As with labour and capital allocation processes, land-uses in Murang'a have changed quite considerably over time. Chapter 3 considers how land tenure and land-uses have developed and evolved over time.

Chapter 3. The Evolution of Kikuyu Land Tenure

Trees and Land Tenure

Tree cultivation and management in Kenya can only be understood within the context of land tenure. Long traditions of land-use have incorporated trees either in passively managed systems (where selected trees or forests may have been protected from felling) or in more active ones (where trees are planted or are otherwise actively managed for the production of certain goods). The objective in this chapter, and in Chapter 4, is to show how changing systems of land tenure affected patterns of tree management in Murang'a District, and to show that there are strong precedents in customary land tenure practices for quite specific contemporary tree cultivation and management practices.

Land tenure systems in Murang'a had been in a state of change long before the colonial administration sought to limit this dynamic process. The Administration's adamant support for a static system of traditional land tenure sought to institutionalize what David Throup called the "moral economy of 'Merrie Africa'"[1] rooted, in the Colonial mind, in a mythical, egalitarian past. Over the last 50 years, the customary system of communal tenure *did* eventually evolve into a system of private tenure but which incorporates community trust obligations

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1. D.Throup (1987). *Economic and Social Origins of Mau Mau*. Nairobi, James Currey. p.4.

inherent in indigenous law.[1]

Customary law in many areas of Kenya generally recognized a distinction between rights of *control* of land (which are usually held by a lineage authority) and rights of *use and access* to it (often determined by the needs of individual members of a community). Because of this distinction, in pre-Colonial times, rights of private land ownership by a single individual -- implying the ownership of the land and everything on it -- were not generally a feature of customary law.[2]

With regard to trees, the distinction is an important one. In customary tenure systems, rights of tree ownership and usufruct could be held and allocated separately: people can own and use trees on land which does not belong to them. In English law (which provided the basis for much of the land tenure legislation of the late 1950s and early 1960s) trees are considered part of the land; the control of things on the land, such as trees, cannot be vested in someone other than in the landowner.[3]

Early Settlement in Murang'a

Murang'a is, roughly speaking, in the centre of Kikuyu country though historically the Kikuyu are relatively recent occupants. Of the land which the Kikuyu migrated into over the last several centuries, settlement in Murang'a dates

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1. H.W.O.Okoth-Ogendo (1987). "Tenure of trees or tenure of lands", in: J.B.Raintree (ed.) (1987). *Land, Trees and Tenure* (Proceedings of an International Workshop on Tenure Issues in Agroforestry, Nairobi. May 27-31, 1985). Nairobi and Madison, ICRAF and the Land Tenure Centre. pp.225-230.

2. The terms "communal" and "private" fail to adequately describe the breadth of tenure systems as they have developed and from which they evolved. Traditional tenure systems had many features which favored individual use and management. Contemporary land tenure systems, while rooted in the Common Law notion of individual tenure, have maintained certain features of communal management.

3. Vested in the maxim *quic quid plantatur (inaedificature) solo solo cedit*, meaning "whatever is planted in (or built on) the soil goes with the soil." P.L.Onalo (1986). *Land Law and Conveyancing in Kenya*. Nairobi, Heineman. p.15.



Figure 3.1: *Mūringa* (Cordia africana) and *Mūgumo* (Ficus thonningii) trees growing together at the site of *Mūkurwe wa Gathanga* in Murang'a District.

the farthest back, at least to the sixteenth century.[1] The Kikuyu emerged as a group with shared common agro-ecological survival strategies which developed in part as an outcome of their movement from arid and semi-arid areas into the high potential agricultural areas on the eastern slopes of the Aberdare mountains.

The centre of dispersal in the heart of Kikuyu country is traditionally associated with the area around the town of Gakũyũ in Gaturi Location of Murang'a District. Gakũyũ is a form of the name for the *mũkũyũ* tree from which the name *Gĩkũyũ* (or *Kikuyu*) is also derived.[2] The site of dispersal at that location, *Mũkurwe wa Gathanga*,[3] is named after another tree, and is where, we are told, God appeared to the man, Gĩkũyũ, and allotted him all the land south and west of Mount Kenya to the edge of the forest. The site was the location where Gĩkũyũ and Mumbi, his wife, made their home and raised their nine

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1. See particularly, G.Muriuki (1974). *A History of the Kikuyu 1500-1900.* Nairobi, Oxford University Press. Chapters 1 and 2.

2. Tradition holds that Gikũyũ, the mythical Adam of Kikuyu legend, met his wife under the *mũkũyũ* tree (probably a Ficus sycomorus) and that his name was thus derived from the name of the tree. J.Kenyatta (1938). *Facing Mount Kenya: the Tribal Life of the Gikuyu*. London, Secker and Warburg. pp.3-6.

3. Literally, the place of sand where an Albizia was growing. Muriuki suggests that, given certain oral traditions, the location of the *Mũkurwe wa Gathanga* was far more likely to have been closer to Ithanga, some 30 miles southeast of what is now Murang'a town. Even so, tradition popularly holds Gakũyũ to be this place. Muriuki (1974). p.58.

Kikuyu clans. Few trees, in any society, have such an important cultural association. Dispersion from Murang'a resulted in movement northward into what is now known as Nyeri District, and a move south into Kiambu District.

Sub-clan boundaries, and subsequent political and economic divisions, were largely a function of the physical geography. Much of Kikuyu land, particularly in Murang'a, is characterized by a series of ridges (*rūgongo*) and deep river gorges running from west to east.[1] This extensive system of ridges and valleys strongly influenced patterns of settlement and the emergence of systems of land tenure. Ridges, for the most part, tended to be cleared and cultivated first, and became the basis for the holdings of a sub-clan or lineage (*mbari*) which could trace its origins to a common male ancestor.

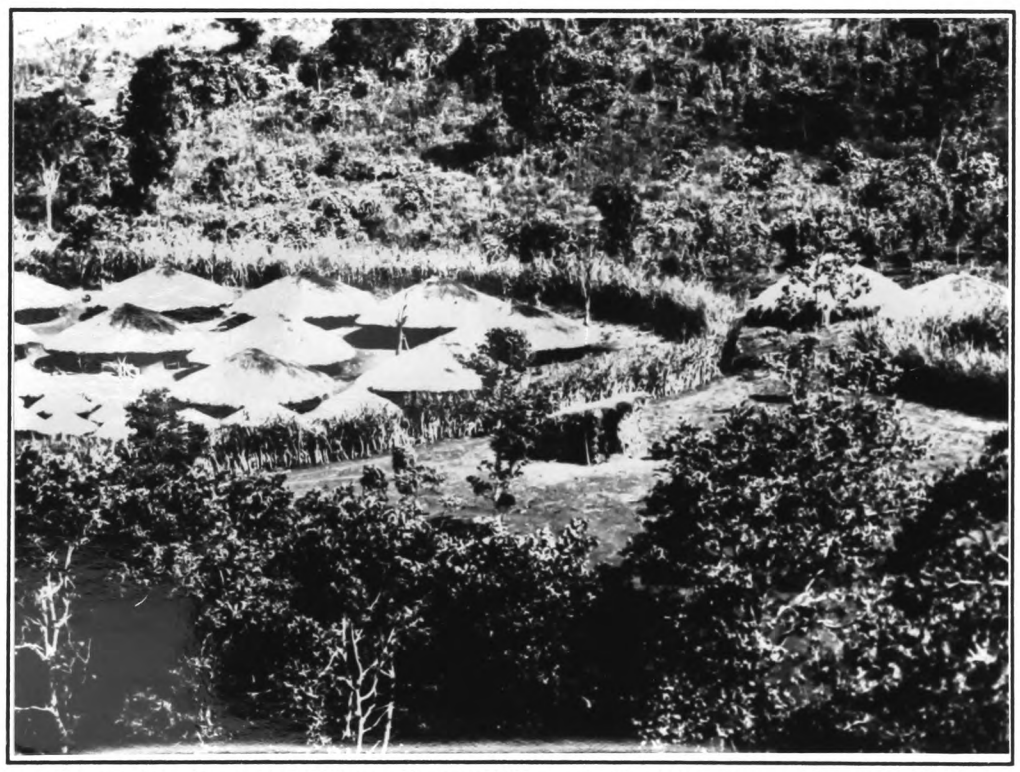


Figure 3.2: Fortified Kikuyu Forest Village in the Nyandarua Forests, 1909

Kikuyu agricultural expansion had long been limited by periodic wars with the Maasai. A forest belt acted as a buffer between the Maasai and the Kikuyu, concealing a series of fortified Kikuyu villages. European intervention put an end to Maasai and Kikuyu raids, and the result was that the buffer forests were no longer needed. A period of intensive forest clearance and cultivation by the Kikuyu followed between 1900 and 1910. Provincial Commissioner S.L.Hinde estimated that during this period, the Aberdare forests were being cleared at a rate of a half

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1. In Kikuyu, west and east are *rūgūrū* and *itherero*, meaning upstream and downstream.

mile a year.[1] Hutchins speculated that between the early 1890s and 1909, around 350 square miles of forests on the slopes of the Aberdares had been cleared.[2] The demarcation of Forest Reserve boundaries, well underway in 1910, put an end to further clearance and expansion of Kikuyu areas. The Administration's land policy put limits on Kikuyu settlement practices and systems of land tenure which were, quite fundamentally, expansionist.

The *Gĩthaka* as the Basic Land Unit

Origins of the *gĩthaka*

Acquisition of land in the areas of earliest Kikuyu settlement was based on the rights of first use, defined originally by the exercise of hunting and trapping (*mũtego*) rights. As described by a Kikuyu elder in the late 1920s,

> "In those days we did not cultivate so much as we do now. A man trapped animals and his hunting area became his *Ngundu* (land claim). His descendants became his clan. Each father had his own hunting area where he set his traps and he would show the boundaries of it to his sons... In the course of time by a natural process the Estate breaks up and each branch of the family gets control of its own Estate... (they) still recognize the eldest son of the eldest branch as the head of the family."[3]

Hunting rights were strengthened by forest clearance and by cultivation. The basic land unit was known as the *gĩthaka* (estate). Technically, as it refers to uncleared bushland, its basis is in hunting, rather than in cultivating, traditions. Rights of use were distributed to male descendants of the first owner, while a non-distributed right of control was held by the eldest son of the senior branch of the sub-clan or family who was its trustee (or *mũramati*). It was reported in the late 1920s that most *gĩthaka* ranged in size from about 20 ha to nearly 2,500 ha

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1. Government of the United Kingdom (1909). *Report on the Forests of British East Africa*, Parliamentary Report. Cmd.4723. p.67.

2. FD 1909/1910, p.5.

3. Colony and Protectorate of Kenya (1929b). *Native Land Tenure in Kikuyu Province: Report of Committee*. Nairobi, Government Printer. p.8.

although they generally were between 80 and 120 ha in size.[1]

Tenancy and the *gĩthaka*

Cultivation rights of the *gĩthaka* belonged to families with lineage rights, and were held in perpetuity. People without lineage rights could obtain temporary rights of cultivation to *mbari* lands through redeemable sales, from land lending, and from tenancy. The redeemable sale of land to a *mũguri* as a mechanism for generating capital is discussed in Chapter 2.

Land lending to people outside the *mbari* took several forms. A *mũhoi* (pl.*ahoi*) for instance, could be lent land for cultivation, usually on the basis of friendship. It would be customary for a *mũhoi* to bring a gift of beer to the man from who he sought to obtain cultivation rights. Subject to the approval of the *mũramati*, these rights could be granted. In certain circumstances, the rights of a *mũhoi* could be passed from generation to generation. Although no rent *per se* featured in a *mũhoi* agreement, occasional gifts were expected.

The cultivation of the *gĩthaka* was the clearest means of retaining land tenure rights. In the event that lineage rightholders were not able to fully cultivate the *gĩthaka*, *ahoi* would be sought to clear and cultivate underutilized land. As land became more scarce and labour more abundant, tenancy arrangements became less common and were widely cancelled. Although in principle an *ahoi* still held lineage rights to his own *mbari* land, in practice it was very difficult to return and regain cultivation rights. Occasionally, a *mũhoi* might become a resident tenant -- a *mũthami* (pl.*athami*) -- who was allowed the right to cultivate and to build a homestead (rights which were normally denied to *ahoi*).

So within the system of customary Kikuyu land tenure, there were precedents for tenancy and land lending arrangements, as well as redeemable land sales

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1. *Ibid.*, p.9.

which could be used for generating capital. Tenancy allowed the building of a homestead, while land lending expressly prohibited it. Land lending thus encouraged the formation of a class of non-resident farm labourers, but it was dependent in part on there being holdings which could not be successfully cultivated by the sub-clan right holder. Tenancy and land lending arrangements could be inherited. Rights of use were inherited by the male lineage. Rights of control were retained by senior male members of the sub-clan.

Pressures on the *gĩthaka* system

Certainly until the time of European settlement, the *gĩthaka* system was reasonably secure. It continued to function to varying degrees in Central Province as late as the mid-1970s, although most customary rights were extinguished during the period of land consolidation and registration in the early 1960s. The earliest pressures on the *gĩthaka* system became evident when the Colonial Administration attempted to resolve disputes involving customary law and land tenure -- something it did not fundamentally understand. In 1914, for instance, it was argued that the Crown's responsibility was to develop "a system of tenure for natives...giving them real and definite rights to the land"[1] -- as if these rights did not already exist. Later, however, the 1929 report of the Committee on Native Land Tenure in Kikuyu Province recommended that customary laws should be accepted as the basis for Kikuyu land tenure and that specific practices regarding the demarcation of holdings -- which involved the planting of trees on farm boundaries -- should be included as rules under the pending Native Lands Trust Ordinance. Draft rules were prepared and agreed upon, but never enacted.[2]

Any possibility for allowing a system of private land tenure for Africans was

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1. *Ibid.*, p.63.

2. See particularly the notes taken by S.H.Fazan, a member of the committee which prepared the report, in RH.Mss.Afr.s.1153.

greatly resisted by the Government. John Ainsworth, the former Chief Native Commissioner, for instance, argued before the 1932 Kenya Land Commission that private tenure was

> "opposed to the normal custom of tribal or clan ownership by occupation" and would "have the most disastrous effects on the Kikuyu as a people... To an African native community (it) would mean practical disintegration if not extinction. It is therefore incumbent upon the Government to refuse to recognize the system, and, if necessary, to legislate for such non-recognition" of private rights.[1]

One of the recommendations of the Commission echoed Lord Lugard's observation that "processes of natural evolution" led to individual ownership "in every civilization known to history."[2] The Commission recommended that tenure systems in Kenya should "be progressively guided in the direction of private tenure, proceeding through the group and family towards the individual holding."[3]

Largely because of the strength of European settler opinion, the recommendation was ignored. Instead, it was legislated that native tenure systems were *not* to be modified. This meant that customary tenure, however the Administration chose to define it, was to guide the resolution of land disputes. The fact was that customary tenure in Kikuyu areas had never been static, but was itself derived from a body of precedent and practice which developed as new pressures presented themselves. By locking customary tenure practices in place, there were increased pressures on these practices. Land disputes were inevitable.

The Administration was particularly opposed to the rise of capitalism which would accelerate if private tenure were granted.[4] Particularly during the 1940s, the Administration insisted that a system of private ownership would cause serious land

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1. J.Ainsworth, KLC(I):497. Ainsworth's policies towards land tenure in the early 1900s were based on a gross misunderstanding of Kikuyu tenure systems. The results were far-reaching.

2. F.D.Lugard (1923). *The Dual Mandate in British Tropical Africa*. London, Wm.Blackwood and Sons. p.280.

3. Government of the United Kingdom (1934b). p.420.

4. Throup (1987), p.63.

degradation in the Reserves,[1]

> "A smallholding system as a method of land tenure... is doomed to failure unless it embodies restrictions forbidding the mortgaging of land and its subdivision or inheritance by more than one son and unless a high standard of husbandry is insisted upon whereby the productive power of each holding is maintained."[2]

These types of developments were taking place anyway. By the early 1930s, the difference between communal and individual tenure was, in many areas of Kikuyu country, mostly semantic. Inherited usufruct, although there may have been communal obligations associated with it, would seldom be revoked by the *mũramati*, whose power had decreased with time. The establishment of permanent crops or plots of trees was also an important mechanism for asserting individual, rather than communal, rights of ownership.[3]

Accompanying the emergence of "private" land rights was the breakdown of the system which granted tenancy rights and, particularly, which allowed these rights to be inherited. By the late 1940s, extensive land litigation was common between sub-clan members and third or fourth generation descendants of the original tenants with whom the tenancy agreements were made. The time which had passed made it extremely difficult to resolve the litigation. Because of the uncertainty of tenure, it was argued that tenants would be hesitant to make long-term improvements in the holding.[4]

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1. See particularly the reports, N.Humphrey (1945a). "The relationship of population to the land in South Nyeri", in: *The Kikuyu Lands*. Nairobi, Government Printer. pp.1-15; and, N.Humphrey (1945b). "Thoughts on the foundations of future prosperity in the Kikuyu lands", *ibid.* pp.19-60.

2. C.Maher (1941), "The people and the land: Some problems. Part 1", *East African Agricultural Journal* (October). pp.63-67.

3. Colony and Protectorate of Kenya (1929b). p.39.

4. For earlier arguments that traditional tenure discouraged farmers from making permanent improvements in their holdings, see, A.J.F.Simmance (1961). Most of the arguments in favor of tenure reform which were considered by the Fort Hall Law Panel in 1949 were based on the notion that farmers must have an incentive to make permanent improvements.

In 1948, the Fort Hall Law Panel, comprised of chiefs, councilors, and court presidents of the District, initiated reforms to make some types of land transactions, particularly land which had been acquired through *aguri* agreements, no longer redeemable. The next year, the Law Panel argued:

> "nobody will bother to improve his land which he knows that immediately he has done so, somebody will come along and redeem the land. Redemption must therefore stop sooner or later to the benefit of the public." *(sic)*[1]

The primary beneficiaries of these reforms would likely have been the members of the Law Panel itself, or others with interests in common with elders and councilors favored by the Administration. Redeemable sales were made, often under duress, as a means of generating capital. The people most able to enter into these agreements were those with livestock to spare -- the already well-off. They would clearly have benefitted if, overnight, all redeemable sales became outright sales. The people most likely to become *aguri* were the already-impoverished with no other means of generating capital. In any case, the move to scrap land redemption and tenant eviction practices gained momentum in the early 1950s. The problem of insecure tenure was large. In the mid-1950s, it was estimated that between 10 and 50 percent of the total land in Murang'a District was still, technically, redeemable.

Changing Tenure and Land-use Systems

Villagization and the Emergency

The social and economic origins of the 1952 State of Emergency are far beyond significant elaboration in this thesis. In addition to the slow process of European decolonization brought about in part by the Emergency, its more direct impacts on land tenure were far reaching and do bear some discussion.

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1. Fort Hall Law Panel, quoted by A.J.F.Simmance (1961).

One of the measures mounted during the Emergency was "villagization." Originally the programme was intended to isolate Mau Mau fighters in the forests from material and food supplies which were being provided by a sympathetic population. The programme also provided protection for Kikuyus who remained loyal to the Government and who could be more easily guarded in these armed and barricaded sites. Some Colonial planners saw it more as an opportunity for providing central educational, agricultural and health services. Regardless of the intention, the villagization programme introduced what were fundamentally new forms of social organization with little customary precedent. Families which had formerly lived on isolated homesteads with 10 to 20 other individuals were forcibly moved into villages with an average of 1200 residents.

Villagization was also meant to deal with the masses of people who returned to the Reserves during the Emergency. As a result of the Emergency, over 100,000 people were returned to the Reserves from towns and from European farms where they had farmed as squatters. In every sense, these were displaced persons who had little connection with the Reserves as they had often been working as squatters for several generations. They too were placed in villages and were given plots. Their return often created suspicion and resentment amongst the long-time residents of the Reserves.

The newly created villages were designed to provide everyone with an eighth of an acre (around 500 m^2) and were partly an attempt to solve the problem of squatter landlessness. Those who had land-use rights were allowed to continue cultivating their holdings. Those who had no land except for their eighth of an acre plot were expected to seek wage employment on the larger holdings. The fact was, however, that there was neither the capital nor the means of production to

support a class of wage labourers.[1]

Nyeri District Commission O.E.B.Hughes later noted that the villages reminded one of "the English mediaeval manor with the village nestling below -- though in this case it was a rugged wired-in home guard post on a high knoll with a series of grass roofed mud-walled huts below."[2] It is unlikely that many residents shared this quaint, albeit heavily fortified, vision of English country life. In the end, the villagization programme was essentially a punitive measure. It was completed by late 1955. By then, 272 villages had been established in Kiambu District, 235 in Murang'a District, and 169 in Nyeri District.[3]

Fragmentation and agricultural land-uses

Villagization was closely linked with land tenure reform, particularly with the consolidation of fragmented holdings. Like other processes which were associated with the Emergency, such as the problems of squatter labour and other migrant labour issues, the fragmentation of agricultural holdings had a long cultural, historic, and economic basis.

From the times of earliest settlement in Kikuyu country, landholdings became progressively and extensively fragmented. Most households had several distinct and geographically separate plots within the *gĩthaka*. This was partly because of the inheritance of usufruct, which basically meant that lineage holdings would become smaller and smaller over time. When these posed a constraint to

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1. M.P.K.Sorrenson (1967). *Land Reform in Kikuyu Country: A Study in Government Policy*. Nairobi, Oxford University Press. p.147; W.H.Thompson, RH.Mss.Afr.s.839, p.10. Displaced and landless Kikuyu who were settled in the Emergency villages did eventually become something of a wage labour force, as had been envisaged. In 1978, the Rural Labour Force Survey reported that between 50 and 75 percent of wage labourers in smallholder agriculture were landless, or nearly so.

2. O.E.B.Hughes (1955). "Villages in the Kikuyu country", *Journal of African Administration*. 7(4):170-174.

3. A.Thurston (1987). *Smallholder Agriculture in Colonial Kenya: The Official Mind and the Swynnerton Plan*. Cambridge, African Studies Centre. p.85.

the household (usually when a man married another wife) he would try to obtain rights to another plot for cultivation -- which was seldom contiguous with plots the household was already cultivating. Fragmentation was also an outcome of the system of land lending and redeemable sale which encouraged *ahoi*, *athami*, and *aguri* to cultivate fragmented *mbari* lands.

One result of fragmentation was that, by cultivating different plots spread over multiple agroecological zones, farmers could spread out their environmental risks. In the event of drought, for instance, crops on a few plots would fail, but not all of them would fail. The cultivation of multiple plots could also even out seasonal patterns of labour demand because cultivation and harvesting tasks could be staggered, depending on where the plots were located. S.H.Fazan, the Nyeri District Commissioner, in the 1930s observed,

> "Sometimes (fragmentation) is because the householder likes to cultivate on different types of soil, a patch of red land, and a patch of brown friable soil, and a patch of swamp. Sometimes it is because he has more than one wife and ... sometimes it is because he is a rightholder on more than one *gĩthaka*."[1]

Fragmentation as an unwitting, though adaptive, land use made tremendous sense in areas of huge agro-ecological variability like Murang'a. Even so, the Administration consistently chose to ignore these types of benefits.[2] The arguments against fragmentation were usually based on the notion that it was detrimental to agricultural practices: fragmentation hindered modernization, it generated inefficiencies in the use of factors of production, and it would be costly to change.[3]

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1. S.H.Fazan, KLC(I):991.

2. Leslie Brown, to his credit, noted that fragmentation was an intelligent system of fairly dividing up holdings and avoiding crop losses. He still concluded though that the benefits of consolidation far outweighed the advantages of fragmented holdings. L.H.Brown (1957). "Development and farm planning in the African Areas of Kenya", *East African Agricultural Journal*. (October). pp.67-73.

3. M.F.McPherson (1983). *Land Fragmentation in Agriculture: Adverse? Beneficial? and for Whom?* (Development Discussion Paper No.145). Cambridge, Harvard Institute for International Development (Harvard University). p.10.; and, B.Binns (1950). *Consolidation of Fragmented Agricultural Holdings* (FAO Agricultural Study No.11). Rome, FAO. p.15 ff.

The extent of fragmentation varied widely. In Kiambu, for instance, it was reported that one farmer held a total of 9 acres made up of 20 plots within a radius of 14 miles.[1] The record was probably in Murang'a though, where district reports noted that one man had 108 fragments spread over 40 acres.[2] The norm in Murang'a was probably that a single farmer would have around 5 or 6 holdings totalling around 5 acres. Households which held only one plot were most certainly the exception.

Agricultural contexts

The notion that traditional African agriculture had any redeeming characteristics whatsoever generally escaped most Colonial planners.[3] Others, however, suggested that the primary *causes* of problems in African agriculture were related to the introduction of European farming practices.[4] Louis Leakey, for instance, pointed out that traditional systems of intercropping, which left some vegetative cover on cultivated land throughout the year, were far less likely to cause soil erosion than the Agriculture Department's recommended practice of planting crops separately. With no ground cover left after the harvest, huge areas were being eroded during seasonal thunderstorms which dropped enormous amounts of rain

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1. F.D.Homan and R.A.Sands (undated). "Land tenure reform and agricultural development in the African lands of Kenya". Unpublished manuscript. (see also RH.MSS.Afr.s.1267). p.5.

2. KNA, "Fort Hall Annual Report, 1958".

3. The view of Sir Philip Mitchell, Governor General until 1952, was not atypical,
"(T)he peoples of East and Central Africa were found in the 1890's to be in an extraordinary condition of backwardness and ignorance... They had no...tools except small hand hoes, axes, wooden digging sticks and the like; they had never heard of wages. They went stark naked or clad in the bark of trees or the skins of animals, and they had no means of writing..."
Colony and Protectorate of Kenya (1947). *The Agrarian Problem in Kenya* (Report by Sir.P.Mitchell). Nairobi, Government Printer. para.5.

4. The 1929 Commission which was established to explore opportunities for developing the agricultural sector noted, for instance
"The Kikuyu are...skillful in their own methods of cultivation which in some cases where the land is broken and accidented are possibly more adapted to the conditions than European practice. Mixed planting is regarded as an insurance against drought, which may destroy the crops in part but yet leave the land carrying something."
Colony and Protectorate of Kenya (1929a). *Report of the Agricultural Commission*. Nairobi, Government Printer. p.33.

over short periods.[1]

African agriculture had, for the most part, been ignored by the Colonial Administration. At the urging of the European settler community, most Africans were prevented, through restictions and controls, from growing any of the better paying export crops. By the mid-1940s, African agriculture was in a fairly bad state. It was seriously undercapitalized and development in the Reserves had come to a virtual standstill. Still clinging to the notion that the problem was linked to the growth of "individualism" and the soil degradation which allegedly resulted, the Administration embarked on a massive programme of communally-based soil conservation which relied on reviving the traditional use of *ngwatio* labour supervised and controlled by tribal elders.

One of the few cash crops which Africans in Murang'a were encouraged to grow (and which had been introduced into the district around 1902) was black wattle. The emergence of wattle as an important cash crop is discussed in greater detail in Chapter 4. Wattle was well-suited to the fragmented system of holdings which had evolved. It meant that a farmer did not have to rely on *ahoi* or *athami* tenants to cultivate his land. Instead he could plant it under wattle and forget about it. It generated significant amounts of income as well. Often, tenant farmers, who may have been farming a plot for generations as *ahoi*, *athami* or as *aguri* were evicted, and their plots would be planted with wattle. Tree planting assumed serious social and political dimensions as it raised capital for a class of African entrepreneurs while dispossessing the otherwise landless.

Income from wattle also enabled people to buy land or to otherwise obtain it through the expensive process of land litigation. Researchers such as Colin Leys have argued that increasing monetization and accumulation by the class favored by

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1. L.S.B.Leakey, KLC(I):677.

the Government -- the chiefs, tribunal elders, and educated minority (who were also the earliest growers of wattle) -- enabled them to buy up small and fragmented holdings from the rural poor.[1]

The Administration did recognize a serious need for land reform, even within its blinkered communal ideal. Norman Humphrey, for instance, argued that parts of Kikuyu country were completely unable to provide even a subsistence standard of living, and that each household needed a *minimum* of around 4.8 ha, in comparison with the 2.6 ha of land which the average household had access to at the time.[2] Humphrey proposed a massive programme of resettlement, recommending that "14,000 families must come off the land as soon as possible."[3]

What Humphrey and others had chosen to ignore in their calculations of land requirements in Reserve areas was the potential for cash cropping. His estimates were based on the land which would be required to provide an annual income of around £20; his calculations showed that existing practices could only generate around £3 a year in disposable income[4] derived solely from the production of potatoes, beans, maize, bananas, and wattle bark.[5]

The reversal of policies toward communal development began around 1947 after the breakdown of the soil conservation programme. That year, the Director of Agriculture announced that the European coffee growers had abandoned their

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1. C.Leys (1975). *Underdevelopment in Kenya: the Political Economy of Neo-Colonialism*. London, Heinemann. p.66.

2. Humphrey (1945a), p.10; and, Humphrey (1945b), p.52.

3. Humphrey (1945a), p.10; and, Humphrey (1945b), p.41.

4. Humphrey (1945a), pp.9-10.

5. Humphrey's position was a difficult one. At several points in his report, he pointed out the suitability of introducing cash crops. [See, Humphrey (1945a), p.8; and Humphrey (1945b), p.18.] As a civil servant however, he could hardly have advocated their adoption simply because of settler and Administration opposition. The result was that he was forced to introduce a sort of Malthusian horizon which was at some variance with what was truly possible.

objections to smallholder coffee production, provided that it was adequately supervised and cultivated away from European farms. Two years later, the Tea Growers' Association abandoned their objections to smallholder tea production.[1]

The consolidation of fragmented holdings

The most significant change in land tenure was brought about as a result of a programme to consolidate fragmented holdings into individual plots. Consolidation particularly affected land-use patterns as well as patterns of labour-use. In economic terms, its impact is surprisingly often understated; few efforts have been mounted to evaluate the effects of consolidation on agricultural production specifically and on the rural economy in general.

Arguments in favor of consolidating fragmented plots date from the 1930s.

> "From the Agricultural point of view, the benefits that may be expected to accrue to cultivation from the consolidation of holdings cannot be overemphasized. The energy that is needlessly dissipated by having to cultivate and protect a number of small scattered plots if applied to a consolidated area might almost double the productive capacity of some areas."[2]

Consolidation was thought to be the key to an agricultural revolution in Kenya, and the granting of individual title was seen as a mechanism for channeling loan funds, and other resources, to smallholder agriculture. Certainly by the 1950s, the conventional wisdom held that fragmentation had to be done away with. The question was how.

Momentum for change gathered from around 1950, with the appointment of Roger Swynnerton as an Assistant Director for Agriculture. In 1953, Swynnerton was asked to draw up a five-year African Land Development plan. His *Plan to Intensify the Development of African Agriculture in Kenya* was a landmark in Kenyan development, and laid important precedents for development planning

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1. Thurston (1987), pp.30-31.

2. Director of Agriculture to the Kiambu District Commissioner, 1 August 1930. (From S.H.Fazan RH.Mss.Afr.s.1153).

which guided post-Independent Kenya for many years to come. Consolidation was a key feature of the Swynnerton Plan.

Consolidation could not have been accomplished without the Emergency.[1] In two respects, the Emergency facilitated the process. Firstly, villagization removed people from the land which meant that the Administration could initiate consolidation without the problem of having to deal with established homesteads. Secondly, consolidation was seen as a mechanism for rewarding loyalists with economic patronage in the absence of any political interference. Most politicians were in detention and had no way of opposing consolidation, or of encouraging others to do so. Initiated as a means of stabilizing a conservative middle class based on the loyalists, it confirmed the landlessness of the terrorists whose confiscated land was thrown into the common land pool prior to consolidation.[2]



Figure 3.3: Land Consolidation Committee meeting (Thuita, late 1950s)

Consolidation was carried out in blocks of between 800 and 1,600 ha -- about the size of a sub-location (*itũũra*). A committee consisting of the chief, a registrar, and a group of elders would be formed to identify rightholders to every piece of land in the sub-location. A team of agricultural assistants would measure each fragment, and the committee would seek to bring about the redemption of

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1. R.Swynnerton, RH.Mss.Afr.s.1426.

2. Sorrenson (1967), p.118.

every plot of land from *aguri*. Redemption was a prerequisite for consolidation.[1] Once fragments had been identified and measured, an aggregated area belonging to each right holder was identified and was marked out on a map and on the ground. Generally, the objective was to include a proportion of arable, cash-crop and grazing land within each consolidated holding. At the same time, the extent of existing cash crops and other improvements was recorded so that compensation for permanent improvements could be paid by the new owner.

The smallest holdings were grouped around villages, and larger holdings were sited beyond these.[2] The landless were given plots in villages, from where they were expected to seek wage labour in agriculture or to become shopkeepers and artisans. Consolidated holdings generally ran in strips from ridges to valleys -- giving a right holder a range (albeit limited) of agro-ecological conditions and soils in which to farm.[3] Consolidation was followed up by boundary marking and farm planning. Basic farm layouts were made for all farms as soon as they were consolidated. They included recommendations to cultivate food crops on land with a slope of less than 20 percent, to cultivate grass or trees on land with a slope of greater than 35 percent, and to cultivate permanent crops on slopes between 20 and 35 percent.[4] Farmers who requested it could benefit from more detailed farm layouts. By 1961, detailed plans had been prepared for around 18 percent of the holdings in Murang'a District (and 10 and 21 percent of the holdings, respectively,

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1. R.G.Wilson (1956). "Land consolidation in the Fort Hall District of Kenya", *Journal of African Administration*. 8(3):144-151.

2. J.Pedraza (1956). "Land consolidation in the Kikuyu areas of Kenya", *Journal of African Administration*. 8(2):82-87.

3. Wilson (1956), p.149.

4. L.H.Brown (1962). "Land consolidation and better farming in Kenya", *Empire Journal of Experimental Agriculture*. 30(120):277-285.

in Kiambu and Nyeri Districts).[1]

Despite the proliferation of farm plans, the Colonial Department of Agriculture was inexperienced when it came to smallholder farming. "We are the victims of dabblers," said W.H.Thompson, a Divisional Officer in Murang'a around the time the consolidation programme had gotten underway.

> "Despite the fact that the whole purpose of agriculture is to produce, you will not find production. Agriculture is limited to the production of terraces. There are no decent crops to grow on them.... There are a few beautiful to look at smallholdings, which have cost the earth to make. They are surrounded by miles of barbed wire and are good as show places for VIPs. They are not, however, economic."[2]

There was no legal basis for consolidation, nor were consolidated holdings recognized in law. Consequently, the Administration imposed a moratorium on all land cases, and in the meantime managed to draft and pass legislation which provided for consolidation, the registration of titles, and inheritance. The outcome was the Native Lands Registration Ordinance of 1959 which, for the first time, legalized private land ownership in the Reserves.

That legislation formed the basis for the legislation which now comprises the accepted body of land law. The 1963 Registered Land Act (Cap. 300) is the primary legal instrument controlling land transactions. Under its terms, customary land rights were extinguished in areas which had been consolidated and registered, as in virtually all of the high potential agricultural areas.[3] Rights of control and rights of access or use were equated with ownership rights; land is consequently inherited by the sons of each house of a rightholders' wives.[4] Women have rights of use, by marriage, but are unable to inherit land unless such inheritance is

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1. *Ibid.*, p.284.

2. W.H.Thompson, RH.Mss.Afr.s.839, p.9.

3. A.N.Allot (ed.). (1968). *Restatement of African Law* (Volume II) London, Sweet and Maxwell. p.2.

4. For instance, if a man with three wives dies, the land is split equally into three; each third is split equally amongst the sons within each line.

specifically provided for in a will.

The impacts of consolidation

Patterns of land-use, defined as a result of the farm planning exercises which followed consolidation, are easily recognized in current land-use practices. Many of these practices were subsequently legislated into the Chief's Act and the Agricultural Act. Villagization and consolidation also clustered smaller holdings around villages.

Consolidation strengthened the African middle peasantry, but largely at the expense of the landless. The people whose position was most seriously damaged by consolidation were the *ahoi*, *athami*, and *aguri*. As plots were consolidated, land lending and tenancy arrangements were cancelled and land sales were redeemed. While it was assumed that the landless would form a labouring class engaged in employment on larger holdings or in villages, these opportunities simply did not exist to absorb the mass of people who lost out.[1] Consolidation did not create a landless class, but it certainly exacerbated the situation.

Patterns of labour organization were radically changed as well. The process freed up enormous amounts of household labour, formerly used for the cultivation of fragmented holdings, to engage in other forms of production. No analysts of the economics of smallholder agriculture in post-Independent Kenya have ever assessed (or even speculated upon) the dramatically changed patterns of labour-use resulting from consolidation. A reliance on labour-extensive land-uses (or *ahoi* arrangements) to keep distant holdings productive was simply no longer necessary. The fact that household labour became more available as a result of consolidation partly negated the view, held by Brown[2] and others, that consolidated holdings

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1. Sorrenson (1967), p.221ff.

2. Brown (1957), p.72.

would provide good opportunities for employment of the landless.

The shift in patterns of labour availability was accompanied by shifts in patterns of land-use as well. In Murang'a District prior to consolidation *the* dominant cash crop was black wattle. As labour was freed up by consolidation, there was no longer the need to cultivate fragmented holdings with labour extensive crops like trees. This created an overwhelmingly positive environment for the introduction of other cash crops such as coffee and tea. Indeed, consolidation, the Swynnerton Plan, and the liberalization of agricultural policies in the Reserves brought about the clearance of large areas which had been cultivated with wattle, their replacement with coffee and tea, and large consequent increases in income from smallholder agriculture. Between 1957 and 1962, the area under coffee in Central Province nearly quadrupled from around 4,800 ha to 17,000 ha.[1] In current terms, income from pyrethrum in Central Province increased nearly five-fold over the same period. Between 1955 and 1964, the value of recorded output rose from £5.2 million to £14 million, with coffee accounting for 55 percent of the increase.[2] Arguably, the immediate benefits were not evenly distributed, and if consolidation could be judged to have been a failure, it was in this respect.

Finally, consolidation greatly changed the relationship between the rights of control of land and rights of use. Contemporary land tenure practices no longer assured people to what had been customary rights of access to trees growing on *mbari* lands. The outcome was that tree resources which could be managed and utilized on a communal basis were no longer accessible to people who may have needed them. The long term impacts of this change are likely related to the widespread cultivation and management of trees on private lands, where rights of ownership and control are one and the same.

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1. Thurston (1987), p.132.

2. C.Leys (1975), p.53.

Chapter 4. Contemporary Tree Cultivation and Management Practices

Kikuyu farmers and communities have long placed a high value on trees within their society and as part of their economy. Many tree cultivation and management practices were well-established long before Colonial settlement. Some of these practices are described in detail in Appendix 6. A number of contemporary tree planting practices, such as the planting of trees on field boundaries, were in part derived from traditional practices. Others, such as the planting of trees in woodlots, are not recognizable in any particular pre-Colonial practice, but were innovations that became popular over time in part because of changes in the rural economy. This chapter discusses these two particular tree planting practices -- tree planting on boundaries, and woodlots -- and describes several other contemporary tree cultivation and management practices in Murang'a.

Boundary Plantings

The legal context for boundary planting

Long before Kenya was colonized by Europeans, trees were commonly used to demarcate *mbari* lands. The customary method of marking out *gĩthaka* boundaries involved the planting of a flower -- *gĩtoka* (pl.*ĩtoka*), the Pajama Lily (Crinum kirkii) -- by the hereditary *gĩthaka* right holder or by representatives of the *mbari* who held lineage rights to it. Boundaries in Murang'a were not fully marked in the days when the *gĩthaka* was a hunting area, but they were sufficiently well enough established to allow for proper marking out when the occasion arose.

Natural features such as streams, prominent trees, game pits, and so on served as boundary markers in the meantime.[1]

The marking out of *gĩthaka* boundaries was usually carried out as cultivation became widespread. Marking was often brought about as an outcome of land disputes, but was also undertaken simply as a means of preventing disputes in the future. It was to be done in the presence of witnesses and of representatives of the *mbari* which owned the land adjacent to the plot in question.

While *gĩtoka* was the accepted boundary marker, a number of trees and bushes were accepted as substitutes. The planting of trees became considerably more common as the need for clearer boundaries to *mbari* land became evident. Trees were planted at irregular intervals, as well as in windrows and hedges. This process was apparently well underway by the time of European settlement. The Routledges wrote about *gĩthaka* land in 1910,

> "The boundary of the estate .... was indicated by the planting of trees in line, by regular hedges, and by boundary stones sunk deep out of site.... The countryside presents the appearance of large allotments or of small fields divided by hedges."[2]

S.H.Fazan, the District Commissioner for Nyeri District in the early 1930s, noted, that in some instances, the boundary of the *gĩthaka* would be marked by coppiced and pollarded tree stumps rather than by planted trees,

> "... that is to say they cut off the tree itself and leave the bushy growth to spring from the root. I saw several of these, and in one place they have the general appearance of having been planted in a row."[3]

The Forest Department, wittingly or not, adopted the practice of boundary demarcation with trees. In 1933, it was reported that the boundaries to the Forest Reserves were being demarcated "by cut or ploughed lines, marked by posts, or

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1. Colony and Protectorate of Kenya (1929b), p.19.

2. Routledge and Routledge (1910), p.6 and p.39.

3. S.H.Fazan, KLC(I):960.

exotic trees planted at intervals."[1] The marking of Forest Reserve boundaries with trees by the Colonial government must certainly have held some significance to the Kikuyu who had always used trees for marking out their own boundaries.

The customary demarcation of *gĩthaka* lands with *ĩtoka* and with trees was first widely discussed during hearings before the Kenya Land Commission in 1933. Kikuyu witnesses to the Land Commission gave evidence that in the early 1930s, trees such as Eucalyptus and Black Wattle were sometimes planted in rows by themselves or in conjunction with indigenous trees over the spots where *ĩtoka* had originally been planted.[2]

Certainly by then, it was becoming increasingly important for farm boundaries to be clearly marked and that these markings should be somehow regularized. Land disputes had become far more common, particularly after the Kenya Land Commission made it clear that additional land would not be made available for the future settlement of Africans. Tree planting along boundaries assumed new importance as a means of unequivocally identifying the limits of a right holder's land.

Although the marking out of *gĩthaka* boundaries with *ĩtoka* lilies became less common over time, the practice of demarcation remained, and was indeed encouraged by the Colonial Administration. The 1929 Report of the Committee on Land Tenure in Kikuyu Province, for instance, made a series of recommendations for including customary boundary marking practices in rules proposed under the Native Lands Trust Ordinance.[3] The Report recommended:

> "...that only *Mugumu* trees and *Itoka* lilies should be used for marking the boundaries

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1. FD 1933, p.6.

2. Luka Wangana, KLC(I):185; Philip Karanja, KLC(I):145.

3. The Committee was comprised of the Chief Native Commissioner, G.V.Maxwell, the Nyeri District Commissioner S.H.Fazan, and Louis Leakey. See particularly, RH.Mss.Afr.s.1153. "Proposed Rules Under the Land Trust Ordinance and suggested Amendment to the Ordinance in order to bring the rules *intra vires* of the Ordinance."

> of a *Githaka*..."; that "it should be made unlawful for (them) to be planted in lines in any place other than on a *Githaka* boundary"; and that "it should be lawful for any native authority to issue orders that any *Mugumu* trees or *Itoka* lilies which may be found to have been planted in lines in any place other than a recognized *Githaka* boundary be removed."

The Chief Native Commissioner, G.V.Maxwell, incorporated these recommendations in a set of draft rules. The draft rules also specified that it would be an offense to plant *mũgumo* and *ĩtoka* on any boundary which was not a *gĩthaka* boundary, such as on field boundaries within holdings.[1]

Maxwell's draft rules were really an attempt to give a legal foundation, within the body of East African land law, to those dimensions of Kikuyu customary land law which could be clearly recognized in English Common Law. Indeed, boundary demarcation with trees has a long precedent in English Common Law. The first hedges in Great Britain (for instance the Hedge of Ida of Northumbria, erected around Bamburgh in AD 547) were recorded in the Anglo Saxon Chronicles. Between the thirteenth and seventeenth centuries, live hedges became more common as the amount of permanently enclosed land increased. Under the common field system, the enclosure of common lands was illegal, but by the end of the of the eighteenth century, numerous acts of Parliament had dismantled the common fields systems, and over 7 million acres of farmland had been enclosed -- largely with hedges.[2]

One outcome of a system of enclosure of the type envisaged by Maxwell and others would have been that it would have given implicit recognition to the right of individual Africans to use and -- in effect -- to own land. This was simply not

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1. RH.Mss.Afr.s.1153. "Draft Rules. Native Lands Trust Ordinance. 1930." [drafted by G.V.Maxwell, according to handwritten notes, entered by S.H.Fazan in the margins].

2. One of the people brought before a 1517 Commission of Inquiry, convened to investigate instances where common lands had been illegally enclosed, noted in his defense that his hedges provided fuel for the poor, who had hitherto burnt straw which should have been used for cattle. He had also planted oak trees in his hedges because timber was more valuable than corn or grass. See, E.Pollard, M.D.Hooper and N.W.Moore (1974). *Hedges*. London, Collins. p.21 and pp.38-39.

acceptable either to the Colonial authorities or to the European farmers whose position depended on their monopoly land-owning rights. Not surprisingly, the Committee's recommendations were never implemented.

In the end however, boundary demarcation became inextricably linked to political changes and to the processes of land reform, which gathered momentum from the early 1950s. Well before he assembled his plan for intensive development in African areas, Roger Swynnerton was advocating "enclosure" in the Reserves and the planting of trees on boundaries to provide timber, firewood and fencing poles.[1] It was perhaps because of Swynnerton's vigorous support for enclosure and tree planting on boundaries, that it became a critical part of the consolidation and registration process. A Divisional Officer in Murang'a District explained to his successor, how these processes were tied,

> "The intention is that all villages, which were built in the heat of the Emergency should now be planned, and everyone living there should be on a properly-measured one-eighth acre plot to which he holds either a freehold title or a lease. As soon as the village has been planned... and the plots marked out on the ground, an elected village committee allocates the plots to individuals. You can then order the new plot owners to hedge their boundaries (under the Native Lands Registration Ordinance.)"[2]

Hedges were the administratively accepted means of boundary demarcation, and were planted immediately after a plot had been consolidated. The reasoning was primarily that they were visible from the air, and could be used for mapping out consolidated holdings from aerial photographs.[3] The ideal hedge was one "sufficiently dense to cast a heavy shadow within itself... about 2 feet wide and between 2 and 6 feet in height."[4] Because of the speed with which it was deemed

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1. KNA AN32/4. 12 February 1952. R.J.M.Swynnerton. *Report on Agrarian Policy for Dealing with Population Increase, Land tenure, and Fragmentation in Kenya* (memorandum).

2. KNA DC/FH2/2, 15 May 1961. *Fort Hall Handing Over Reports (Divisional), Kiharu Division.* C.A.Gardner to H.M.Burton.

3. J.W.Wright (1956). "Reference marks in land settlement", *Journal of African Administration.* VIII(1):38-45., "Reference marks in land settlement".

4. Department of Agriculture (1957). *Fort Hall Gazetteer.*

necessary to map out and register the plots, it was desired as well that hedges were fast growing.

Demarcation by the planting of trees on boundaries eventually came to be a legal requirement for land registration, and during the consolidation process, registered land owners who failed to plant field boundaries or to maintain them could be prosecuted.[1] The legal requirement that boundaries are demarcated is specified in the Land Consolidation Act (Cap.283) which notes that,

> "The Demarcation Officer may order any landowner...to demarcate his land, and for the purpose of such demarcation, to erect or plant...such boundary markers as the said officer may direct."

Hedges and windrows

It is not surprising, then, that the planting of hedges and windrows in Murang'a District and in many other areas continues to be especially common. The preferred species in high rainfall areas of Murang'a include an exotic species of cypress (Cupressus lusitanica), as well as *mũbage* (Caesalpinia decapetala), *mũkawa* (Carissa edulis), *kaiaba* (Dovyalis caffra), and *mũtũndũ* (Croton macrostachyus). In lower rainfall parts of the district, the dominant species is *kariaria* (Euphorbia tirucalli). Hedges are often allowed to become windrows. The three dominant windrow species are cypress, *mũbariiti* (Grevillea robusta), and *mũkindũri* (Croton megalocarpus).

Cypress is very commonly managed as a "multi-story hedge." Every 3 metres or so along a tightly-clipped hedge, a stem will be left untrimmed, and will grow into a full-sized tree. In some parts of Kikuyu country, these stems are side-pruned. The branches are used for fuelwood, or are sometimes used to make furniture, or small farm structures such as cattle enclosures and fences. Side pruning also increases the light which is available to crops. The stems are

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1. KNA DC/FH2/2, August 1959. *Fort Hall Handing Over Reports (Divisional), Kandara Division*. J.A.C.Reed to P.T.W.Powell.

occasionally felled by pitsawyers who convert them into sawn timber. Cypress is usually only planted in rows; individual stems are seldom planted, except occasionally for shade around households.



Figure 4.1: Boundary Planting of Cypress (Cupressus lusitanica) (Murang'a District, 1990)

Cupressus lusitanica was first introduced in Kenya sometime before 1920, although the exact date is uncertain. The planting of cypress on farms in Murang'a and other Kikuyu areas for saw logs was first noted by the Forest Department in the mid-1940s when the practice was reportedly quite widespread. Plantings apparently conflicted with other land-uses which were deemed to be more important, such as the planting of arable crops on flatter land, and the Department noted that the widespread planting of cypress "may not be such a desirable development... unless such planting is confined mainly to the steeper hillsides."[1]

Cypress is especially easy to regenerate. On-farm nurseries account for the bulk of new plantings, although it is still one of the major species grown in Forest Department nurseries and which are sold to farmers. The Department sells at heavily subsidized prices, although seedlings are often resold at much higher prices.

Mũbariiti (Grevillea robusta) is also occasionally grown and managed in windrows much like cypress and is used for both fuelwood and timber and for small farm structures. Unlike cypress, however, it is often planted in and around

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1. FD 1944, p.7.

fields as well as in woodlots. It was originally introduced as a shade tree for coffee plantations.

Mūkindūri (Croton megalocarpus) is a fast-growing species with a high, twisted canopy. It is unsuitable for building timber, but is occasionally harvested for woodfuel. It doesn't compete too heavily with crops. It is maintained primarily for its amenity value, but is also used as woodfuel.

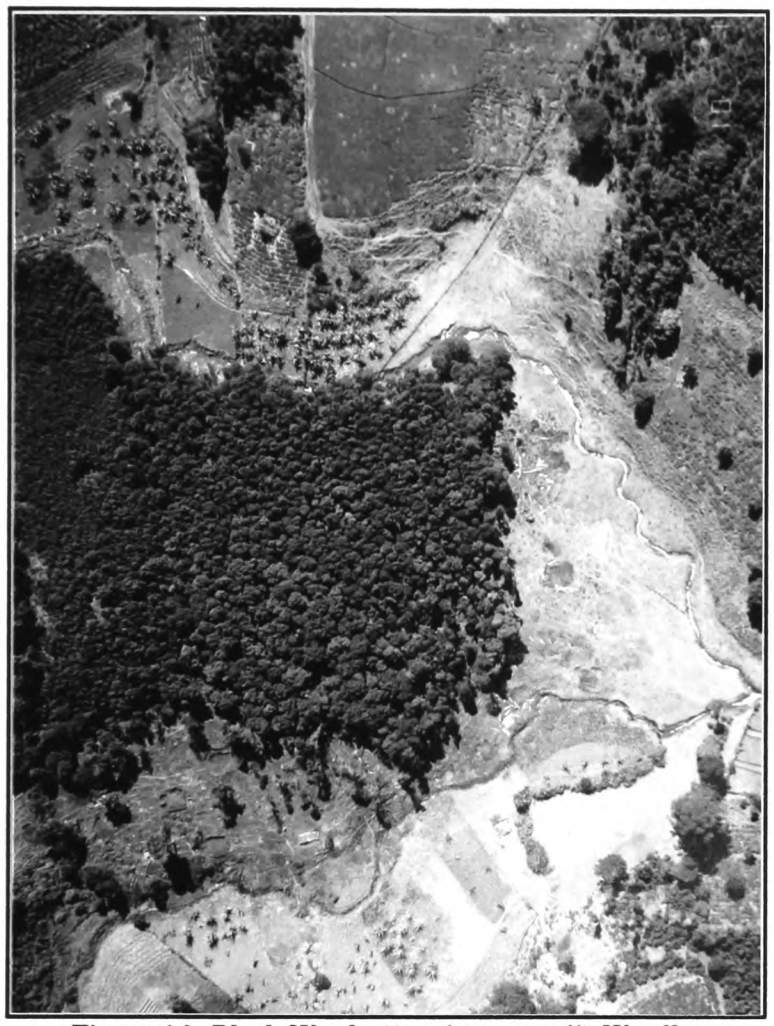


Figure 4.2: Black Wattle (Acacia mearnsii) Woodlot

Block Plantings

Contiguous blocks of trees are sometimes planted over large areas. It has been estimated that there are around 6,000 hectares of woodlots in Murang'a District, and that the aggregate area of woodlots in high potential zones of Kenya totals around 80,000 ha.[1] The effect of block plantings on the rural economy is poorly understood, but the impact of the large areas which are planted must be considerable. The primary block planting species are black wattle (Acacia mearnsii) -- the dominant woodlot species in Murang'a District -- and eucalyptus. This discussion is limited to black wattle. There are also small block plantings of Grevillea robusta in some areas, but these are more commonly planted in fields and in windrows.

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1. World Bank (1988), Main Report, p.14.

The introduction of black wattle

Black wattle[1] is a species indigenous to Australia and is widely grown in a number of countries because of the high tannin content in its bark which is processed into tanning extracts. This was not, however, what brought about its introduction as a farm tree in Kenya.

It is likely that black wattle was first introduced into Kenya by the Reverend Stuart Watt, an early missionary, who farmed and preached at Ngelani near Machakos. Watt brought wattle, eucalyptus and grevillea seeds from Australia where he had lived before coming to Kenya in 1885.[2] He also established Kenya's first fruit orchards which later provided the bulk of the Colony's supplies of fresh fruit.[3]



Figure 4.3: John Boyes, who introduced wattle into Murang'a District in 1898 (photo from around 1910).

Black wattle was introduced into Murang'a District in 1898. During the time of the great famine of 1898, a mercenary, merchant and adventurer named John Boyes settled in Murang'a in the village of Tusu (or Tuthu) under the patronage of a local strongman named Karuri. The area was one of the few in Kenya where there had been much rain, and Boyes worked as a middleman, selling

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1. Acacia mearnsii was earlier incorrectly known variously as either Acacia mollisima or Acacia decurrens. See, S.P.Sherry (1971). *The Black Wattle*. Pietermaritzburg, University of Natal Press. pp.5-7.

2. Papers of J.A.Stuart Watt, the son of Stuart Watt. RH.Mss.Afr.s.391.

3. E.Trzebinski (1985). *The Kenya Pioneers*. London, Heineman. p.23; see also, R.M.Maxon (1980). *John Ainsworth and the Making of Kenya*. Lanham (Maryland), University Press of America. pp.34-35.

vegetables and other food stuffs raised by the Kikuyu to the crews working on the railway line which was being constructed between Mombasa and Kisumu. Boyes acquired some wattle seed from a seed merchant and planted it on a plot he had been given by Karuri.[1] The plot was eventually given to a Catholic mission.[2]

By 1919, around 4,000 ha of plantations had been established on European farms, and a factory was built in Njoro to process the bark from these plantations.[3] The 1919 Economic Commission which was set up to explore commercial opportunities for the colony noted with regard to wattle that "the industry requires very little labour and its prospects are excellent."[4]

The Administration first began actively encouraging farmers in Nyeri District to plant wattle and eucalyptus trees from around 1911, and later in Murang'a from 1917.[5] At first, the Administration's objective was to reduce pressures on the indigenous forests for wood products which had greatly increased since the demarcation of the boundaries of the Forest Reserves on the eastern slopes of the Aberdares between 1900 and 1910. A push by the Administration to encourage the planting of trees on farms began in earnest in 1921, but was widely resisted.

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1. KNA AGR/4/526, 31 July 1933. Letter from J.Boyes to W.G.Leckie (Agricultural Officer, Kikuyu Province).

2. J.Boyes (1911). *John Boyes, King of the Wa-Kikuyu*. London, Methuen. p.241. Boyes was arrested by the Administration in 1900 and was charged with *dacoity* for leading Karuri's warriors in cattle raids against neighboring villages -- under the British flag. The charges were eventually dropped. He had accumulated 3 Kikuyu wives before his arrest. He later moved to Thika where he became a dairy farmer, and died in 1951. Karuri died of leprosy in 1916, shortly after having converted to Catholicism at the encouragement of the Italian Catholic priests who had occupied Boyes' former shamba. For a time, they operated a water-powered sawmill at Tuthu and constructed prefabricated buildings for other mission stations in Kenya. I am indebted to the Consolata Fathers at Tuthu and in Nairobi for numerous old photographs from their archives which I have incorporated here. I must also acknowledge the hospitality of Father Martinelli at the Tuthu mission, who spent the better part of a day showing me around Tuthu: Karuri's grave and shamba, the site of Boyes' shamba, and the sawmill site.

3. E.Huxley (1935). *White Man's Country: Lord Delamere and the Making of Kenya*. London, Chatto and Windus. Volume 1, p.167.

4. Government of the United Kingdom (1919). East Africa Protectorate, Economic Commission Final Report, Part 1.

5. M.Cowen (1977). pp.61 and 69.

The situation had radically changed by the late 1920s however, when wattle was being widely planted as a response to the bark trade.

> "In Kikuyu, small black wattle plantations are numerous and in more accessible areas, their increase has been encouraged by the trade in wattle bark."[1]

> "There is no organized planting, but the planting of black wattle is extending rapidly and thousands of small wattle clumps are quite rapidly changing the appearance of many parts of the Reserve."[2]

Within a few years, the Forest Department claimed that "the afforestation problem had been solved" in Kikuyu Province.[3]

There was limited capacity to process the bark at this early stage in the development of the industry, and most of it was exported. Extract factories were opened in Limuru and Thika in the early 1930s. The Limuru facilities were largely dependent on wattle produced by European farmers, while the Thika factories were almost entirely dependent on smallholder production. In order to ensure that the facilities in Limuru and Thika had sufficient bark to operate, a vigorous marketing network was established by the factories through a number of Asian intermediaries.



Figure 4.4: Wattle Bark Stacked for Drying, Thika (1985)

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1. FD 1928, p.18.

2. FD 1930, p.16.

3. FD 1932, p.16. In the same breath, however, it was noted that the "inculcation into the natives of an interest in tree planting makes only slow progress." This is an interesting and fundamental contradiction which is as common today. It is widely acknowledged that farmers have planted many trees on their farms, but it is still claimed that farmers know little about the subject, are unable to plant enough trees to meet their needs, and must be taught to do so and provided seedlings by the extension services.

Increased access to markets for bark, which accompanied the establishment of these factories, greatly contributed to the popularity of wattle as a smallholder crop. The Native Affairs Department reported that in 1935 the total area under wattle had nearly doubled since the previous year (from 18,000 ha to 40,000 ha) and that there were plans to add another 20,000 ha the following year.[1] By 1937, it was estimated that there were nearly 18,000 ha of wattle in Murang'a District alone (compared with 9,700 ha in Nyeri and 6,100 ha in Kiambu).

There were three major periods of intensive wattle development in Kenya which corresponded with periods of rising market prices for tanning extracts: from 1921 to 1929, in 1935, and in the late 1940s. Although the earliest campaigns were directed at a relatively small class of educated elite, later programmes were much farther reaching and introduced wattle to the widest possible economic range of farmers. Wattle production came to be concentrated on the holdings of the middle peasantry, primarily because it produced a broad range of household commodities (fuelwood, charcoal, building poles, wood for the construction of farm buildings and cattle enclosures, and so on) while generating income for the household at the same time.[2]

The political economy of early wattle production

Wattle production in the late 1920s and 1930s was especially profitable. Africans were excluded from the production of other cash crops, and returns to food crops such as maize and potatoes were, by comparison, quite low. In 1934, the Nyeri District Commissioner J.W.Pease noted that

> "...at the moment, the price of a ton of chopped wattle bark is about the same as the price of a ton of native maize. If this continues I shall anticipate a much greater increase than 50 percent in land under wattle in this district; it might easily be

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1. Colony and Protectorate of Kenya (1935). *Native Affairs Department, Annual Report*. Nairobi, Government Printer. p.100; and, Kitching (1980). p.64.

2. Cowen (1977), p.190-191.

> doubled in the next 10 years."[1]

The situation remained very much the same until the late 1950s.

The emergence of wattle as a cash crop in Kikuyu areas had a number of immediate and long-term impacts. At the time that wattle was first cultivated in Murang'a, in the 1920s, it was most widely adopted by chiefs (who were compelled to plant it by the Administration) and by the emerging class of relatively educated elite -- Africans who had gone to mission schools and who had jobs as school teachers or as clerks, traders, or businessmen.[2] From its very beginnings as a cash crop in Central Province, wattle was grown primarily by this latter group -- absentee farmers unable to cultivate their land with other more labour intensive crops.

The need for labour to strip and plant wattle contributed to the introduction of new forms of labour organization. The chiefs were able to use compulsory labour to strip bark from their trees, retaining profits from the sale of the bark and timber for themselves. For the educated elite, however, with no access to compulsory labour, existing forms of labour organization -- primarily *ngwatio* communal labour as well as *wīra* work groups -- were not able to provide enough labour for wattle cultivation. As a result, these groups became dependent on an emerging wage labouring class for wattle woodlot cultivation and management.[3]

Wattle enabled *mbari* right holders to maintain their rights of use, through the cultivation of permanent crops, to sub-clan land, even though they may have lived and worked elsewhere. It greatly reduced their dependence on *ahoi*, *aguri*, or *athami* tenants to cultivate their plots. Tenants could more firmly establish long-

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1. J.W.Pease, KLC(I):1061.

2. Cowen (1977), pp.72-75.

3. Cowen and Murage (undated), p.41.

term rights to land on which they themselves had planted wattle. The emergence of wattle as a permanent cash crop, then, encouraged farmers to take land cases to the courts: on the one hand, right holders sought to regain control over their land by evicting their tenants and planting their land with wattle, and on the other, tenants, in effect, sought to insure their long-term rights of use, *de jure*, by tying up the land they had borrowed with permanent cash crops.[1]

By the late 1940s, wattle production had been adopted by a broad spectrum of farmers, on the smallest holdings to the largest. Many of the processes -- land litigation, the development of small businesses and shops, urban employment, and so on -- which had characterized the earliest adopters of wattle had become much more widespread. Between 1945 and 1955, the production of wattle extract more than tripled and had become the colony's largest source of earnings from exports to the United States.[2]

While the earliest adopters found wattle attractive *because* they lived and worked away from their land, it appealed to others because it *allowed* them to live and work away from their shamba and to develop businesses elsewhere, while at the same, generating an income. As Cowen has suggested,

> "(D)uring those lengthy periods when landowners... were engaged in wage employment outside of the reserve, the irregular seasonal application of labour permitted the production of wattle without the continuous presence of labour power.[3]

As more and more people planted wattle, further shifts occurred in the structure of the labour supply. Early innovators had depended on wage labourers

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1. Wattle was nowhere as popular a farm crop as in Kikuyu areas. At the same time as wattle was being promoted in the 1930s, a programme involving the widespread distribution of eucalyptus seedlings was underway in Kisii and North Kavirondo (Kakamega) District. Like wattle, eucalyptus provided a fast-growing source of construction timber and fuelwood at a time when the Forest Department was restricting access to the natural forests. Kitching (1980), p.102.

2. Cowen (1977), p.265.

3. *Ibid.*, p.191 ff.

to fell their woodlots and to strip their bark. The increasing popularity of wattle increased competition for rural wage labour at the same time that European farms were placing heavier demands on the same labour supplies.

Wattle had also been increasingly adopted by the very class of labourers on whom the peasant elite had earlier been so dependent. They had their own woodlots to take care of. Expanded peasant production of wattle -- and the labour strategies which accompanied it -- reduced the supplies of wage labour which were necessary to strip it. Increasingly, felling and stripping tasks were undertaken by household labour in the absence of wage labour. By the early 1950s (before the villagization programme), women had largely become responsible for stripping the bark from household wattle woodlots although men were responsible for felling. Unlike during the earlier period when wattle was originally being adopted and popularized by the peasant elite, felling and stripping wattle woodlots was seldom carried out by paid labourers.[1]

Wattle contributed to the development of political processes in Central Province during the late 1940s as well. The ability to articulate disaffection rested with those who were educated and with those who had been empowered by the process of capital accumulation, rather than with the Administration-controlled chiefs. These were frequently wattle growers. Chiefs often controlled large areas of land -- control which had been asserted by virtue of their position of favor within the Administration. Income from wattle enabled people to challenge the authority of the chiefs through land litigation. In this respect, political empowerment took voice through the system, by challenging in the courts both the authority of the chiefs, as well as by challenging the Government's interpretation of customary land tenure systems, frozen in place since the early 1930s.

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1. J.M.Fisher (1954). *The Anatomy of Kikuyu Domesticity and Husbandry* (mimeo). Nairobi, Department of Technical Cooperation. p.265.

A number of wattle producers societies were formed, such as the Central Province Wattle Growers' and Producers' Association, the Wattle Bark and Native Produce Cooperative Society, and the Murang'a Wattle Growers and Sellers Association, and they developed close working links with political organizations such as the Kenya African Union (KAU). The Kenya Fuel and Bark Supplies Company, formed around 1945, negotiated the purchase of a building in Nairobi, Kiburi House, (unheard of at the time for an African-owned company) which eventually housed the offices of the KAU as well as most of the trade unions which had existed before the Emergency. Jomo Kenyatta himself maintained offices there as well. It still houses the headquarters of the Kenya Union of Domestic, Hotels, Educational Institutions, Hospitals, and Allied Workers Union.[1]

In order to more closely control the extent to which wattle was financing processes of political organization, the Government increasingly sought to control all aspects of the trade. In consultation with the Wattle Manufacturers' Association, it fixed prices and introduced strict controls on the trading of bark with the Marketing of Native Produce Ordinance of 1935. Licensing was coupled with strict quota arrangements which, at least in theory, limited the income any single producer or trader could make from the sale of wattle bark. In practice, both trading licenses and quotas were widely circumvented, and a black market in licenses flourished.[2]

Soil conservation and wattle in the 1940s

In some respects, black wattle is an ideal agroforestry species because it can be easily incorporated into farming systems, it is nitrogen fixing, it produces

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1. P.Ngugi (1980). "Don't let the name mislead you", *Daily Nation* (29 June). p.24.

2. See also, KNA AGR/4/220, 21 August 1945, memorandum from G.J.Gollop, Assistant Agricultural Officer, Kiambu to the acting Senior Agricultural Officer, Kiambu, "Wattle Rules and Marketing, 1942-46".

wood-based products for the household, it is easily grown and can generate income from the sale of bark. The Administration mounted all of these arguments in favor of wattle during its planting programmes.[1] Growing concern about the economic and political impact of wattle eventually found a voice in the soil conservation programmes of the 1940s.



Figure 4.5: Stacking of Wattle Logs for Burning into Charcoal. (Murang'a District, 1989.)

Expanded peasant production of wattle did two things that caused the Administration great concern. Firstly, as we have pointed out, it increased rural incomes to such an extent that Africans were becoming increasingly empowered economically and, consequently, were able to gain a political voice. But secondly, so much money could be made from wattle that the Administration feared that farmers would overcultivate their holdings with wattle and destroy their soils. Soil conservation was the primary focus of the Government's policy toward agriculture in African areas in the 1940s. It saw the growth of individualism in the Reserves and the potential for income generation as being primarily responsible for deteriorating soils.

By the mid-1940s, these two concerns -- income generation (and political empowerment) and soil conservation -- caused the Administration to reverse its policies toward wattle in the Reserves and wattle became a target. Arguments

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1. W.G.Leckie (1938). "The Growing of Wattle and Production of Wattle Bark in Kenya", *East African Agricultural Journal* (July). pp.51-62.

against wattle were increasingly being made in terms of the soil conservation debate, rather than in terms of its economic or political consequences. There were some interesting contradictions. In the mid-1930s, the Department of Agriculture recommended that "all cultivated land should be planted under wattle to prevent declines in fertility."[1] By the mid-1940s however, Norman Humphrey, whose opinions on the state of African agriculture carried tremendous weight, noted that

> "(E)xperience showed that under certain conditions wattle... can become a potent factor in increasing soil erosion. As a result steps have been taken to lessen the acreage under this crop, whilst greater control of self-sown plantations, all too often overcrowded and neglected, will have to be ensured if wattle is to take its rightful place in the farming economy."[2]

Although the arguments were being made with all the rhetoric of a concern about soil conservation (which characterized the debate about *all* African farming in the 1940s), the bottom line was that wattle was frustrating the Administration's efforts to strengthen tribal authority within some sort of communal framework because of its role in income generation and differentiation, land litigation and political empowerment.

From around 1940, the Department of Agriculture, rather than arguing for an improvement of general management practices (in a way which probably could have increased production and income), campaigned instead against the planting of wattle, particularly on slopes greater that 15 percent. Because of the ridge-valley topography of the most heavily settled areas of Central Province, the Department's campaign affected most of these areas.

By this time, however, other income generating land-use opportunities, such as pasture development, were possible and, in the face of increasing opposition from the Administration, wattle production in many areas was abandoned. Farmers

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1. KNA AGR/4/525, 7 May 1934. memorandum from the Deputy Director of Agriculture to Agricultural Officer, Central Province.

2. Humphrey (1945b), p.25.

who felled their wattle woodlots in the late 1940s were able to benefit because of peak post-war tanning extract prices. This final wattle boom period, which lasted into the early 1950s, contributed significantly to the "individualism" brought about by rising levels of income which the Administration so greatly feared.

The abandonment of wattle cultivation on a large scale was precipitated by the Emergency. The creation of a large number of Emergency villages resulted in the clearance of large areas of wattle for building timbers and for village fortifications. The trade in wattle bark became concentrated in the hands of loyalists who were the only persons able to get trading licenses and they greatly benefited.

Consolidation and the post-Independence wattle economy

Particularly as a result of consolidation and the Swynnerton Plan, wattle lost favor as a cash crop. There were too many other far more lucrative opportunities. Wattle had made great sense in the first place because of

-- the need to firmly establish cultivation rights by planting permanent crops;

-- the need to increase the control of right holders over fragmented plots, and particularly to reduce the influence of their *ahoi*, *aguri*, and *athami* tenants over these plots;

-- the need to generate income to mount land litigation;

-- the appeal of a land-use which generated income while producing commodities for household consumption;

-- the need to keep land productive with minimum expenditures of labour time; and

-- the lack of alternative income generating strategies.

Land reform made wattle less appealing. Previously, it had strengthened rights of use to land, both when it was planted by the original right holders as well as when it was planted by tenants. It reduced right holders' reliance on customary tenancy arrangements. With land reform, rights of use were guaranteed through adjudication, and there was no longer any need to assert rights of use through cultivation. Land reform and consolidation also changed patterns of labour organization by freeing up household labour which had formerly been used to cultivate dispersed fields. Finally, the removal of controls on the smallholder

production of coffee and tea and other cash crops presented an entirely new set of income generating strategies with which wattle could only compete with some difficulty.

Although there were efforts to incorporate wattle into the farm planning exercises of the early 1960s, nothing came of them. The price of wattle extract fell sharply between 1955 and 1960. A strong case for continued or expanded plantings could not be made. Between 1951 and 1962, African production of bark fell from 74 percent of the total to 36 percent[1] while producer prices fell by roughly a half. The balance of production shifted from smallholders, to estates operated by the tannin extract companies. Prices and exports of wattle bark and tanning extracts are discussed in greater detail in Appendix 5.

Even after prices slumped however, wattle was still widely grown, but not solely for bark. In Nyeri in the mid-1950s, for instance, it was reported that trees were cut in large quantities for poles and that the bark was not being stripped from them.[2] Most estate producers would have gone out of business had they been dependent on bark production alone. Stems can be harvested, and uses can be found for them, at virtually any rotation length. The decision to harvest at any particular time during the growth cycle will depend on the household's need for capital or wood-based products like fencing or building material as well as on the prevailing prices for charcoal, fuelwood, building poles, and *fitos*[3] and on access to alternative supplies of capital. All of these factors were acting to divert bark supplies from the tannin factories. At the same time, the presence of a huge range

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1. Colony and Protectorate of Kenya (1962). Agriculture Gazetteer of Kenya. Nairobi, Government Printer.

2. KNA AGR/4/343, 3 November 1955, memorandum from the Nyeri District Assistant Agricultural Officer to the Director of Agriculture.

3. *Fitos* are finger-thick stems which are used for the construction of a huge variety of farm structures, and which, most recently, have been heavily in demand as tomato stakes.

of possible uses for wattle ensured that it remained a popular on-farm tree.

Current wattle planting practices

Where wattle has been cleared in Central Province, land has largely been used for the planting of coffee, tea and for pasture development. Between 1957 and 1968, the area under smallholder coffee in Central Province increased from just under 5,000 ha to around 40,000 ha.[1] By 1985, the area under smallholder tea in Murang'a District (which had not been planted on any scale before 1960) increased to around 10,000 ha.[2] By comparison, wattle still accounts for around 6,000 ha of agricultural land in Murang'a. In some areas, it covers as much as 20 percent of farmland. There are still a number of very large woodlots in the district -- some as large as 15 ha.

As with many Colonial controls, it took many years for the Government of independent Kenya to remove controls on the wattle bark trade. The system of issuing permits for stripping bark was abolished in 1977, and movement controls on the transport of bark were abolished the following year.[3]

While wattle continues to account for large areas of land, little of it is intensively managed. Fieldwork in Murang'a suggested that many wattle woodlots are little more than fallow lands -- underutilized land which is maintained under trees -- and were originally planted many years ago. Only a third of the households surveyed reported that they had established their woodlots since 1980. Some woodlots, however, still continue to provide wattle bark, fuelwood, poles and charcoal on a regular basis. Woodlot management and utilization is discussed in Chapter 8.

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1. Thurston (1987), p.132; and, Kitching (1980), p.318.

2. Kenya Tea Development Authority (1985). *Annual Report.* Nairobi, KTDA.

3. Department of Agriculture (1978). *Annual Report, Murang'a District.* p.32.

Shade and Other Trees

Brief mention should be made of a number of other trees of economic value. The two other most frequently found trees on farms in Central Province are Grevillea robusta and eucalyptus. Grevillea first became popular in Kenya primarily as a coffee and tea shade tree. Young coffee and tea seedlings require protection from the sun, and also benefit from protection from wind.[1] Grevillea, as a fast growing tree which is relatively easy to regenerate, filled that role. It was adopted by coffee planters from the very earliest days of the industry in Kenya, and by 1910, the Forest Department had started planting it in mixed stands with cypress. In the 1940s, it was widely recommended as a timber tree for planting at altitudes below 2,000 metres, while cypress was recommended for higher altitudes.[2]

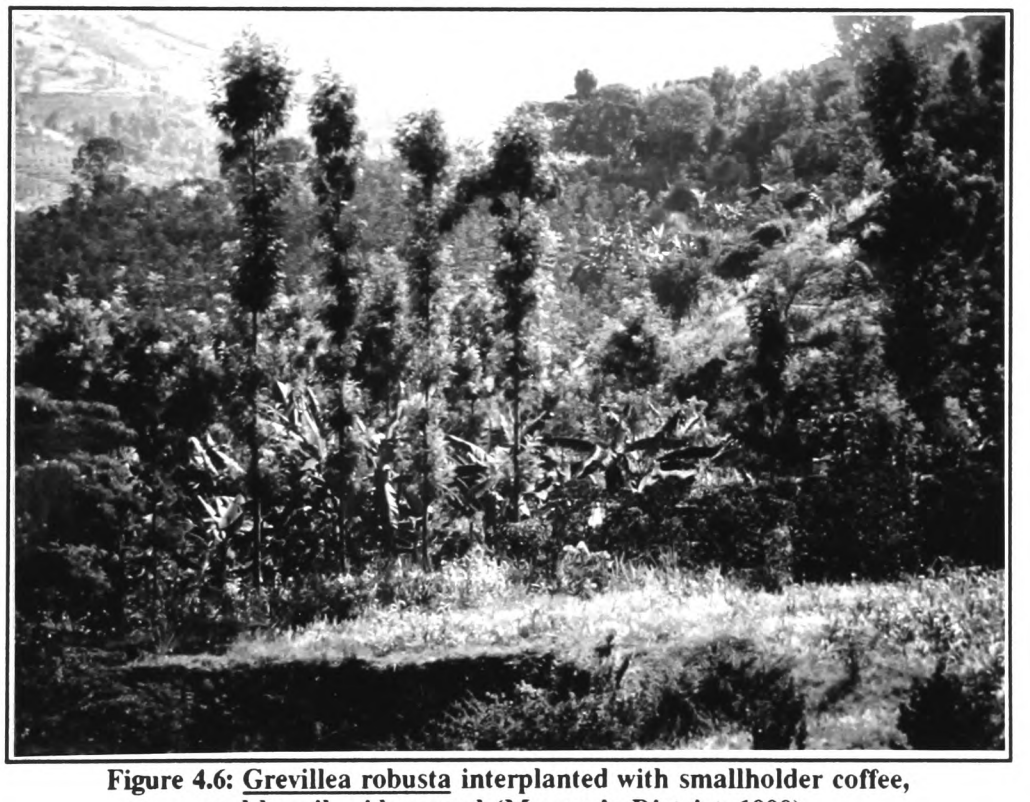


Figure 4.6: Grevillea robusta interplanted with smallholder coffee, and heavily sidepruned (Murang'a District, 1990).

The tree has a wide range of uses, in addition to the roles it serves in timber production and in protecting crops from sun and wind. Leaf litter is widely used in locally-developed green manure agroforestry systems in Central Province. The wood is appreciated as a fuel because it dries quickly. Much like on-farm cypress tree management, the branches are usually heavily

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1. G.H.Warren (1941). "Shelterbelts", *East African Agricultural Journal* (July). pp.8-19. While grevillea and eucalyptus were both recommended as shade and shelterbelt trees, Warren makes a convincing case for a number of indigenous trees such as *mūkūyū* (Ficus capensis and F.sycomorus).

2. R.M.Graham (1945). "Notes on the growing of cypress timber on farms", *East African Agricultural Journal* (January). pp.132-139.

pruned for fuel and for the construction of small farm buildings.

The practice of intercropping Grevillea trees with tea and coffee came into question in the 1960s. Research carried out at the East African Agriculture and Forestry Research Organization (EAAFRO) suggested that reduced windspeeds in tea estates increased the extremes of temperature, resulting in higher temperatures during the day and lower temperatures during the night.[1] Grevillea has also long been associated with a high incidence of the root-rot Armillaria mellea in coffee and tea.[2] Possible negative impacts of grevillea on cash crops have brought the tree into some disfavor amongst commercial coffee and tea growers, but the tree remains extremely popular amongst smallholders in many areas.

Eucalyptus was first widely promoted in Central Province in the 1930s, but never became as popular there as it did in Western Kenya where it was introduced as a fast-growing pole and fuelwood tree. In some areas, it was very widely planted to provide fuelwood for the railways, and old railway easements are easily identifiable by the predominance of old-growth eucalyptus. Generally however, gum trees have a far more limited range of values than trees like grevillea, wattle, or cypress, even though growth is much faster. The most common species planted on farms are E.grandis and E.saligna, as well as related hybrids which have developed over the many years these trees have been cultivated. In drier areas, E.camaldulensis predominates.

One of the tree's advantages was that it could be planted on swampy or water-logged soils, and would tend to dry them out and make them suitable for cultivation. Generally, E.robusta was preferred for this role. One of the Kikuyu

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1. E.A.Ripley (1967). "Effects of shade and shelter on the microclimate of tea", *East African Agricultural Journal* (July). pp.67-80.

2. G.B.Wallace (1935). "Armillaria root rot in East Africa", *East African Agricultural Journal* (November). pp.182-192. There is some evidence that this association was evident in the earliest days of the industry. See, FD 1924, p.22, which suggested that grevillea had fallen out of favor with coffee and tea growers as a shade tree.



Figure 4.7: Smallholder-grown Eucalyptus timber, split and stacked by the roadside for sale as fuelwood (Murang'a District, 1990)

names for eucalyptus, *mũnyua maai*, literally means "the drinker of water". The agricultural extension services have tried to discourage the planting of gum trees because of its alleged impacts on stream flows, but without much success.

Changes in Land Tenure and their Impact on Tree Tenure

A number of contemporary tree planting practices, such as the planting of trees on boundaries, are little changed from their pre-Colonial predecessors. Other practices, such as the management of trees that were under the control of *mbari* elders, changed substantially with the land tenure changes introduced in the late 1950s and 1960s. These changes affected rights to tree ownership and use which had formerly been guaranteed by customary law.

The Registered Land Act (Cap.300) of 1963 specified that, for holdings which were registered under the act, customary law would no longer apply. The outcome was that rights of control, and rights of use both became vested in the landowner, rather than in a lineage authority or lineage right holder. This legislation introduced important changes affecting tree tenure. Trees, as well as "all things growing on the land...and other things permanently affixed to the land" were the property of the registered land owner. Rights of control, then, were vested in the land owner, rather than in a lineage authority, and it would be up to the land owner to determine if an individual could use the trees growing there.

The effects of the legislation, like much of the land-related legislation of the 1950s and early 1960s, were most profoundly felt by the landless, who may have had rights of use to land, or to trees growing on *mbari* land which had been guaranteed to them by the *mũramati*, but who lost these rights as *mbari* land was registered in the names of the original right holders as private land owners.

Mbari lineage land-use right holders lost usufruct to communal tree resources as well. Landed farmers, however, were far more able to respond to the tree scarcities brought about by consolidation and registration than were the landless. Farmers who might otherwise have relied on *mbari* trees for timber and fuelwood supplies, but who no longer had access to them, were able instead to grow trees on their own, now consolidated, holdings. Indeed, they were already doing so from the 1940s, as real physical scarcities of trees were developing both on right holders' lands and on communal lands.

It is unlikely that the guarantees of private tree ownership *per se*, introduced by the Registered Land Act, actually encouraged farmers to plant more trees. In fact, the ownership of planted trees had long been guaranteed by customary law. Planted trees always belonged to whomever planted them, *but only as long as they held some sort of cultivation rights*. The Registered Land Act increased the security of *these* rights, and it was this security which likely had a greater impact on the farmer's interest in tree planting and in making other improvements to the land.

Controls on Tree Planting

While it might have been conveyed that farmers are freely able to plant and harvest trees as they choose, this is not exactly the case. Several pieces of legislation place some controls on tree planting and other land-uses and bear mention here. These are the Chief's Authority Act (Cap.128), the Agricultural (Basic Land Usage) Rules and the Agricultural Act (Cap.318) from which they were

derived.

The earliest versions of the Chief's Authority Act were first introduced in Kenya in the 1920s as the Administration sought to develop a framework of local government which could be responsive to its needs. The chiefs were widely enlisted in the Government's various agricultural campaigns, and they were empowered in the process to regulate a wide range of land-uses.

The current Chief's Authority Act is extremely wide ranging. Chiefs are able to require,

> "...persons to plant any specified crops for the support of themselves and their families when the area concerned is suffering from or threatened with a shortage of foodstuffs."

The Act also allows a chief to prohibit grazing in areas which are being rehabilitated or which have been planted with fodder crops. Finally, it also empowers a chief to employ compulsory labour in the event of natural catastrophes or other emergencies, and for "the conservation of natural resources" (a euphemism for compulsory tree planting and soil conservation work).

With regard to tree harvesting, Section 10 of the Act specifies that,

> "Any chief may from time to time issue orders to be obeyed by the persons residing or being within the local limits of his jurisdiction for...(the purposes of) regulating the cutting of timber and prohibiting the wasteful destruction of trees...*or for any other purpose appointed by the Minister in writing.*" (emphasis added)

This last provision gives wide-ranging authority to a chief to enforce any land-use practice which he, or the Government, wishes to introduce.

The provisions of the Chief's Act are strengthened by the Agricultural Act and the Agricultural (Basic Land Usage) Rules which empower the Minister to require afforestation or reforestation. The Agricultural Act also makes provision for the regulation of the planting of cash crops such as coffee and tea. These crops can neither be planted nor taken out without a permit.

The Land Usage Rules also regulate hillside cultivation. They prohibit the cutting of trees and the grazing of livestock on hills with slopes of greater than 35 percent. They empower Agricultural Officers to prohibit cultivation on land which is greater than 20 percent slope, and to require soil conservation measures on any cultivated land between 12 percent and 35 percent in slope.

There is no consistency whatsoever in the extent to which controls on farmer tree growing are enforced. As they are most commonly enforced, chiefs may require a farmer to obtain a license before trees can be harvested in exchange for a payment of one form or another. In some areas, this requirement has acted as a disincentive to plant trees because there is no assurance that the trees can be harvested. Indeed, the general practice of requiring licenses to plant particular crops acts as a disincentive to alter patterns of land-use in response to changing economic conditions.

Rules and regulations about tree planting are introduced and enforced with great irregularity and as it becomes politically expedient to do so. In 1985 for instance, eucalyptus came under heavy attack in Parliament, following the head-of-state's vocal concern about the possible negative impacts of these trees on the environment. A ban on the planting of gum trees was very nearly introduced. Since then, the discussion about eucalyptus has been greatly tempered, in part because of a growing realization of the economic value of the tree to the rural economy.

More generally, however, potential problems with the authorities are reduced by the discrete harvesting and management of trees. This means that trees are sometimes harvested and managed individually or in small blocks, rather than as an even-aged group: if a few poles are harvested from a woodlot and sold, no one really notices; if the woodlot were entirely cleared, there might be problems. Where permits are not generally required, it is more common to see entire stands of trees or windrows felled at the same time.

Chapter 5. Scope and Organization of Household Studies

Background

Previous chapters have made the case that woodlots have long been an integral feature of the rural economy and social setting in Murang'a. As land became more scarce and as traditional land tenure systems became less secure, woodlots became increasingly important because of the need to firmly establish cultivation and tenure rights by planting permanent crops, the need to generate income to fight (or to mount) land litigation, and the need for alternative ways of producing wood-based products as access to trees on communal lands became constrained.

Less directly linked to land tenure processes were other characteristics of the pre-Independence rural economy which had made woodlot growing a favorable proposition for African smallholders. These were related to features of the migrant labour economy which encouraged the adoption of land-uses which would keep the land productive with minimum expenditures of household labour time. There were also few alternative strategies for on-farm income generation because Africans were virtually excluded from cash crop production until the late 1950s; trees filled an extremely important role in this respect.

Some of the characteristics of the pre-Independence rural economy which encouraged tree cultivation and management continue to play a role. For instance,

-- there are limited alternatives for obtaining wood-based products for household consumption;

-- some households have a continuing need to reduce expenditures of household labour time on agricultural land-uses; and

-- households may be excluded from alternative on-farm income generating strategies.

The objective of the field-based component of this research project, then, has been to explore some of the relationships between tree growing practices and factor allocation processes at the household level, particularly to test the hypotheses that:

-- tree growing as a labour conserving activity, complements urban wage employment as a strategy for overcoming malfunctioning factor markets and helps to ease land-use constraints imposed by labour migration; and that

-- tree growing as a land-use which requires low capital and recurrent costs is pursued where malfunctioning factor markets have made it problematic for farmers to plant other capital-intensive crops.

In order to test these hypotheses, a household survey was undertaken. This Chapter describes how the household survey was implemented.

Selection of the Study Area

In focussing on a particular part of Murang'a District in which to carry out the household survey, there were a number of characteristics of the study site which were especially desirable: agroecological variability should be relatively limited; there should be enough social and economic variability to test the hypotheses; and the area should have been settled for a reasonably long-time.

Land-use practices in Kenya are closely associated with characteristics of the agroclimate such as rainfall, temperature, soils, and so on. Land-use surveys discussed in Chapter 1 clearly show that the proportion of land which is left under -- or planted with -- woody cover is roughly the same across agroecological zones in Murang'a, but that other land-uses (whether farmers planted tea, coffee, maize, bananas, and so on) vary across zones. While the total area accounted for by trees is relatively constant across zones, the *types* of tree cultivation and management practiced across zones *do* vary.

Species choice and farmers' tree management approaches are often specific to particular agroclimatic zones. The quality of black wattle bark, for instance, is quite dependent on ambient temperatures. The lower the temperature, the thicker

the bark and the higher the tannin content. For this reason, wattle is especially uncommon at lower altitudes, and is more frequently found above around 1500 metres. Productivity is optimal at still higher altitudes. Grevillea does well below 2000 metres but does poorly above that altitude. Cypress is common across a wide range of zones. Different varieties of eucalypts (such as E.camaldulensis) are best suited for drier areas.

Based on earlier land-use studies, a zone between 1500 metres and 2000 metres in elevation was tentatively identified to help delineate the boundaries of the study area. There are a number of particularly interesting tree-growing strategies which are common in this area; trees are planted in windrows, along boundaries, scattered in fields, and in woodlots. Maize and maize intercrops are the primary food crops in this area and smallholder tea and coffee are the primary cash crops. This area was around 15 km wide (east to west), and around 30 km long (north to south) and so covers an area of around 450 km^2.

Using aerial photography, the choice of study sites was further defined and was selected to closely follow the 1800 metre contour across the district. By doing this, agroecologic variability was kept to a minimum so that variation between households could be expected to be a function of their factor endowments, rather than a function of agricultural conditions. The study area is at roughly the transitional altitude between the upper coffee zone and the lower tea zone. Of the two crops in the study area, amongst sample households, tea predominates.

The selection of a sampling frame stratified on the basis of income was not possible because of a lack of household-specific information (which could only have been collected through extensive and expensive sampling and pretesting). The subject under consideration -- economic differences amongst woodlot and non-woodlot growing households -- suggested instead that the sampling frame could be

"tree dependent" -- one of the objects of the exercise being to establish how *these* households were economically differentiated. Aerial photography proved to be particularly valuable in this regard. The use of aerial photographs for establishing the sampling frame is discussed below.

A third criteria for the selection of the study area relates to the length of time the area has been settled and cultivated. The problem was to avoid areas where woodlots are an innovation which are being introduced in newly cultivated areas, rather than an already accepted land-use practice. The objective was to ensure that tree growing practices are largely a function of the household's factor endowments, rather than a function of a lack of knowledge about tree growing or about the most appropriate trees for each agroecological zone.

The most densely populated parts of the district, which are between 1500 and 2000 metres in altitude, have been settled the longest (as long as 400 years in some areas). These were the areas which were the focus of the earliest wattle planting campaign in 1917. Clearly, wattle is a widely known and well-understood agricultural technology in this zone.

The Sampling Frame

Aerial photography

An extensive series of low level aerial photographs of the study area were taken and were used in conjunction with larger format photos and maps to establish the sampling frame. Rather than using a "point-sampling" approach such as that described by Norton-Griffiths,[1] a series of photographic transects representative of the study area were assembled.

Flight lines along which low level aerial photos were to be taken were laid out using topographic maps at a scale of 1:50,000. The 1800 metre contour was

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1. M.Norton-Griffiths (1988). "Aerial point sampling for land use surveys," *Journal of Biogeography*. 15:149-156.

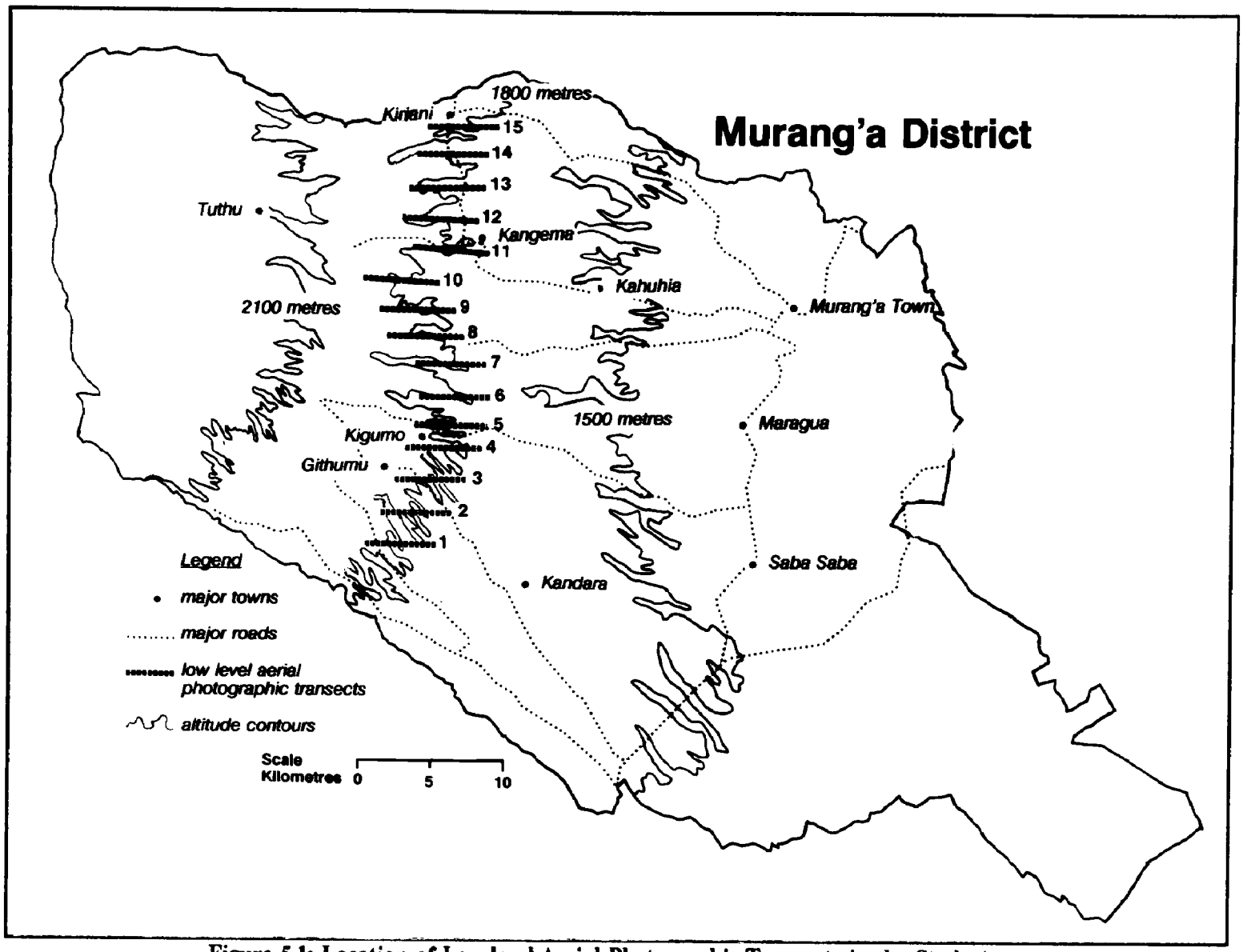


Figure 5.1: Location of Low-level Aerial Photographic Transects in the Study Area

first outlined and then 15 east/west transects were drawn such that they were bisected by the contour, at 2 km north/south intervals. Transects were 5 km long. Using this approach, the study area covered around 140 km^2. Figure 5.1 shows the location of the transects.

A camera was mounted outside the open window of a Cessna 152 single-engine aircraft. Photographs were taken with a Nikon FG camera fitted with a 50 mm f2.0 lens, a motor drive, a cable release, and a data back. Transparencies were taken using Kodachrome ASA 200 colour diapositive film. Sequential numbers were recorded on each exposure. Photographs were taken at an altitude of around 2000 feet above ground level. Each photograph covered around 11.5 ha of ground area. The aircraft travelled at a ground speed of 80 knots (about 40 metres per second), and exposures were taken at 7 second intervals, producing

photographs at a scale of around 1:12,000 with 30 percent overlap. The period of aerial reconnaissance took about 22 hours of flying time, stretched out over about 6 months. Over 1500 aerial photographs were taken.[1]

Once low-level photos had been taken, ground locations were plotted on 1:50,000 topographic maps. Ground locations could be plotted on the topographic maps to within 50 metres of their true locations. The number of each photograph was marked at its corresponding location on the map. Working copies of the original transparencies were prepared as colour print enlargements (5"x7") at a scale of about 1:2000.

Selection of the sample

Full coverage panchromatic 1:20,000 enlargements of a set of 1:50,000 photographs taken in 1967 were compared with the recent set of aerial photos.[2] Woodlots are one of the few gross land-use features which are evident in these high altitude photos. When comparing these photos with recent low-level aerial photos, it was relatively easy to identify parcels which are currently used for growing woodlots as well as parcels which were used for growing a woodlot in 1967, but which have been cleared and are being used for something else. By focusing on these groups of parcels, the intention was to trace entry and exit into tree growing, and to explore the incentives which have encouraged (or discouraged) households which operate these parcels to adopt or to abandon tree growing.[3]

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1. Low-level photographs were taken on 31 January 1989 (transects 2,3,9, and 10); 2 February 1989 (transects 11 and 14); 15 March 1989 (transects 7, 8, 12, and 13); and 17 March 1989 (transects 1, 4, 5, and 6). The full set of low-level photographs which were used in setting up the sample comprises around 325 exposures.

2. Survey of Kenya (Ministry of Lands and Settlement) 1:50,000 series aerial photos, Numbers V13B/595: 147, 148, 149, 151, 152, and 153; 22 January 1967, 10 to 11 a.m. Mr.T.Ongeri, of the Survey of Kenya, was particularly helpful in locating the photographs I was interested in and his assistance was greatly appreciated.

3. There was of course no way of determining from the photographs the nature of tenure rights to the parcels in question. In this sense, the survey was quite unique in that the sampling frame was established *solely* on the basis of differences in land-use, without any reference to characteristics of the households which operated the sampled parcels.

Woodlot coverage in the 1967 aerial photos was compared with coverage on recent low-level photos. Specific parcels were identified which are no longer used for growing woodlots. A total of 198 former woodlot sites were located. Sites were numbered, and a random number generator was used to select a sample, comprising 80 parcels. The same approach was used for setting up a sample of woodlot growing households. A total of 534 woodlots met selection criteria, and a random sample of 80 parcels were selected for household interviews.

If sampled plots fell within the same north-south axis or bordered other sample plots, they were rejected and a new plot from the original sample was chosen. This approach was taken to limit a bias toward parcels that were photographed at the highest aircraft-to-ground altitudes and to reduce the likelihood that two sampled parcels would be operated by the same tenure holder.[1]

The subsample of woodlot operating households considered only current land-use practices, and did not consider whether or not a woodlot was on this site in 1967.

The Survey

The questionnaire

A questionnaire was developed and pretested in September and October 1989, and was revised on the basis of the results from pretesting. A number of problems became immediately evident during pretesting:

-- There were problems in determining the scale of the aerial photographs and problems of photographic coverage of entire parcels. The original objective was to measure parcels and plots from the aerial photographs, but it became clear during pretesting that few entire parcels appeared in the photographs, and so would have to be measured on the ground anyway.

-- A team of local enumerators, working in the vernacular, would have been most appropriate for implementing the survey.

-- The survey was unnecessarily complex in some respects, and was insufficiently precise in others.

-- Questions regarding income, savings, expenditure and remittances were far too sensitive to confidently address.

-- Many farmers cultivated multiple parcels, and there had been no allowance for this in the original questionnaire.

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1. Aerial photographs were taken from an aircraft which flew at a constant altitude. The ground altitude varied. Photographs which were taken at a higher aircraft-to-ground altitude covered a proportionately larger area. This introduced the potential for sampling error, which was limited by selecting single parcels on the same north-south axis.

The questionnaire was revised on the basis of pretesting. In its revised form, the questionnaire largely relates to the household's factor endowments and its resource allocation processes, particularly

-- household composition: size, the extent of the resident household, nonresident relatives of resident household members; age, education; children in school; dependency;

-- labour composition: gender; labour hired in (permanent, casual, seasonal); labour hired out (urban formal or informal, rural agricultural or nonagricultural); seasonality; remittances to the household;

-- general features of land-use: period of residence, additions to the shamba, additions of other land holdings, the extent of local land purchase/rental; cropping patterns; changes in cropping patterns; crop marketing;

-- livestock: number; meat or dairy; grade, cross-bred, traditional;

-- extent and quality of farm assets: building quality, number; machinery, equipment, bicycles, etc.; recent changes in assets, how financed;

-- household savings: use of banking or non-bank financial institutions; role of Savings and Credit Cooperative Organizations; involvement in cooperative marketing, input, and processing organizations;

-- household investments: sources of finance for investments in the farm (borrowing, land sales, remittances, sale of assets).

-- harvesting and processing of woodlot products: charcoal, fuelwood, poles, wattle bark; the extent to which these were sold or used by the household; seasonality of harvest; who harvests; disposition of income.

The questionnaire is included as Appendix 2.

Field measurements

For every plot within each parcel in the sample, field measurements were taken. The length of each side of each plot was measured using either a measuring wheel or a measuring tape. A siting compass was used for taking the bearings of each side of the plot. A clinometer was used to measure the slope of each plot in the parcel. Enumerators recorded the use of each plot at the time of the survey (January to April, 1990), what the plot was being used for during the previous short rains (October to November, 1989), and what the plot was being used for during the previous long rains (March to May, 1989). The altitude of each sampled household was determined from topographic maps and was recorded.

In addition to the field measurements which were taken, enumerators drew the boundaries of each parcel and plot on a transparent overlay positioned over the aerial photograph. This allowed for the further checking and validation of the field measurements.

Around 60 percent of the households surveyed were cultivating multiple parcels. Reported holding sizes and information about fragmentation and tenure was recorded at the time of the interview, but field measurements were only undertaken of the parcel which appeared in the aerial photographs -- regardless of whether or not that parcel was the parcel of the household's primary residence. It was envisaged that regression analysis, using field measurements and other survey data, would be used to estimate total holding size.

Implementation

Arrangements were made with the Central Bureau of Statistics, through the Murang'a District Statistical Officer, to employ 4 enumerators and a supervisor to assist in carrying out the survey. The survey was initiated after a short training period and was carried out from 4 January through 16 March 1990.

The sample comprised 160 households, 37 of which were rejected because the parcel was vacant, the woodlot on the parcel was not a black wattle woodlot, the parcel was being operated by a school, cooperative society or was owned by the Government, the operator of the parcel had already been interviewed as the operator of a second parcel in one of the 2 subsamples, or the operator of the parcel was unwilling to cooperate. Only 2 of the sample parcels could not be located.

Data entry and cleaning

Data from the questionnaire was reviewed and returned to the enumerators for clarification or correction usually within a few days after each interview. After

obvious problems with the data had been sorted out, it was entered into an SPSS data base using a data entry software package. Other data discrepancies and coding problems were identified using a cleaning routine which captured relational data errors and some entry errors. A third cleaning stage was undertaken during preliminary data analysis which checked for consistencies between data files.

In order to clean and analyze the data collected from field measurements, a routine was written in *Basic* computer language which calculated the area of each measured plot. Coordinates for each plot were calculated and computer generated scale drawings were produced for comparison with aerial photos and sketched overlays. If irregularities were encountered at this stage, measurements were returned to enumerators for checking and possible remeasurement. Corrected areas were imported into an SPSS data file for analysis. The algorithm for calculating area measurements and documentation for the computer programmes used to enter area measurement data is included in Appendix 3.

Descriptive statistics summarizing some of the key findings from the field work follow in Chapters 6, 7 and 8. Chapter 6 examines how household composition and employment differ amongst surveyed households. Chapter 7 addresses patterns of land-use and distribution. Chapter 8 covers savings and investment, assets, input use, income generation, and woodlot management and woodfuel issues. An analysis of the data in Chapters 6, 7 and 8 is developed in Chapter 9, and for this reason, a discussion of the data in Chapters 6, 7, and 8 has been limited.

Chapter 6. Household Composition, Age Structure, and Employment

This Chapter reviews the findings of the survey with regard to household composition and employment. The hypotheses posited earlier in this dissertation suggested that labour-availability may be playing a key role in the household's decision to adopt or to abandon the growing of a woodlot. Differences in the ways in which households are able to allocate available labour supplies can be particularly instructive. For instance, woodlot growing households could be expected to have a lower labour-to-land ratio than households which don't grow woodlots.[1] Other differences might be evident in differences in household composition, age structure, and in participation in off-farm or migrant employment. This section explores some of these differences.

Household Composition

Differences in household composition between the sampled households are summarized in Table 6.1. Table 6.2 summarizes differences in age and education amongst resident household members. Table 6.3 categorizes resident household members by general activity and age: children in school and not, working-age adults, elderly adults, and so on. Data about household composition is developed

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1. There is something of a semantic difficulty in the use of this terminology. The sample was determined on the basis of whether there was a woodlot growing on one of the current household's plots in 1967. The relationship of the current household with the household which was resident in 1967 was not used in determining whether or not a household should have been included in the sample. To refer to these households as "households which are no longer growing a woodlot" or "household's which don't grow woodlots" is a technically incorrect way of saying "households which are current operators of plots which were used for growing a woodlot in 1967."

Table 6.1: HOUSEHOLD COMPOSITION, RESIDENT HOUSEHOLD MEMBERS

RESIDENT HOUSEHOLD MEMBER	WOODLOTS: MEAN NUMBER OF RESIDENTS PER HOUSEHOLD	FORMER WOODLOTS: MEAN NUMBER OF RESIDENTS PER HOUSEHOLD	SIGNIF-ICANCE	T VALUES
MALE HEAD	0.71	0.68		0.4
FEMALE HEAD	0.29	0.32		-0.2
WIFE OF HEAD	0.78	0.67		1.1
SON OF HEAD	1.71	2.28	*	-1.8
DAUGHTER OF HEAD	1.49	1.95		-1.5
DAUGHTER-IN-LAW	0.13	0.05		1.3
MOTHER OF HEAD	0.05	0.03		0.4
OTHER MALE	0.30	0.37		-0.4
OTHER FEMALE	0.11	0.17		-0.7
TOTAL	5.57	6.52	*	-1.79

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

Table 6.2: AGE AND EDUCATION OF RESIDENT HOUSEHOLD MEMBERS

RESIDENT HOUSEHOLD MEMBER	WOODLOTS: MEAN AGE OF HOUSEHOLD MEMBER (YEARS)	WOODLOTS: MEAN LEVEL OF EDUCATION (YEARS COMPLETED)	FORMER WOODLOTS: MEAN AGE OF HOUSEHOLD MEMBER (YEARS)	FORMER WOODLOTS: MEAN LEVEL OF EDUCATION (YEARS COMPLETED)	SIGNIFICANCE: AGE	SIGNIFICANCE: EDUCATION	T-VALUES: AGE	T-VALUES: EDUCATION
MALE HEAD	53	5	46	7	**		2.0	-1.6
FEMALE HEAD	57	2	47	2	**		2.1	0.0
WIFE OF HEAD	43	5	38	5	*		1.6	-1.1
SON OF HEAD	15	5	13	5			1.0	0.6
DAUGHTER OF HEAD	15	4	13	4			1.2	-0.3
DAUGHTER-IN-LAW	27	8	30	7			-0.3	..
MOTHER OF HEAD	78	0	66	0			1.1	..
OTHER MALE	14	3	11	3			1.0	0.3
OTHER FEMALE	9	4	9	4			0.1	0.1

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent

further in Figure 6.1.

There are significant differences in the total number of people resident in the sampled households. Households which are no longer growing woodlots are around 17 percent larger than households which are growing a woodlot. The

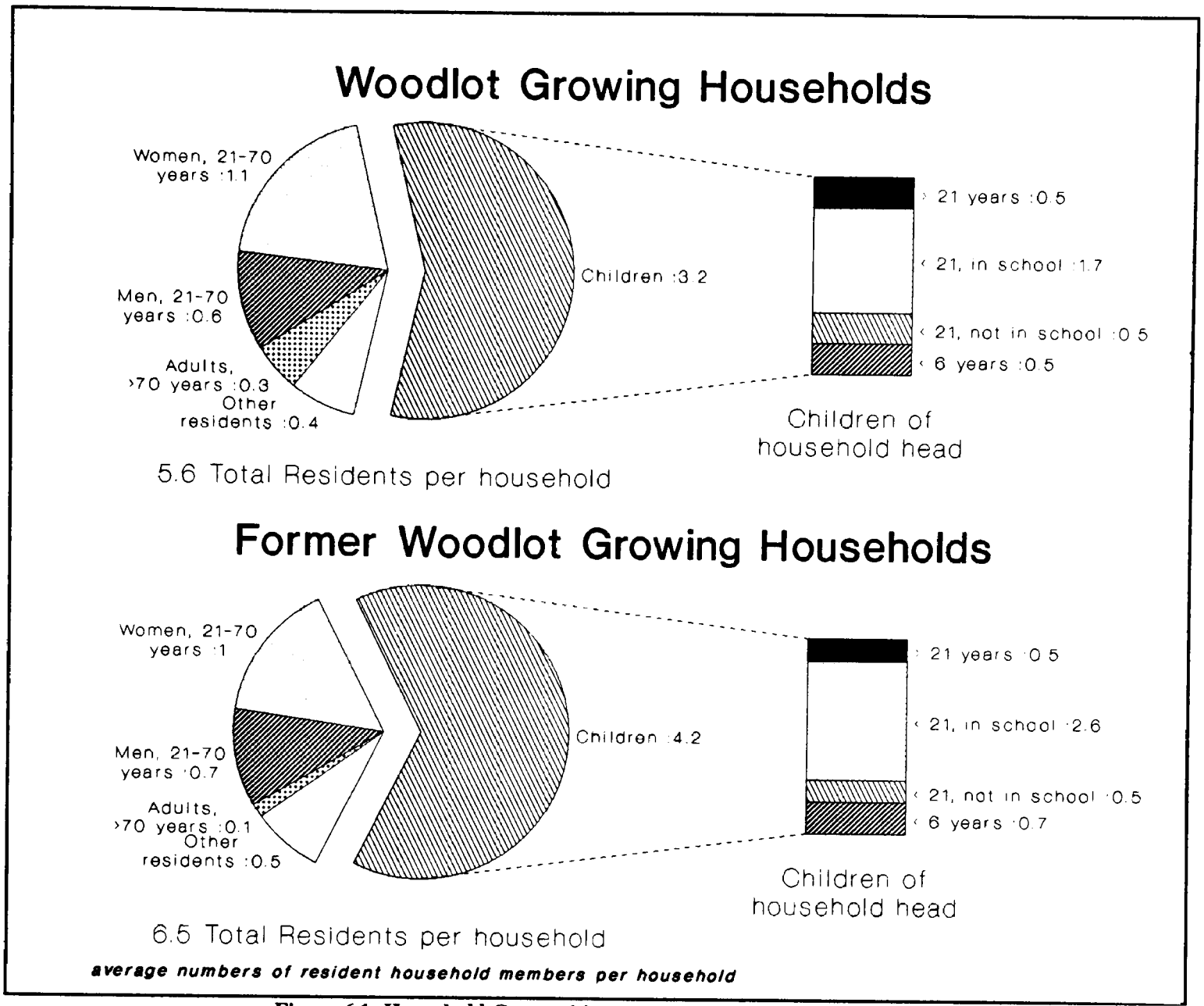


Figure 6.1: Household Composition Amongst Surveyed Households

difference is mostly accounted for in terms of the number of children in the respective households. Former woodlot growing households, on average, have one more resident child per household. If gender is considered, former woodlot growing households have around 30 percent more resident sons than woodlot growing households. There were no significant differences in the total numbers of resident and nonresident children in sampled households. Around 30 percent of the households in both groups were headed by women who were widowed, unmarried, or whose husbands were permanently away.

Differences in the numbers of resident household members are likely related to differences in the age structure of the respective households. Heads of woodlot growing households (and the wives of male heads) are generally older than the

Table 6.3: HOUSEHOLD CHARACTERISTICS: RESIDENT HOUSEHOLD MEMBERS

HOUSEHOLD CHARACTERISTICS	WOODLOT GROWING HOUSE-HOLDS	FORMER GROWING HOUSE-HOLDS	SIGNIF-ICANCE	T-VALUES
NUMBER OF HOUSEHOLDS IN SAMPLE	63	60		
NUMBER OF RESIDENT HOUSEHOLD MEMBERS	351	391		
RESIDENT HOUSEHOLD MEMBERS, PER HOUSEHOLD	5.57	6.52	*	-1.8
DISTRIBUTION OF RESIDENT CHILDREN OF HOUSEHOLD HEADS				
NUMBER OF CHILDREN >21 YEARS OF AGE (1)	0.49	0.45		0.3
NUMBER OF CHILDREN OF SCHOOL AGE (2)	2.05	2.85	**	-2.0
NUMBER OF CHILDREN OF SCHOOL AGE IN SCHOOL	1.63	2.42	**	-2.1
NUMBER OF CHILDREN OF SCHOOL AGE, NOT IN SCHOOL	0.41	0.43		-0.1
NUMBER OF CHILDREN ≤ 6 YEARS OF AGE	0.67	0.93		-1.3
TOTAL NUMBER OF RESIDENT CHILDREN PER HOUSEHOLD	3.21	4.23	**	-2.1
DISTRIBUTION OF WORKING AGE ADULTS (3)				
MEAN NUMBER OF WORKING-AGE WOMEN PER HOUSEHOLD				
FEMALE HEAD				
HUSBAND IS AWAY	0.14	0.15		-0.1
WIDOW OR UNMARRIED	0.10	0.15		-0.9
WIFE OF HEAD OR OTHER COWIFE	0.75	0.67		0.8
DAUGHTER OF HEAD	0.19	0.15		0.5
DAUGHTER-IN-LAW	0.11	0.05		1.0
MOTHER OF HEAD	0.02	0.02		0.0
TOTAL NUMBER OF WORKING-AGE WOMEN PER HOUSEHOLD	1.30	1.18		0.9
MEAN NUMBER OF WORKING-AGE MEN PER HOUSEHOLD				
MALE HEAD OF HOUSEHOLD	0.54	0.62		-0.9
SONS OF HEAD	0.30	0.30		0.0
OTHER MALE	0.05	0.07		-0.5
TOTAL NUMBER OF WORKING-AGE MEN PER HOUSEHOLD	0.89	0.98		-0.6
RATIO OF WORKING-AGE WOMEN TO MEN	1.46	1.20		..
MEAN NUMBER OF ADULTS PER HOUSEHOLD >70 YEARS OLD	0.25	0.08	***	2.5
MEAN NUMBER OF OTHER RESIDENTS PER HOUSEHOLD	0.41	0.53		-0.6
DEPENDENCY RATIO (4)	0.94	1.22		..

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated
(1) The distribution of working-age resident sons and daughters is given below, under working-age adults.
(2) Defined as being >6 years old but ≤ 21 years old.
(3) Defined as being >21 years of age but ≤ 70 years old. Heads of households and wives less than 21 years old are excluded.
(4) Defined as the ratio of Residents 0-15 and 64+ years of age to residents between 15 and 64 years of age.

heads of households of former woodlot growing households. Male heads of woodlot growing households are around 7 years older than the male heads of former woodlot growing households. Female heads are around 10 years older, and wives are around 5 years older.

If these households are older, it could be expected that the ages of their

Table 6.4: COMPOSITION OF NON-RESIDENT RELATIVES OF RESIDENT HOUSEHOLD MEMBERS

NON-RESIDENT RELATIVE OF RESIDENT HOUSEHOLD MEMBER	WOODLOTS: MEAN NUMBER OF NON-RESIDENT RELATIVES PER HOUSEHOLD	FORMER WOODLOTS: MEAN NUMBER OF NON-RESIDENT RELATIVES PER HOUSEHOLD	SIGNIFICANCE	T-VALUES
HUSBAND	0.11	0.13		-0.4
WIFE	0.02	0.00		..
SON	0.89	0.48	**	2.1
DAUGHTER	1.29	0.58	***	3.0
TOTAL	2.30	1.20	***	3.04

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

Table 6.5: AGE AND EDUCATION OF NON-RESIDENT RELATIVES OF RESIDENT HOUSEHOLD MEMBERS

NON-RESIDENT RELATIVE OF RESIDENT HOUSEHOLD MEMBER	WOODLOTS: MEAN AGE OF RELATIVE (YEARS)	WOODLOTS: MEAN LEVEL OF EDUCATION (YEARS COMPLETED)	FORMER WOODLOTS: MEAN AGE OF RELATIVE (YEARS)	FORMER WOODLOTS: MEAN LEVEL OF EDUCATION (YEARS COMPLETED)	SIGNIFICANCE: AGE	SIGNIFICANCE: EDUCATION	T-VALUES: AGE	T-VALUES: EDUCATION
HUSBAND	54	6	52	5			0.6	0.1
WIFE	26	13	..	..			..	..
SON	31	9	27	8	*		1.6	1.1
DAUGHTER	34	6	27	7	***	*	3.6	-1.9

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

children would also be older. Amongst resident children of household members however, there are no significant differences in age between the two sets of sampled households. This is not too surprising, as there are accepted norms for how long children live at home. The *number* of children still in residence, however, *is* greater amongst former woodlot growing households, suggesting that there are children in these households who are not yet old enough to have married and moved away.

Because households have different age structures, it could be expected that

Table 6.6: CHARACTERISTICS OF NON-RESIDENT RELATIVES OF RESIDENT HOUSEHOLD MEMBERS

HOUSEHOLD CHARACTERISTICS	WOODLOT GROWING HOUSE-HOLDS	FORMER GROWING HOUSE-HOLDS	SIGNIF-ICANCE	T-VALUES
NUMBER OF HOUSEHOLDS IN SAMPLE	63	60		
NUMBER OF NON-RESIDENT RELATIVES OF RESIDENT HOUSEHOLD MEMBERS	145	72		
NON-RESIDENT RELATIVES, PER HOUSEHOLD	2.30	1.20	***	3.0
DISTRIBUTION OF NON-RESIDENT CHILDREN OF RESIDENT HEADS OF HOUSEHOLD				
NUMBER OF CHILDREN >21 YEARS OF AGE (1)	1.79	0.83	***	2.8
NUMBER OF CHILDREN OF SCHOOL AGE (2)	0.37	0.23		1.1
NUMBER OF CHILDREN OF SCHOOL AGE IN SCHOOL	0.25	0.07	**	2.0
NUMBER OF CHILDREN OF SCHOOL AGE, NOT IN SCHOOL	0.11	0.17		-0.8
NUMBER OF CHILDREN ≤ 6 YEARS OF AGE	0.02	0.00		..
TOTAL NUMBER OF NON-RESIDENT CHILDREN PER HOUSEHOLD	2.17	1.07	***	3.2
DISTRIBUTION OF WORKING AGE ADULTS (3)				
HUSBANDS	0.11	0.13		-0.4
WIVES	0.02	0.00		..
SONS	0.70	0.37	**	2.1
DAUGHTERS	1.10	0.47	***	2.7
TOTAL NUMBER OF WORKING AGE NON-RESIDENT RELATIVES OF RESIDENT HOUSEHOLD MEMBERS	1.92	0.97	***	2.7
RATIO OF WORKING-AGE NON-RESIDENT WOMEN TO MEN	1.37	0.93		..
MEAN NUMBER OF NON-RESIDENT ADULT RELATIVES PER HOUSEHOLD >70 YEARS OLD	0	0		..

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated
(1) The distribution of working-age resident sons and daughters is given below, under working-age adults.
(2) Defined as being >6 years old but ≤ 21 years old.
(3) Defined as being >21 years of age but ≤ 70 years old. Heads of households and wives less than 21 years old are excluded.
(4) Defined as the ratio of Residents 0-15 and 64+ years of age to residents between 15 and 64 years of age.

differences would also be evident in the numbers and ages of children who are no longer in residence: older households could be expected to have a larger number of their children living away from the shamba, and younger households could be expected to have a larger number of children living at home under the age of marriage.

These ideas are borne out by data about the age and composition of non-resident relatives of resident household members. The distribution of non-resident relatives (husbands, wives, sons or daughters) of resident household members

Table 6.7: OCCUPATION AND EMPLOYMENT AMONGST RESIDENT HOUSEHOLD MEMBERS

	OCCUPATION/EMPLOYMENT IN NUMBERS OF RESIDENTS PER HOUSEHOLD									
	PARCELS WITH WOODLOTS					PARCELS FORMERLY WITH WOODLOTS				
RESIDENT HOUSEHOLD MEMBER	WORKS ON FAMILY FARM	WORKS AS WAGED LABOUR (1)	STUDENT IN SCHOOL	NOT IN LABOUR FORCE (2)	TOTAL	WORKS ON FAMILY FARM	WORKS AS WAGED LABOUR (1)	STUDENT IN SCHOOL	NOT IN LABOUR FORCE (2)	TOTAL
MALE HEAD	0.48	0.19	0.00	0.05	0.71	0.53	0.13	0.00	0.02	0.68
FEMALE HEAD	0.24	0.03	0.00	0.02	0.29	0.27	0.05	0.00	0.00	0.32
WIFE OF HEAD	0.73	0.03	0.00	0.02	0.78	0.63	0.03	0.00	0.00	0.67
CHILD OF HEAD	0.75	0.11	1.79	0.56	3.21	0.78	0.08	2.58	0.78	4.23
OTHER RESIDENT	0.16	0.08	0.17	0.17	0.59	0.08	0.08	0.25	0.20	0.62
TOTALS	2.35	0.44	1.97	0.81	5.57	2.30	0.38	2.83	1.00	6.52

	T-VALUES					SIGNIFICANCE				
RESIDENT HOUSEHOLD MEMBER	WORKS ON FAMILY FARM	WORKS AS WAGED LABOUR	STUDENT IN SCHOOL	NOT IN LABOUR FORCE	TOTAL	WORKS ON FAMILY FARM	WORKS AS WAGED LABOUR	STUDENT IN SCHOOL	NOT IN LABOUR FORCE	TOTAL
MALE HEAD	-0.6	0.9	..	1.0	0.4					
FEMALE HEAD	-0.4	-0.5	..	..	-0.4					
WIFE OF HEAD	0.9	-0.1	..	..	1.1					
CHILD OF HEAD	-0.2	0.5	-2.2	-1.3	-2.1			**		**
OTHER RESIDENT	1.1	-0.1	-0.6	-0.2	-0.1					
TOTALS	0.2	0.5	-2.4	-0.9	-1.8			**		*

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-value not calculated

(1) includes labour hired out to work on small farms, resident labour hired by the household, labour hired out to work on large-scale farms, employment in both urban and rural businesses, self-employment, employment in the public sector, employment as a teacher, and those looking for waged work.

(2) includes the elderly, the disabled, and young children.

amongst the sample households is summarized in Table 6.4. Their age and education are summarized in Table 6.5. Table 6.6 categorizes non-resident relatives of resident household members by general activity and age: children in school and not, working-age adults, elderly adults, and so on.

On average, there are around 2.30 non-resident relatives for every woodlot growing household, and only 1.20 relatives for households which formerly grew a woodlot, the difference being statistically very significant. Most of the difference is accounted for by the fact that there are proportionately nearly twice as many

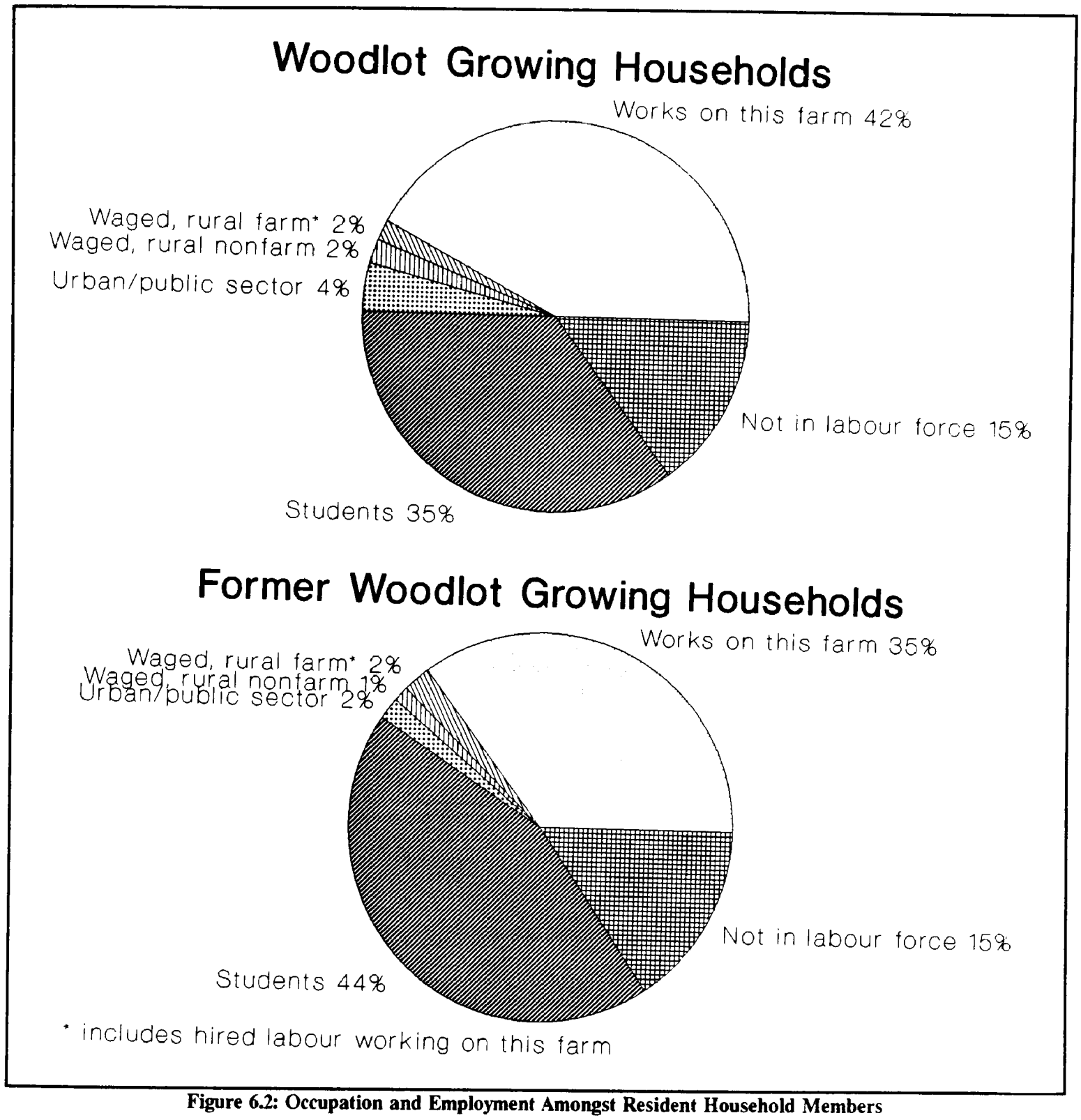


Figure 6.2: Occupation and Employment Amongst Resident Household Members

non-resident sons and daughters in woodlot growing households than in former woodlot growing households.

The ages of non-resident sons and daughters do indeed reflect the older age structure of woodlot growing households. Non-resident daughters of residents of woodlot growing households are significantly older, by 7 years, than non-resident daughters of former woodlot growing households. Non-resident sons are older as well, by 4 years. Gender differences between sampled households are related to the fact that daughters in woodlot growing households would have been more likely

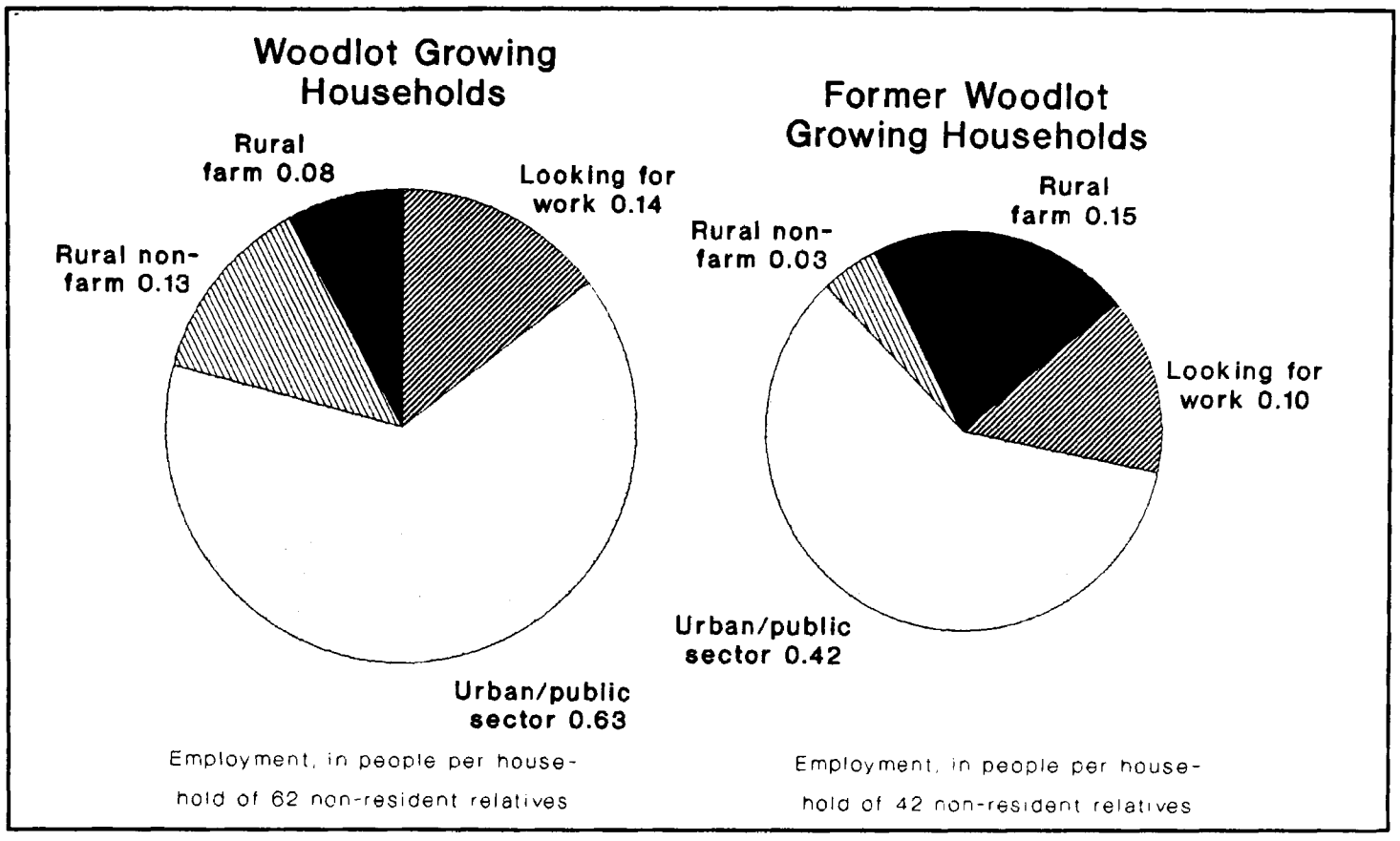


Figure 6.3: Wage Employment Amongst Non-resident Relatives of Resident Household Members

to be old enough to marry and leave home, as is traditional amongst Kikuyu women.

Some researchers have suggested that the ratio of women to men in the "working age range", between 21 and 70 years, is a relevant indicator of the availability of farm labour because it reflects the impact of labour migration on the household.[1] In the sampled households, the ratio of women to men in the working age range is around 20 percent greater amongst woodlot growing households than amongst the households which formerly grew woodlots.

Another means of exploring labour/age relationships is to examine the dependency ratio, reflecting the relative productivity of household members within different age groups. The dependency ratio is defined as the ratio of "economically unproductive" resident household members less than 16 years of age and greater than 63 years of age to the number of "economically productive" household members between 16 and 63. Using this definition, dependency ratios are 0.94 and

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1. Wasow (1981).

Table 6.8: OFF-FARM EMPLOYMENT AMONGST RESIDENT HOUSEHOLD MEMBERS, BY TYPE OF EMPLOYMENT

NUMBER OF REPORTED JOBS PER HOUSEHOLD BY TYPE OF EMPLOYMENT AND BY RESIDENT HOUSEHOLD MEMBER

RESIDENT HOUSEHOLD MEMBER	WOODLOTS: FARM LABOUR	WOODLOTS: NON-FARM LABOUR	WOODLOTS: URBAN/PUBLIC SECTOR	WOODLOTS: TOTAL NUMBER OF REPORTED JOBS	FORMER WOODLOTS: FARM LABOUR	FORMER WOODLOTS: NON-FARM LABOUR	FORMER WOODLOTS: URBAN/PUBLIC SECTOR	FORMER WOODLOTS: TOTAL NUMBER OF REPORTED JOBS
MALE HEAD	0.10	0.02	0.11	0.22	0.13	0.03	0.08	0.25
FEMALE HEAD	0.00	0.02	0.02	0.03	0.15	0.00	0.02	0.17
WIFE OF HEAD	0.13	0.00	0.03	0.16	0.08	0.00	0.03	0.12
CHILD OF HEAD	0.17	0.03	0.03	0.24	0.25	0.03	0.00	0.28
OTHER RESIDENT	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.00
TOTALS	0.43	0.06	0.19	0.68	0.62	0.07	0.13	0.82

RESIDENT HOUSEHOLD MEMBER	SIGNIFICANCE: FARM LABOUR	SIGNIFICANCE: NON-FARM LABOUR	SIGNIFICANCE: URBAN/PUBLIC SECTOR	SIGNIFICANCE: TOTAL NUMBER OF REPORTED JOBS	T-VALUES: FARM LABOUR	T-VALUES: NON-FARM LABOUR	T-VALUES: URBAN/PUBLIC SECTOR	T-VALUES: TOTAL NUMBER OF REPORTED JOBS
MALE HEAD					-0.6	-0.6	0.5	-0.3
FEMALE HEAD				*	..	..	0.0	-1.9
WIFE OF HEAD					0.6	..	-0.1	0.6
CHILD OF HEAD					-0.6	-0.1	..	-0.4
OTHER RESIDENT					..	..	..	..
TOTALS					-0.9	-0.1	0.7	-0.6

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

1.22 for woodlot growing households and for former woodlot growing households, respectively. (This definition can be somewhat problematic, as young people and the elderly are often an extremely productive source of household labour.) This is largely a function of the greater number of younger children in these households. Although the number of elderly adults is quite small in both sets of sampled households, differences between households were significant. There were 3 times as many adults over 70 years of age amongst households which were growing woodlots.

Occupation and Employment

Occupation and employment amongst resident household members

Responses of resident household members to questions about their current

Table 6.9: OFF-FARM EMPLOYMENT AMONGST RESIDENT HOUSEHOLD MEMBERS, BY PERIOD OF EMPLOYMENT

	NUMBER OF REPORTED JOBS BY PERIOD OF EMPLOYMENT AND BY RESIDENT HOUSEHOLD MEMBER					
	WOODLOTS			FORMER WOODLOTS		
RESIDENT HOUSEHOLD MEMBER	LESS THAN THREE MONTHS	MORE THAN THREE MONTHS	TOTAL NUMBER OF REPORTED JOBS	LESS THAN THREE MONTHS	MORE THAN THREE MONTHS	TOTAL NUMBER OF REPORTED JOBS
MALE HEAD	0.08	0.14	0.22	0.12	0.13	0.25
FEMALE HEAD	0.00	0.03	0.03	0.12	0.05	0.17
WIFE OF HEAD	0.08	0.08	0.16	0.07	0.05	0.12
CHILD OF HEAD	0.14	0.10	0.24	0.17	0.10	0.27
OTHER RESIDENT	0.03	0.00	0.03	0.00	0.00	0.00
TOTALS	0.33	0.35	0.68	0.47	0.33	0.80
	SIGNIFICANCE			T-VALUES		
RESIDENT HOUSEHOLD MEMBER	LESS THAN THREE MONTHS	MORE THAN THREE MONTHS	TOTAL NUMBER OF REPORTED JOBS	LESS THAN THREE MONTHS	MORE THAN THREE MONTHS	TOTAL NUMBER OF REPORTED JOBS
MALE HEAD				-0.6	0.2	-0.3
FEMALE HEAD			*	..	-0.4	-1.9
WIFE OF HEAD				0.2	0.6	0.6
CHILD OF HEAD				-0.2	-0.1	-0.2
OTHER RESIDENT				..	..	..
TOTALS				-0.7	0.1	-0.6

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

occupation or employment situation are summarized in Table 6.7 and in Figure 6.2. The one significant difference between households is in the number of children who are in school. This is a reflection of the age structure of the respective households: the absolute numbers of school-aged children in woodlot growing households are significantly fewer than in households which formerly operated woodlots.

The number of people in regular rural waged employment is relatively small, although many household members do seek some sort of occasional waged employment during the year. The type of employment which resident household members are engaged in is summarized in Table 6.8 while the length of employment (permanent or temporary) is summarized in Table 6.9.

The only significant difference between sampled households was in the participation of female-heads of households in wage employment. Female heads of woodlot growing households reported far less frequent wage employment. Female heads of former woodlot growing households more often sought wage employment, generally as farm labourers for periods of less than 3 months.

Table 6.10: OCCUPATION AND EMPLOYMENT AMONGST NON-RESIDENT RELATIVES OF RESIDENT HOUSEHOLD MEMBERS

OCCUPATION/EMPLOYMENT IN NUMBERS OF RESIDENTS PER HOUSEHOLD

NON-RESIDENT RELATIVE OF RESIDENT HOUSEHOLD MEMBER	PARCELS WITH WOODLOTS: WORKS ON OWN FAMILY FARM	WAGED LABOUR: RURAL (1)	WAGED LABOUR: URBAN (2)	STUDENT IN SCHOOL	NOT IN LABOUR FORCE (3)	TOTAL	PARCELS FORMERLY WITH WOODLOTS: WORKS ON OWN FAMILY FARM	WAGED LABOUR: RURAL (1)	WAGED LABOUR: URBAN (2)	STUDENT IN SCHOOL	NOT IN LABOUR FORCE (3)	TOTAL
HUSBAND	0.02	0.00	0.10	0.00	0.00	0.11	0.00	0.03	0.10	0.00	0.00	0.13
WIFE	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
SON	0.08	0.14	0.46	0.19	0.02	0.89	0.08	0.10	0.25	0.05	0.00	0.48
DAUGHTER	0.83	0.06	0.22	0.14	0.03	1.29	0.32	0.05	0.17	0.03	0.02	0.58
TOTAL	0.92	0.21	0.78	0.35	0.05	2.30	0.40	0.18	0.52	0.08	0.02	1.20

T-VALUES

NON-RESIDENT RELATIVE OF RESIDENT HOUSEHOLD MEMBER	WORKS ON OWN FAMILY FARM	WAGED LABOUR: RURAL	WAGED LABOUR: URBAN	STUDENT IN SCHOOL	NOT IN LABOUR FORCE	TOTAL
HUSBAND	..	..	-0.1	..	..	-0.4
WIFE	..	..	..	..	..	..
SON	-0.1	0.5	1.7	1.8	..	2.1
DAUGHTER	2.5	0.2	0.5	1.8	0.5	3.0
TOTAL	2.2	0.2	1.4	2.4	1.0	3.0

SIGNIFICANCE

NON-RESIDENT RELATIVE OF RESIDENT HOUSEHOLD MEMBER	WORKS ON OWN FAMILY FARM	WAGED LABOUR: RURAL	WAGED LABOUR: URBAN	STUDENT IN SCHOOL	NOT IN LABOUR FORCE	TOTAL
HUSBAND						
WIFE						
SON			*	*		**
DAUGHTER	**			*		**
TOTAL	**			**		***

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

(1) includes hired labour on small farms, hired labour on large-scale farms, employment in a rural business, or self-employment in a business or as a craftsman.
(2) includes employment by an urban business, for the government or for a parastatal, employment as a teacher, and those looking for waged work.
(3) includes the elderly, the disabled, and young children.

While only 2 resident household members of woodlot growing households reported their regular occupation as agricultural labourers, another 25 (or around 1 in 5.5 working-age adults) reported they had worked, at some time or another in wage employment on another farm over the last year. Amongst residents of

former woodlot growing households, 5 reported their regular occupation as agricultural labourers, while another 32 (or around 1 in 4.0 working age adults) reported they had worked in wage employment on another farm. Differences in the numbers of residents in urban waged employment or employed in the public sector (including teachers in the Teachers Service Commission) are not significant.

Occupation and employment amongst non-resident relatives

Employment amongst non-resident relatives of resident household members is summarized in Table 6.10. A large proportion of non-residents in both samples are engaged in work on their own farm. Total numbers are significantly higher amongst woodlot growing households, accounted for by the higher numbers of non-resident daughters.

The number of non-residents in urban wage or public sector employment is higher amongst woodlot growing households than in households which formerly grew woodlots (0.78 persons per household compared with 0.52 persons per household respectively) though this difference is only statistically significant to 20 percent. Differences in the numbers of non-resident sons employed in urban or public sector employment, however, are significant, being 80 percent higher amongst woodlot growing households. Proportionate numbers of non-resident individuals who are either engaged in wage employment or who are seeking wage employment is considered in Figure 6.3.

Chapter 7. Patterns of Land Use and Distribution

This Chapter reviews the findings of the survey with regard to land use and distribution and is based on field measurements of sampled parcels taken at the time of the survey, and on reported area measurements of the household's holdings.

Distribution of Holdings

Generally, woodlot growing households operate larger holdings than households which are operating parcels which have been cleared of their woodlots. The mean reported holding size (comprised of all operated parcels) amongst woodlot growing households was 2.2 ha ($\sigma = 1.6$) compared with 1.6 ha ($\sigma = 1.6$) amongst households which operate parcels which had been cleared of their woodlots since 1967 ($t = 1.89$, significant to 6 percent).[1]

The distribution of holdings in the two samples is indicated graphically in Figure 7.1. The distribution of holdings that were formerly used for woodlots is clustered around the mean while the distribution of holdings amongst woodlot growing households tends to be more spread out over the range of holding sizes. Indices of kurtosis for woodlot growing households and for households which operate parcels which had formerly been used for growing woodlots are 2.8 and 21.5, respectively.

Patterns of Land-use

Every plot of every sample parcel was measured and land-uses of each plot

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1. For the purposes of this discussion, *holdings* are made up of one or more geographically distinct *parcels*. *Parcels* are made up of one or more adjoining *plots*.

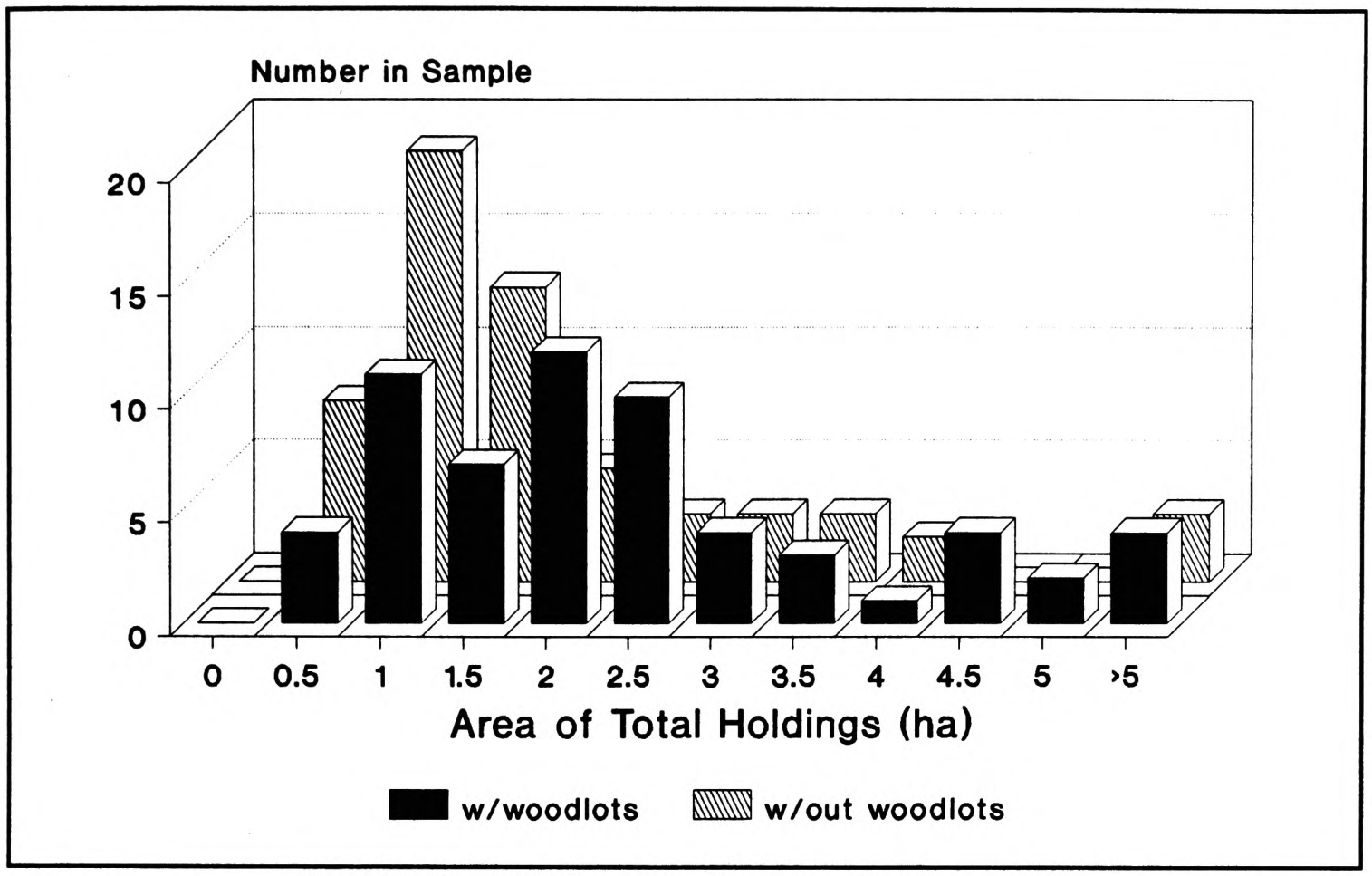


Figure 7.1: Reported Patterns of the Distribution of Holdings, by Size

were recorded. Entire holdings were not measured unless they were comprised of a unitary parcel.

Land-use groupings

A total of 74 different land-uses were recorded, reflecting the large number of different types of intercropping strategies undertaken by farmers. These categories were subsequently grouped into more general land-use categories. The objective was to cluster land-uses (admittedly rather subjectively), by characteristics which reflected the traditional view of crops as labour intensive seasonal ones (*irio cia ĩmera* -- "sprouting foods") like maize, beans and vegetables or as the more labour extensive perennial crops (*irio cia menja* -- "digging foods") such as yams, arrowroot, cassava and bananas. Reported seasonal differences in land-use were also recorded.

With the exception of smallholder coffee and tea, monocropping was relatively uncommon. *Monocropped annual and perennial food crops* comprised the

first grouping of land-uses. Annual crops were almost always intercropped with other annuals and with perennial food crops. These comprised the second category of land-uses, *intercropped annual food crops*. The land-uses in this category involve similar more intensive labour-use strategies, i.e. labour would be principally used for the cultivation of annual food crops (such as maize, beans, or vegetables), but in a way which would benefit other crops planted in the same plot (often perennial food crops). The third category, *intercropped perennial crops*, grouped land-uses where perennial food crops required the largest amounts of labour. Crops in this category included intercrops of yams, passion fruit, and trees such as macadamia and avocado trees.

The fourth grouping comprised *pasture and fodder crops*. The fifth grouping comprised *smallholder coffee*. The sixth grouping comprised *smallholder tea*. The seventh grouping was made up of *wattle or wattle/pasture* combinations. The final grouping included *other uncultivated areas* such as the homestead, bush, fallow, or woodlots of other species (principally cypress and eucalyptus). Appendix 4 lists all land-uses which were recorded during the survey, and the 8 primary categories into which these land-uses were grouped.

Differences in land-use

The mean measured areas of different land-uses of sample parcels, clustered in these groupings, are summarized in Table 7.1 and in Figure 7.2. Parcels which are currently being used for cultivating woodlots are generally larger, by around 30 percent, than parcels which were used for growing woodlots in 1967 but which have since been cleared. Woodlots account for around 30 percent of the total parcel area on woodlot growing parcels. Parcels which have been cleared of their woodlots since 1967 have not been entirely cleared, as 3 percent of the land area on these parcels has been left under black wattle. The other significant difference

Table 7.1: LAND-USES ON MEASURED PARCELS

LAND-USE	AREA OF LAND-USE, IN HA (1): PARCELS WITH WOODLOTS ON THEM	PARCELS WHICH FORMERLY HAD WOODLOTS ON THEM	SIGNIF-ICANCE	T-VALUES
MONOCROPPED ANNUAL AND PERENNIAL FOOD CROPS	0.04	0.03		0.46
ANNUAL FOOD CROPS (INTERCROPPED)	0.10	0.11		-0.26
PERENNIAL FOOD CROPS (INTERCROPPED) AND MINOR CASH CROPS	0.05	0.08		-0.82
sub-total FOOD CROPS	0.19	0.22		-0.59
PASTURE AND FODDER CROPS	0.09	0.04	*	1.71
COFFEE	0.14	0.16		-0.62
TEA	0.26	0.33		-1.12
WATTLE OR WATTLE/PASTURE	0.34	0.03	***	7.37
HOUSEHOLD COMPOUND, FALLOW, OR OTHER UNCULTIVATED LAND	0.09	0.08		0.21
TOTAL	1.11	0.87	**	1.94

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

(1) Consists of compiled measurements across all plots measured in the survey. Excludes data from multiple parcels operated by the same household. Measurements reflect land-use at the time of the previous short rains (November 1989).

in land-use is in the area under pasture. Woodlot operating households keep over twice as much land (proportionately 60 percent more) under pasture and fodder crops.

Smallholder coffee and tea account for the largest proportionate areas in both sets of parcels, occupying 36 percent of woodlot growing parcels, and 57 percent of parcels which have been cleared of their woodlots. Annual and perennial monocrops and intercrops account for a proportionately larger area (25 percent of the total area) on parcels which have been cleared of their woodlots than on parcels which are being used for growing woodlots (17 percent).

Although woodlot-growing parcels are generally larger than parcels which were formerly used for cultivating woodlots, their income-generating potential (in terms of the extent of the area under cash crops), is the same as households which operate parcels cleared of their woodlots. (Woodlot management practices are

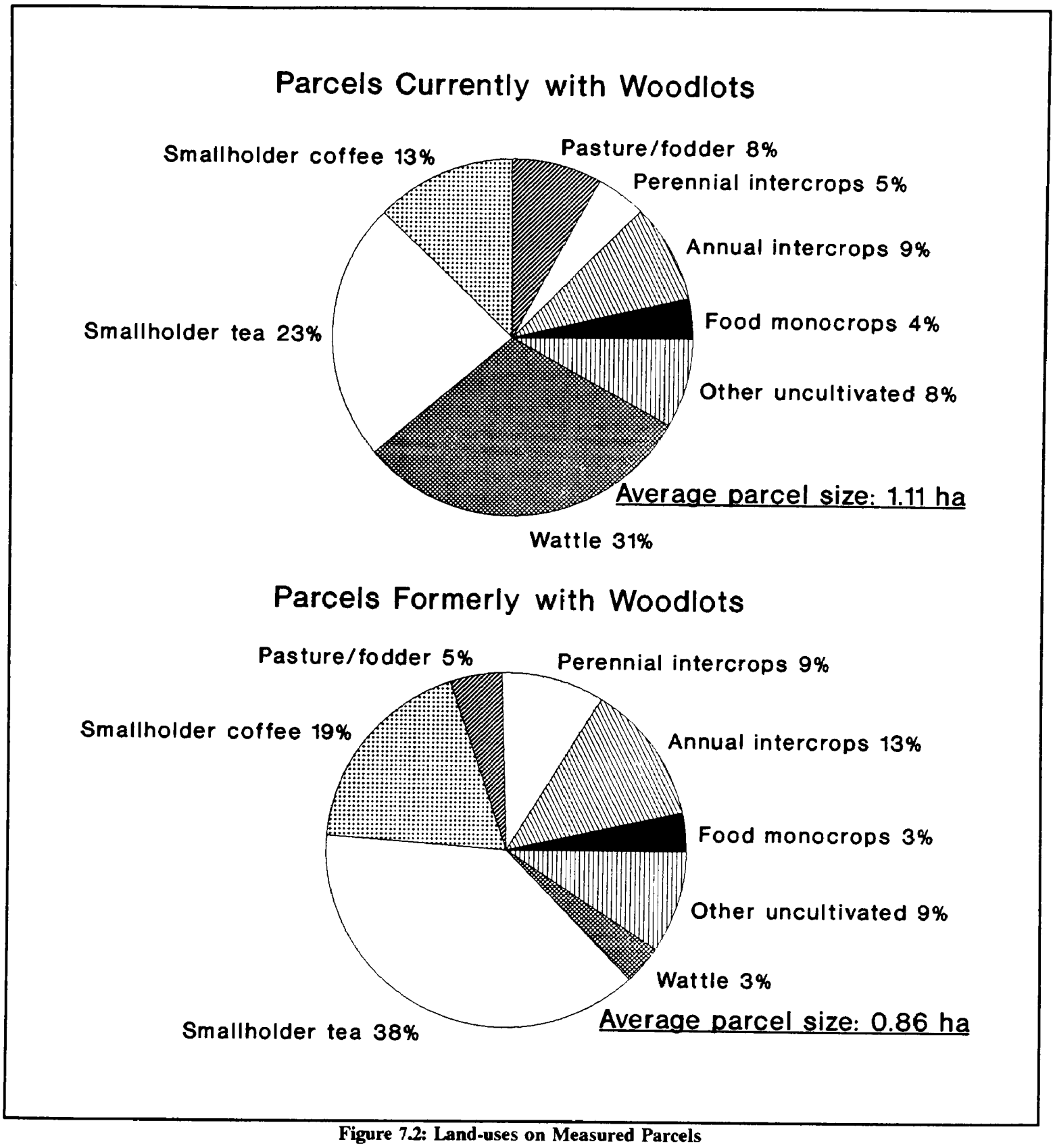


Figure 7.2: Land-uses on Measured Parcels

discussed in Chapter 8. Most woodlot-operating households reported that they seldom sold production from their woodlots. Woodlot land-uses, then, could be considered to be of low-income generating potential.)

Fragmentation and its impact on land-use

An important feature of land-use which became evident during pretesting was that many households cultivated multiple parcels. There is little published information about the extent of fragmentation or its impact on farming systems in

Table 7.2: NUMBERS AND AREAS OF FRAGMENTED PARCELS

NUMBER OF PARCELS	PERCENTAGE OF HOUSEHOLDS WITH AT LEAST THIS NUMBER OF PARCELS		CORRECTED MEAN AREA OF PARCELS (HA)		SIGNIFICANCE		T-VALUES	
	WOODLOTS	FORMER WOODLOTS	WOODLOTS	FORMER WOODLOTS	NUMBER OF PARCELS	MEAN AREA (HA)	NUMBER OF PARCELS	MEAN AREA (HA)
1	100.0%	100.0%	1.20	0.99			..	1.5
2	55.6%	50.0%	1.01	0.60		**	0.6	2.3
3	7.9%	5.0%	0.85	1.18			0.7	-0.7
4	3.2%	1.7%	0.90	1.98			0.5	..
5	0.0%	1.7%	0.00	0.99			..	..

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

contemporary Kenya. It is widely accepted that few farmers cultivate unitary holdings, although this was the entire objective of the consolidation programme of the late 1950s and early 1960s. Arguably, the entire government bureaucracy, from the agricultural extension services to the commodity marketing boards, is geared toward farmers who cultivate unitary holdings.

Some households in the sample operated as many as 4 or 5 parcels. Field measurements were taken only of parcels which were identified from aerial photographs; information about other parcels was collected during the interviewing process. A total of 123 parcels were measured and their land-uses were classified. Sample households operated another 77 parcels, which were not measured. The areas of these parcels were determined on the basis of information provided during the interview and on the relationship between the reported and actual areas of the parcel which was measured.

The number of parcels operated by sample households and the corrected mean area for homestead and other parcels is summarized in Table 7.2. Over half the households in both samples operated more than one parcel. Differences in the numbers of parcels operated by the respective samples, however, were not significant.

Table 7.3: NUMBER OF YEARS HOUSEHOLDS HAVE OPERATED PARCELS

	WOODLOT GROWING HOUSEHOLDS — PERCENTAGES OF TOTAL PARCELS OPERATED, GROUPED BY NUMBERS OF YEARS OF OPERATION								FORMER WOODLOT GROWING HOUSEHOLDS — PERCENTAGES OF TOTAL PARCELS OPERATED, GROUPED BY NUMBERS OF YEARS OF OPERATION							
PARCEL	0 TO 5	6 TO 10	11 TO 15	16 TO 20	21 TO 25	26 TO 30	> 30	TOTAL	0 TO 5	6 TO 10	11 TO 15	16 TO 20	21 TO 25	26 TO 30	> 30	TOTAL
HOME-STEAD	8%	10%	3%	10%	10%	13%	8%	60%	4%	12%	10%	13%	10%	13%	3%	64%
2	9%	4%	2%	4%	4%	7%	5%	33%	7%	9%	3%	5%	3%	3%	1%	32%
3	4%	0%	0%	0%	0%	1%	0%	5%	0%	1%	0%	0%	0%	1%	0%	2%
4	1%	0%	0%	1%	0%	0%	0%	2%	0%	0%	0%	0%	0%	1%	0%	1%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%
TOTAL	21%	13%	5%	14%	13%	21%	12%	100%	12%	21%	14%	18%	13%	18%	4%	100%

	SIGNIFICANCE							T-VALUES						
PARCEL	0 TO 5	6 TO 10	11 TO 15	16 TO 20	21 TO 25	26 TO 30	> 30	0 TO 5	6 TO 10	11 TO 15	16 TO 20	21 TO 25	26 TO 30	> 30
HOME-STEAD			*					1.1	-0.4	-1.9	-0.6	0.1	0.3	1.5
2							*	0.4	-1.3	-0.5	-0.4	-0.3	1.2	1.6
3								no t-values calculated						
4														
5														
TOTAL			*				*	1.6	-1.1	1.9	-0.5	0.2	0.6	1.7

* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

Homestead parcels are generally larger in both samples than secondary or tertiary parcels. Secondary parcels operated by woodlot growing households are reported to be 15 percent smaller than the homestead parcel. Secondary parcels operated by households which have cleared their woodlots are around 40 percent smaller than the homestead parcel. The distance of fragmented parcels from the homestead parcels were compared between samples; there were no significant differences.

Similarly, there were no significant differences in the sources of the households' rights to operate their parcels, whether inherited, purchased or rented. The rights to operate between 80 and 85 percent of the parcels in both samples were acquired through inheritance. Nearly all of the balance were acquired through purchase. There were minor differences in the length of time parcels have

Table 7.4: LAND-USES ON HOMESTEAD PARCELS COMPARED WITH LAND-USES ON ALL OTHER PARCELS

LAND-USE	AREA OF HOMESTEAD PARCEL (HA)		AREA OF ALL OTHER PARCELS (HA)		SIGNIFICANCE		T-VALUES	
	WOOD-LOTS	FORMER WOOD-LOTS	WOOD-LOTS	FORMER WOOD-LOTS	AREA OF LAND USE ON HOMESTEAD PARCEL	AREA OF LAND USE ON ALL OTHER PARCEL	AREA OF LAND USE ON HOMESTEAD PARCEL	AREA OF LAND USE ON ALL OTHER PARCEL
ANNUAL AND PERENNIAL FOOD CROPS (MONOCROPPED)	0.05	0.03	0.01	0.02			0.9	-0.6
ANNUAL FOOD CROPS (INTERCROPPED)	0.12	0.10	0.06	0.13			0.5	-0.7
PERENNIAL FOOD CROPS (INTERCROPPED) AND MINOR CASH CROPS	0.07	0.09	0.03	0.04			-0.5	-0.4
sub-total FOOD CROPS	0.25	0.22	0.10	0.20			0.5	-0.9
PASTURE AND FODDER CROPS	0.12	0.05	0.05	0.03	**		1.9	0.5
COFFEE	0.16	0.15	0.10	0.19			0.2	-0.8
TEA	0.35	0.36	0.12	0.24			-0.1	-1.4
WATTLE OR WATTLE/PASTURE	0.29	0.03	0.42	0.01	***	***	6.6	4.8
HOUSEHOLD COMPOUND, FALLOW OR OTHER UNCULTIVATED LAND	0.13	0.10	0.03	0.02			0.6	0.4
TOTAL	1.29	0.91	0.82	0.69	**		2.4	0.6

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

Table summarizes measurements of independently operated parcels. There is no relationship between the operators of 'homestead parcels' and operators of 'all other parcels.'

been operated by the household, and these are summarized in Table 7.3.

Area measurements were undertaken for parcels identified in the aerial photographs. These parcels were selected independently of any knowledge of whether or not they were homestead parcels or were operated in addition to the homestead parcel. Area measurements are disaggregated in Table 7.4 by whether the measured parcel was a homestead parcel or was a parcel which was operated in addition to the homestead parcel.

On parcels where woodlots are found, the proportionate area under wattle is twice as great on secondary or tertiary parcels than it is on the homestead parcel. The proportionate area under coffee on parcels where woodlots are found is about the same on homestead parcels as on other parcels, but the proportionate area under tea is around 73 percent greater on homestead parcels which are used for growing woodlots. The proportionate area of annual and perennial monocrops and

intercrops, as well as of pasture, is also greater on homestead parcels where woodlots are grown than on other parcels where woodlots are grown.

These differences suggest that if a household is going to grow (or maintain) a woodlot and if the household operates multiple parcels, then the likelihood is greater that the woodlot will be established on a remote parcel, rather than on the homestead parcel. Further, crops with the largest labour requirements are more likely to be established on the homestead parcel rather than on a secondary parcel.

Variability in Agricultural Conditions

Two other variables which were included in the data set were the altitude of the sample parcel and slope. Altitude was recorded from topographic maps. The slope of each plot on sample parcels was measured using a clinometre and this was recorded at the time the area measurements were taken.

Differences in altitude

One of the objectives of using the 1800 metre contour to help delineate the study area was to limit the effect of altitude on land-use practices amongst sampled households. Amongst sampled parcels, the mean altitude was 1838 metres (σ=51.08). Despite the effort to limit the sample to parcels with similar agricultural conditions (defined by altitude), altitude between sampled households varied significantly.

Parcels which were being used for growing woodlots were generally lower in elevation (1829 metres) than parcels which had been cleared of their woodlots (1848 metres). The difference between the mean altitudes is small -- less than 20 metres -- but is significant to less than 5 percent (t = -2.18).

This is an interesting point. On the one hand, wattle does much better at higher altitudes and so one would expect to find parcels with woodlots to be found at a higher altitude than other parcels. On the other hand, certain other land-uses

are also well-suited to higher altitudes. Tea, for instance, grows quite well in the higher zones in Murang'a. The fact that cleared parcels are at a higher elevation may be a reflection of this fact: parcels which are lower in elevation are used for growing woodlots while parcels at higher altitudes are more likely to be cleared of their woodlots and used for growing something else.

Differences in slope

Slope evidently plays an important role in farmers' decisions to use certain plots for certain land-uses. This is partly to be expected, as the Agricultural Act (Cap.318) and the Agricultural (Basic Land Usage) Rules, derived from their Colonial predecessors, regulate the cultivation of hillsides. The Land Usage Rules prohibit the cutting of trees and the grazing of livestock on hills with slopes of greater than 35 percent (19°). They also empower Agricultural Officers to prohibit cultivation on land which is greater than 20 percent in slope (11°) and to require soil conservation measures on any cultivated land between 12 percent and 35 percent in slope (7° and 19°).

Amongst sampled parcels, food and fodder crops and pastures are generally found on the least sloping hillsides, with household compounds found on fairly flat land. Coffee and tea are grown on steeper slopes, and the steepest slopes are used for growing wattle. Pairwise comparisons of land-uses were carried out to see if differences in slope between land-uses were significant. Mean slopes for different crops and land-uses, and the results from t-tests of significance for all parcels are summarized in Table 7.5.

Differences *between* sampled households were also tested. The mean slopes for different plots operated by the respective sample households are summarized in Table 7.6. For most land-uses -- annual, perennial and permanent crops as well as household compounds -- the slope of plots on woodlot growing parcels are

Table 7.5: DIFFERENCES BETWEEN SLOPES OF PLOTS USED FOR DIFFERENT CROPS AND LAND-USES, ALL PARCELS

LAND-USE ON PLOT	MEAN SLOPE (DEGREES)	STANDARD ERROR
MONOCROPPED ANNUAL AND PERENNIAL FOOD CROPS	12.0	1.8
ANNUAL FOOD CROPS	13.1	1.1
PERENNIAL FOOD CROPS AND MINOR CASH CROPS	12.4	1.1
PASTURE AND FODDER CROPS	14.0	1.4
COFFEE	16.4	0.9
TEA	16.6	0.8
WATTLE OR WATTLE/PASTURE	21.5	1.2
HOUSEHOLD COMPOUND, FALLOW OR OTHER UNCULTIVATED LAND	7.6	0.7

T-VALUES TESTING THE SIGNIFICANCE OF DIFFERENCES BETWEEN SLOPES ON DIFFERENT LAND-USES

LAND-USE ON PLOT	MONOCROPPED ANNUAL AND PERENNIAL FOOD CROPS	ANNUAL FOOD CROPS	PERENNIAL FOOD CROPS AND MINOR CASH CROPS	PASTURE AND FODDER CROPS	COFFEE	TEA	WATTLE OR WATTLE/PASTURE
ANNUAL FOOD CROPS	-0.6	..					
PERENNIAL FOOD CROPS AND MINOR CASH CROPS	-0.2	0.5	..				
PASTURE AND FODDER CROPS	-0.9	-0.6	-1.0	..			
COFFEE	-2.3	-2.4	-2.9	-1.4	..		
TEA	-2.5	-2.7	-3.1	-1.5	-0.1	..	
WATTLE OR WATTLE/PASTURE	-3.8	-5.2	-5.6	-3.8	-3.3	-3.3	..
HOUSEHOLD COMPOUND, FALLOW OR OTHER UNCULTIVATED LAND	2.6	4.6	3.9	4.1	8.1	8.7	9.9

SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN SLOPES

LAND-USE ON PLOT	MONOCROPPED ANNUAL AND PERENNIAL FOOD CROPS	ANNUAL FOOD CROPS	PERENNIAL FOOD CROPS AND MINOR CASH CROPS	PASTURE AND FODDER CROPS	COFFEE	TEA	WATTLE OR WATTLE/PASTURE
ANNUAL FOOD CROPS		..					
PERENNIAL FOOD CROPS AND MINOR CASH CROPS			..				
PASTURE AND FODDER CROPS				..			
COFFEE	**	**	***		..		
TEA	**	***	***	*		..	
WATTLE OR WATTLE/PASTURE	***	***	***	***	***	***	..
HOUSEHOLD COMPOUND, FALLOW OR OTHER UNCULTIVATED LAND	**	***	***	***	***	***	***

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent

Table 7.6: SLOPE OF PLOTS USED FOR DIFFERENT LAND-USES ON MEASURED PARCELS

LAND-USE	SLOPE OF PLOT WITH THIS LAND USE (DEGREES): HOUSEHOLDS WHICH OPERATE PARCELS WITH WOODLOTS ON THEM	HOUSEHOLDS WHICH OPERATE PARCELS WHICH FORMERLY HAD WOODLOTS ON THEM	SIGNIF-ICANCE	T-VALUES
MONOCROPPED ANNUAL AND PERENNIAL FOOD CROPS	12.17	10.00		0.76
ANNUAL FOOD CROPS (INTERCROPPED)	13.17	13.26		-0.04
PERENNIAL FOOD CROPS (INTERCROPPED) AND MINOR CASH CROPS	14.61	11.34		1.29
mean slope FOOD CROPS	13.41	11.76		
PASTURE AND FODDER CROPS	14.36	13.03		0.43
COFFEE	17.42	14.92		1.41
TEA	18.87	15.35	**	2.13
WATTLE OR WATTLE/PASTURE	20.05	21.22		-0.34
HOUSEHOLD COMPOUND, FALLOW, OR OTHER UNCULTIVATED LAND	8.76	6.03	*	1.99
AGGREGATE SLOPE, ALL LAND-USES	17.06	13.55	***	3.11

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

consistently greater than on parcels which were formerly used for growing woodlots. Differences in the slope of plots which are used for growing tea and for the household compound are significant.[1]

Slopes were also weighted by the land area used for particular crops, and aggregate slopes were calculated for sampled households. If these aggregated slopes are considered, parcels which are used for growing woodlots are generally steeper (by around 4°) than parcels which were used for growing woodlots but which have been cleared.

It could be expected that woodlots would be planted on steeper slopes because of soil erosion problems in the area and because it is more difficult to

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1. Slope is not a normally distributed variable, having a minimum of 0° and a theoretical maximum of 90°. The distribution of the slopes in the sample however approximate the normal distribution, and so the use of the t-test to evaluate the significance of differences between samples is considered to be valid.

cultivate other crops on steep slopes. The fact that tea (which poses few soil conservation problems) is planted on steeper slopes by woodlot growing households, and the fact that these parcels are generally steeper overall, suggests that there is a fundamental difference in the quality of the basic land endowment amongst sampled households. This has further implications for labour use because of the greater difficulty involved in working on steep hillsides.

Chapter 8. Assets, Inputs, Income Generation and Woodlot Management

This Chapter examines differences between households with regard to the extent of assets, savings and investment, and inputs and income generation from cash crops. It further summarizes how woodlots amongst sampled households are being managed, and discusses preferred land-use alternatives to woodlots. Finally, it examines how households differ with respect to woodfuel use.

Access to Infrastructure and Services

Households were questioned about general characteristics of their holdings: proximity to markets and schools, proximity to local crop buying centres, sources of water, and rural electrification. For most of these variables however, there were few statistical differences between subsampled households and they were, in many respects, strikingly similar.

Most households were in reasonably close proximity to local shops ($d = 1.15$ km, $\sigma = 0.53$), to primary schools ($d = 1.09$ km, $\sigma = 0.58$), secondary schools ($d = 1.76$ km, $\sigma = 1.07$), coffee factories ($d = 1.82$ km, $\sigma = 1.51$), and tea buying centres ($d = 0.94$ km, $\sigma = 0.57$). There were no statistical differences between subsampled households for these variables.

Rural electrification was relatively uncommon. Two households in the entire sample had been electrified.

The primary sources of water for most households were rivers. Around 75 percent of the households which operate parcels which were formerly used for

growing woodlots and only 57 percent of woodlot growing households, were dependent on rivers for their water supply. The balance of supplies were provided by on-farm sources, either from wells or piped water. Differences between households were significant to 10 percent (chi-square=6.60).

Assets

Households were questioned about the extent of their physical assets, such as the number of radios, bicycles, and so on. There were no significant differences between groups of households in this regard.

Dwellings

There were no significant differences in the types of dwellings built by subsampled households. Around two-thirds of the dwellings in both subsamples were built of mud and wattle; 19 percent were built of stone, and 11 percent were of timber construction. Roofing material was generally corrugated iron (72 percent) or flattened vegetable oil tins (25 percent).

Livestock

Around 65 percent of the households in both subsamples owned at least one chicken. Around 25 percent owned at least one goat, and around 20 percent owned at least one sheep. There were no statistical differences between subsampled households in the quantity or the value of this livestock.

Although there were no differences in the numbers of cattle owned by the subsampled households, there were differences in the total *value* of this cattle. The total value of all cattle owned by woodlot growing households was around 40 percent greater than the value of cattle owned by households which operate parcels which were formerly used for growing woodlots. The mean value and number of cattle owned by subsampled households are summarized in Table 8.1.

Table 8.1: CATTLE OWNERSHIP AND VALUE

	WOODLOTS	FORMER WOODLOTS	T-VALUES	SIGNI-FICANCE
CATTLE OWNERSHIP (in numbers per household)				
BREEDING BULLS	0.03	0.00	..	
MALE CALVES, < 1 YEAR	0.17	0.20	-0.33	
MALES, 1 TO 3 YEARS	0.16	0.08	1.28	
MALES OVER 3 YEARS	0.02	0.03	-0.62	
FEMALE CALVES, < 1 YEAR	0.41	0.32	0.95	
HEIFERS (NOT CALVED)	0.14	0.27	-1.44	
COWS	1.25	1.05	1.24	
TOTAL CATTLE OWNED	2.19	1.95	1.00	
VALUE OF CATTLE OWNED (in KSh per household)				
BREEDING BULLS	63	0	..	
MALE CALVES, < 1 YEAR	156	105	0.66	
MALES, 1 TO 3 YEARS	165	92	1.04	
MALES OVER 3 YEARS	11	78	-1.16	
FEMALE CALVES, < 1 YEAR	568	517	0.24	
HEIFERS (NOT CALVED)	457	433	-0.45	
COWS	5021	3650	1.90	*
VALUE OF CATTLE OWNED	6441	4875	1.81	*

* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

Savings and Investment

Around 48 percent of all sampled households reported that someone in the household held a savings account with a financial institution of some sort. There were no differences between subsampled households in this respect.

When questioned about sources of capital to cover investment costs of farm operation and other large household expenses, subsampled households showed important differences (Table 8.2). Nearly three quarters of all households which were questioned about sources of capital to cover large expenses (such as dowry, school fees, funeral, or wedding expenses) reported that they were primarily dependent either on sources of regular household income to cover these costs or would otherwise seek to obtain a loan from the local cooperative society. Amongst woodlot growing households, however, nearly half reported they were primarily dependent on regular household income to meet these expenses, while only a

Table 8.2: SOURCES OF CAPITAL FOR INVESTMENT AND EXPENDITURE

	WOODLOTS	FORMER WOODLOTS	CHI-SQUARE	SIGNI-FICANCE
SOURCES OF CASH FOR LARGE EXPENSES				
REGULAR FARM INCOME	48.4%	23.3%		
OFF FARM INCOME	4.8%	1.7%		
COOPERATIVE SOCIETY LOAN	25.8%	50.0%		
OTHER LOAN	11.3%	10.0%		
HARAMBEE	3.2%	3.3%		
SAVINGS	6.5%	10.0%		
OTHER	0.0%	1.7%		
TOTAL	100.0%	100.0%	13.45	*
SOURCES OF CASH FOR INPUTS AND REGULAR FARM EXPENSES				
REGULAR FARM INCOME	25.8%	13.3%		
OFF FARM INCOME	8.1%	1.7%		
COOPERATIVE SOCIETY LOAN	62.9%	85.0%		
SAVINGS	3.2%	0.0%		
TOTAL	100.0%	100.0%	8.90	**

* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent

quarter of former woodlot growing households reported they were primarily dependent on the same source. This difference between households was significant.

Input use and Crop Production

Households were surveyed about input use and income generation from tea and coffee and about sources of capital to pay for regular farm inputs.

Sources of capital

When questioned about sources of capital to cover the costs of inputs and other regular farm expenses, a quarter of woodlot growing households reported they were primarily dependent on regular farm income to cover these costs and 63 percent reported they were primarily dependent on cooperative society loans. On the other hand, amongst former woodlot growing households, only 13 percent were primarily dependent on regular farm income to meet these expenses, while 85 percent reported they were primarily dependent on cooperative society loans. Differences between households were significant (see Table 8.2).

Income and expenditure

The reported numbers of bearing coffee and tea bushes were also recorded during the survey. Reported income and expenditure on coffee and tea are recorded in Table 8.3.

There were no statistical differences between subsampled households with regard to tea cultivation. Around 74 percent of the tea in the sample was planted before 1980; the mean age of tea bushes was reported to be 13.9 years ($\sigma = 7.23$). Reported numbers of tea bushes were very consistent with the areas measured during the survey, and were not statistically different between subsampled households. Tea bushes yielded an average of 1.27 kg per bush ($\sigma = 0.85$). Net income from tea was substantial, totalling, across all households, an average of around KSh 7,800/- per household.

Around 72 percent of all coffee had been planted before 1980; the mean age of coffee bushes was 14.2 years ($\sigma = 7.96$), and there were no differences between subsamples. Differences in the numbers of coffee bushes per resident household member were significant. Woodlot growing households reported they had more than twice as many coffee bushes per household member than former woodlot growing households. Net income from coffee for woodlot growing households was significantly greater than for former woodlot growing households, which incurred large losses. Although differences in gross income and expenditure on coffee were not significant, significant differences in net income were accounted for by higher levels of gross income and lower levels of expenditure amongst woodlot growing households and lower levels of gross income and higher levels of expenditure amongst former woodlot growing households.

This seems something of a contradiction. If physical yields of coffee bushes are compared, despite relatively higher expenditures on inputs by former woodlot

Table 8.3: EXPENDITURE AND INCOME FROM COFFEE AND TEA

TEA OR COFFEE (1)	WOODLOTS	FORMER WOODLOTS	T-VALUES	SIGNIF-ICANCE
TEA				
TOTAL PRODUCTIVE TEA BUSHES (NUMBER)				
PER HOUSEHOLD	2,151	2,893	-0.98	
PER RESIDENT HOUSEHOLD MEMBER	490	683	-0.99	
INCOME AND EXPENDITURE ON TEA (in KSh over the previous year)				
INCOME PER HOUSEHOLD	7,706	11,287	-1.07	
EXPENDITURE PER HOUSEHOLD	1,621	1,990	-0.75	
NET INCOME FROM TEA (in KSh over the previous year)				
PER HOUSEHOLD	6,085	9,297	-1.01	
PER RESIDENT HOUSEHOLD MEMBER	1,397	1,963	-0.91	
COFFEE				
TOTAL PRODUCTIVE COFFEE BUSHES (NUMBER)				
PER HOUSEHOLD	338	229	1.25	
PER RESIDENT HOUSEHOLD MEMBER	88	43	1.60	*
INCOME AND EXPENDITURE ON COFFEE (in KSh over the previous year)				
INCOME PER HOUSEHOLD	2,508	1,655	1.07	
EXPENDITURE PER HOUSEHOLD	1,925	2,340	-0.60	
NET INCOME FROM COFFEE (in KSh over the previous year)				
PER HOUSEHOLD	583	(685)	2.34	**
PER RESIDENT HOUSEHOLD MEMBER	147	(146)	1.98	**

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

(1) statistics were calculated only for households which supplied all data about income and expenditure. Households for which data was missing were excluded.

growing households, there are no significant differences in yields per bush between groups of households. Coffee bushes were reported to yield an average for all households of 3.38 kg per bush ($\sigma = 2.99$). It would have to be concluded that either the results are spurious, or that yields are only being maintained at acceptable levels by the heavy use of inputs and that the inherent fertility and resistance to disease of coffee plots operated by woodlot growing households is greater.

Use of hired labour

Although specific information about the use of hired labour for coffee and tea production was not collected, the reported frequency, duration and seasonal

Table 8.4: SEASONALITY AND DURATION OF USE OF SHORT-TERM HIRED LABOURERS

SEASON	NUMBER OF SHORT-TERM HIRED LABOURERS PER HUNDRED FARMS (1)		DURATION OF EMPLOYMENT OF SHORT-TERM HIRED LABOURERS, IN WEEKS	
	WOODLOTS	FORMER WOODLOTS	WOODLOTS	FORMER WOODLOTS
JANUARY TO MID-MARCH	7.9	1.7	2.0	2.0
END OF MARCH	36.5	13.3	6.6	9.8
EARLY APRIL TO END OF MAY	33.3	55.0	3.0	3.1
EARLY JUNE	15.9	30.0	3.6	2.8
END OF JUNE TO MID-OCTOBER	9.5	45.0	3.2	3.3
END OF OCTOBER	19.0	40.0	4.2	3.0
NOVEMBER TO MID-DECEMBER	34.9	56.7	4.6	3.3
END OF DECEMBER	19.0	11.7	3.7	2.6

SEASON	NUMBER OF SHORT-TERM HIRED LABOURERS PER HUNDRED FARMS (1)		DURATION OF EMPLOYMENT OF SHORT-TERM HIRED LABOURERS, IN WEEKS	
	SIGNIF-ICANCE	T-VALUES	SIGNIF-ICANCE	T-VALUES
JANUARY TO MID-MARCH		0.8		..
END OF MARCH	***	2.6		-1.5
EARLY APRIL TO END OF MAY		-1.1		-0.2
EARLY JUNE		-1.2	*	1.6
END OF JUNE TO MID-OCTOBER	***	-2.7		-0.2
END OF OCTOBER		-1.4	**	2.0
NOVEMBER TO MID-DECEMBER		-1.1	*	1.6
END OF DECEMBER		0.7		1.4

two-tailed t-tests
  * significant to 10 percent
 ** significant to 5 percent
*** significant to 1 percent
 .. t-values not calculated

(1) Defined as someone employed for less than 20 weeks out of the year.

Main Agricultural Seasons

January to mid-March: dry season between the short rains and the long rains
End of March: just before the long rains

Main Agricultural Seasons (continued)

Early April to end of May: during the long rains
Early June: just after the long rains
End of June until mid-October: mist season between the long rains and the short rains
End of October: just before the short rains
November until mid-December: during the short rains
End of December: just after the short rains

use of hired labour used for all farm tasks are summarized in Table 8.4 and in Figure 8.1. The types of jobs which were undertaken by hired labour are summarized in Table 8.5 and in Figure 8.2. Heaviest demands for hired labour amongst woodlot growing households fall around the beginning of the long rains toward the end of March. Heaviest demands amongst households which formerly grew woodlots are spread between the beginning of the long rains and the end of

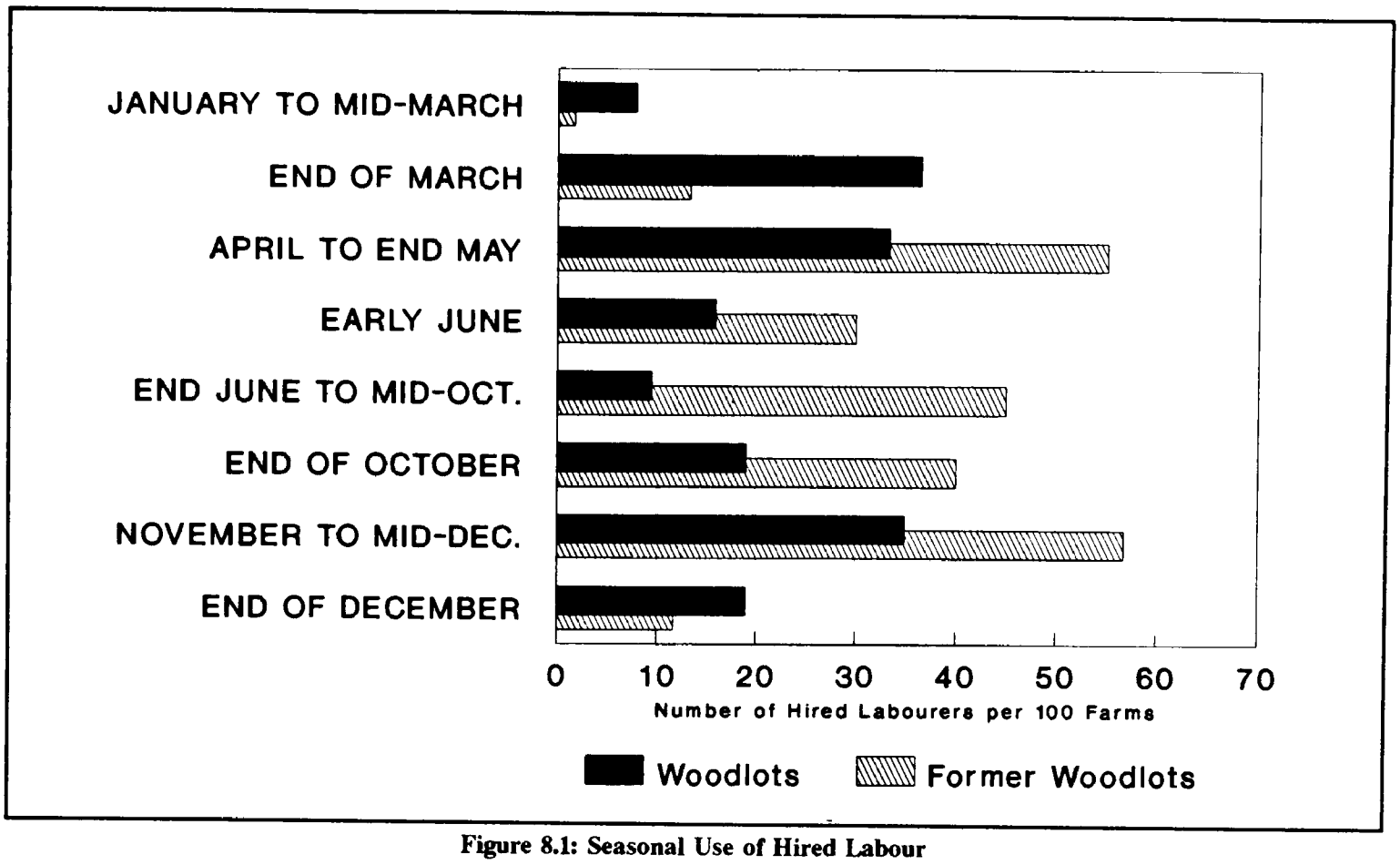


Figure 8.1: Seasonal Use of Hired Labour

Table 8.5: TYPES OF JOBS UNDERTAKEN BY HIRED LABOURERS

TYPE OF JOB	NUMBER OF TIMES REPORTED AS A TASK FOR HIRED LABOUR, PER HOUSEHOLD: WOODLOTS	FORMER WOODLOTS	SIGNIF-ICANCE	T-VALUES
PICKED TEA	1.54	2.48	**	-2.0
PICKED COFFEE	1.22	1.08		0.4
OTHER TASK, TEA	0.37	0.52		-0.7
OTHER TASK, COFFEE	0.37	0.47		-0.5
OTHER CROP, DIGGING	0.73	0.55		0.8
OTHER CROP, OTHER TASK (1)	0.76	0.65		0.5
TENDED LIVESTOCK	0.24	0.22		0.2
HOUSEHOLD	0.00	0.02		..

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

(1) includes planting, weeding, harvesting, and application of pesticides and herbicides.

the short rains in November. Demands for hired labour amongst these households are more evenly distributed throughout the year.

Significant differences in the seasonal employment of short term hired labourers are evident at the end of March when woodlot growing households employ over two times as many casual labourers as former woodlot growing households. Differences are also most evident between the end of June and mid-

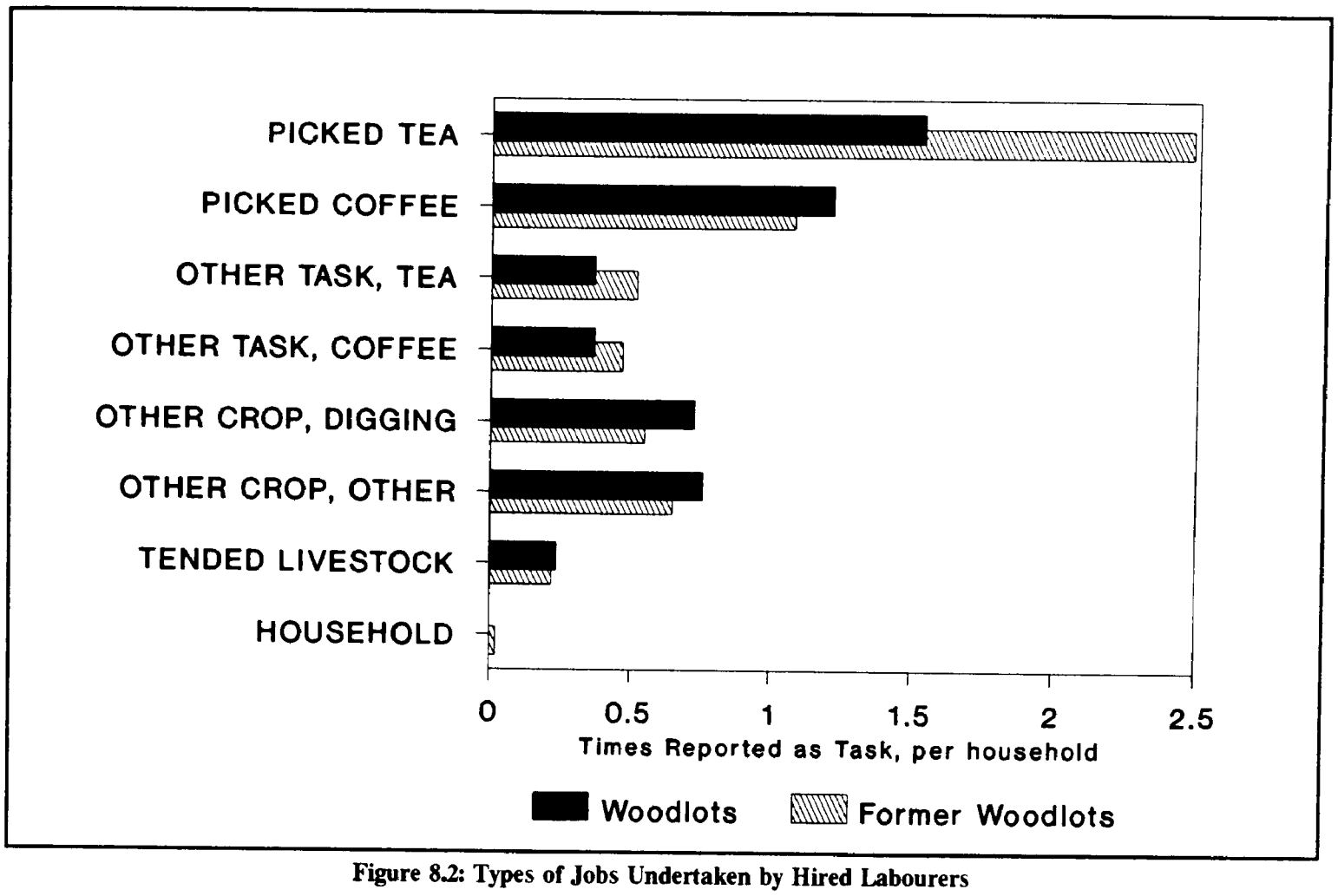


Figure 8.2: Types of Jobs Undertaken by Hired Labourers

October, when demands for labour on woodlot growing households decline but increase on former woodlot growing households.

The duration of employment of short term hired labourers is significantly longer during two periods amongst woodlot growing households: in early June, and between the end of October and mid-December. In some senses then, the important difference between the households is that woodlot growing households hire fewer labourers throughout the year, but that during peak periods of demand, they employ them for longer periods, than former woodlot growing households.

The primary tasks undertaken by hired labour were the picking of coffee and tea amongst all households. The number of times labourers were employed to pick tea is significantly greater amongst former woodlot growing households. Digging, in preparation for planting, is also an important task for hired labourers, but there were no significant differences between households in the frequency with which labourers were employed to dig.

Transportation of inputs and outputs

There was little dissimilarity between subsampled households with regard to the ways in which inputs and outputs were taken to and from the farm. Most households reported they primarily brought inputs to the household by carrying them on their back (78 percent), while the balance reported they were brought by *matatu* (public transport). Around 94 percent of the households reported that they primarily took crops to markets and buying centres on their back. Less than 5 percent relied on public transport to carry outputs to the market or to a crop buying centre.

Labour-to-Land Ratios

In order to develop a better sense of the relationship between land and labour amongst sampled households, labour-to-land ratios were calculated for different categories of residents and non-residents. If woodlots are an outcome of a labour constraint, it could be expected that woodlot growing households would have lower labour-to-land ratios than households which operate parcels which were formerly used for cultivating woodlots.

Labour-to-land ratios are shown in Table 8.6. There are significant differences for most categories of residents and non-residents between samples. These differences are consistent with the view that woodlot growing households have limited access to household labour, possibly exacerbated by labour migration and by the participation of relatives in off-farm activities.

Labour-to-land ratios for woodlot growing households are consistently, and significantly, lower than ratios for households which operate parcels cleared of their woodlots. There are just over half as many residents per unit area of these households than amongst households which have cleared their woodlots. These households also have a significantly higher ratio of resident older people -- over 4

Table 8.6: LABOUR-TO-LAND RATIOS

RESIDENT HOUSEHOLD MEMBERS OR NON-RESIDENT RELATIVES OF RESIDENT	NUMBER OF PERSONS PER HECTARE OF OPERATED HOLDING: WOODLOTS	FORMER WOODLOTS	SIGNIF-ICANCE	T VALUES
RESIDENTS				
HEAD OF HOUSEHOLD, (MALE OR FEMALE)	0.93	1.32	**	-2.6
WIFE OF HEAD	0.79	0.92		-0.6
SON OF HEAD	1.40	3.39	***	-3.4
DAUGHTER OF HEAD	1.27	2.55	***	-3.0
TOTAL, CHILDREN OF HEAD	2.68	5.94	***	-4.0
ADULTS > 70 YEARS OF AGE	0.27	0.06	**	2.6
OTHER RESIDENTS	0.06	0.03		-0.5
TOTAL RESIDENTS	4.47	8.20	***	-3.7
NON-RESIDENT RELATIVES				
SON OF HEAD	0.82	0.42	*	1.7
DAUGHTER OF HEAD	1.17	0.53	**	2.4
TOTAL, CHILDREN OF HEAD	1.99	0.95	**	2.4
OTHER RELATIVES	0.09	0.14		-0.4
TOTAL NON-RESIDENTS	2.08	1.09	**	2.2

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

times as many people over the age of 70 than amongst households which operate cleared woodlot parcels. Both of these facts suggest that labour may be constrained, and indeed is *constraining* woodlot growing households from adopting more labour-intensive land-uses.

If the ratio of non-resident relatives per hectare of operated holding is considered, the reverse seems to be the case. There are nearly twice as many non-resident relatives of residents of woodlot growing households, per hectare, than households which have cleared their woodlots. Significant differences are particularly evident in the numbers of non-resident children per hectare between sampled households.

Other Sources of Income

In addition to off-farm employment, households were questioned about sources of income coming from other activities such as small rural businesses, wage

Table 8.7: FREQUENCY OF WAGE REMITTANCES FROM NON-RESIDENT RELATIVES OF RESIDENT HOUSEHOLD MEMBERS

FREQUENCY OF WAGE REMITTANCES FROM NON-RESIDENT RELATIVES	WOODLOT GROWING HOUSEHOLDS	FORMER WOODLOT GROWING HOUSEHOLDS	SIGNIF-ICANCE	T-VALUES
MORE OFTEN THAN ONCE A MONTH	11.5%	25.0%	*	-1.6
ABOUT ONCE A MONTH	52.5%	21.4%	***	2.8
ABOUT ONCE EVERY SIX MONTHS	23.0%	42.9%	**	-1.9
LESS OFTEN THAN ONCE EVERY SIX MONTHS	13.3%	10.7%		0.3
TOTAL	100.0%	100.0%		..

two-tailed t-tests
* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent
.. t-values not calculated

remittances from non-resident relatives, or income from the sale of food or handicrafts. Reported income from off-farm businesses was nil.

There were no statistical differences in the proportions of non-resident relatives who remitted earnings to the household. There were differences, however, in the frequency with which earnings are remitted. These are indicated in Table 8.7. Non-resident relatives of resident household members of woodlot growing households remit earnings with greater frequency: 64 percent reporting they remitted once a month or more often, compared with 46 percent of non-resident relatives of former woodlot growing households who reported they remitted with the same frequency. Differences are likely accounted for by the higher proportion of non-resident relatives of woodlot growing households who are in public sector and urban wage employment and receive a regular income, as well as by the age distribution of the respective samples.

Woodlot Management

Households which operated parcels with woodlots on them were surveyed about current utilization and management practices. Questions related to income generation from woodlots, the types of products grown and used, the frequency of harvest, labour-use for harvesting, effects of wattle on other crops, planned use of

land after the next harvest, and charcoal and wattle bark prices.

Income and utilization

Relatively few households (11 percent) sold bark from their woodlot the last time it was harvested. Around 70 percent of households surveyed responded that they did not sell any wood from their woodlot the last time it was harvested. The balance sold charcoal (3 percent), poles (3 percent) and fuelwood (14 percent). Clearly, relatively few woodlots are being regularly harvested for income generation.

Woodlot operators reported that the last time trees were harvested, on average, around 30 percent of the trees were felled ($\sigma = 0.33$). Only 15 percent reported that they had clearfelled their woodlot -- the standard practice when bark is harvested or when charcoal is burnt from wattle. Seventy percent of the operators reported they had felled less than a quarter of their trees in the previous harvest.

The mean reported age of woodlots operated by sampled households was 16.1 years ($\sigma = 10.55$). Of woodlot operators who were able to report when they had established their woodlots, 43 percent had originally established their woodlot before 1970, and two thirds had been established before 1980.

The mean reported age of trees which were last harvested was 4.8 years ($\sigma = 2.02$). Around 74 percent of woodlot operators reported that they had last harvested trees from their woodlots within the previous 2 years. Around 80 percent of woodlot operators reported that they would harvest trees again within the next 2 years. Around 9 percent reported that they would not harvest trees again for more than 5 years.

The irregular harvesting of trees grown on a short rotation seems to be the standard woodlot management practice. This suggests that woodlots are being seriously underutilized, and could be made much more productive if more intensive

harvesting practices were undertaken. No age-class inventories were undertaken as part of this research.

Woodlots and other land uses

Woodlot operators were questioned about the effect of wattle on adjacent crops and about the best and worst crops to plant on old wattle sites. Around 58 percent reported that wattle caused no problems to other crops. Woodlot operators reported that the best crops to plant on old woodlot sites would be tea (63 percent) or coffee (34 percent). Around 80 percent reported that maize would be the worst crop to plant on old wattle sites, followed by bananas (9 percent), beans (7 percent) and potatoes (4 percent).

Operators of parcels which were formerly used for growing woodlots were questioned about current land-uses on old woodlot sites. Around 70 percent of these households responded that they had planted tea on old wattle sites, 19 percent had planted coffee, 9 percent had planted food crops (maize, beans, and sorghum) and the balance was fallow. Around 40 percent of these households reported that they had cleared their woodlots before 1970; 90 percent reported they had been cleared before 1980. Of these, 93 percent reported woodlots had been cleared only after their parcels had been consolidated and after titles had been issued.

Over 45 percent of current woodlot operators reported that they definitely planned to leave wattle on the woodlot site, and would not convert it to any other land-use. Around 18 percent reported they were going to clear their woodlot and plant tea. Most of the rest had not decided what they would do with the site after they next harvested from it.

Three-quarters of those households which had established their woodlot since 1980 reported that they were planning to leave their woodlot under wattle;

17 percent were going to clear their woodlot and plant tea; 8 percent had no plans or didn't otherwise know what they would do. Of households which had established their woodlot before 1980, 39 percent reported that they were going to leave their woodlot under wattle, 18 percent reported they were going to plant tea, and 39 percent had no plans.

Around 85 percent of woodlot operators surveyed responded that harvesting was carried out solely by household labour. The balance, 15 percent, was provided by a combination of hired and household labour.

Only a small proportion (3 percent) of woodlot operators had ever heard of a woodlot being used as security for a loan. Of household which operate parcels which had formerly been used for growing a woodlot, 42 percent reported that either someone in their family or someone they knew had belonged to one of the wattle bark cooperatives which used to operate in the area.

Woodfuel Use and Supply

An assessment of the relationship between tree growing and woodfuel use is often problematic. Even if accurate woodfuel consumption statistics were available for surveyed households, it would still be difficult to establish causal relationships between different variables on rates and quantities of woodfuel consumed. Definitions of woodfuel "scarcity" seldom reflect the full range of energy options available to smallholders, both in terms of supply augmentation and demand management. A fuller discussion of the "woodfuel crisis" and how widely held perspectives of the issue have obscured more fundamental problems of capital, land and labour allocation is included as Appendix 1.[1]

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1. Appendix 1 is a revised form of the article,
P.A.Dewees (1989a). "The woodfuel crisis reconsidered: Observations on the dynamics of abundance and scarcity," *World Development* 17(8):1159-1172.

Only a few specific questions in the household survey addressed woodfuel supply and demand options. These were related primarily to the maintenance of woodfuel stores, the length of time these stores would last, the types of woodfuel currently being used, frequency of woodfuel collection, and sources of supply. Although they failed to provide sufficient information about the extent and nature of woodfuel scarcities, several of the findings are worth repeating.

Woodfuel storage and supply

Around 64 percent of the households surveyed indicated that they maintained special woodfuel stocks (*itari* or *kĩbaca kĩa ngũ).* There were no statistical differences in the numbers of households which maintained woodfuel stores between the subsamples of woodlot growing households and former woodlot growing households.

Households were also asked how long their current stores of woodfuel would last them. Woodlot growing households replied that stores would last 8.6 days, while former woodlot growing households reported stores would last 4.5 days. The difference was significant to 10 percent ($t = 1.68$).

There was no statistical difference in the primary type of woodfuel which was being used by the subsampled households at the time of the survey. Half of the households were using split timber as their primary source of woodfuel. Another 30 percent were primarily using thick branches. The balance of the households were primarily using thin twigs (12.7 percent), crop residues (5.1 percent) and charcoal (1.7 percent).

Seasonal differences in sources of woodfuel supply and in the frequency of woodfuel collection are summarized in Table 8.8. Reported differences in sources of supply from season to season are insignificant. Woodlot growing households, however, consistently obtain more than 95 percent of their woodfuel supplies from

Table 8.8: SEASONAL DIFFERENCES IN SOURCES OF WOODFUEL SUPPLY AND IN THE FREQUENCY OF WOODFUEL COLLECTION

SEASON	WOODLOTS	FORMER WOODLOTS	CHI-SQUARE	T-VALUES	SIGNI-FICANCE
DRY SEASON					
SOURCES OF SUPPLY:					
OWN FARM	98.4%	42.9%			
BOUGHT FROM MARKET	1.6%	25.0%			
BOUGHT FROM NEIGHBORS	0.0%	30.4%			
FREE FROM NEIGHBORS	0.0%	1.7%			
TOTAL	100.0%	100.0%	45.18	..	***
FREQUENCY OF COLLECTION (IN TIMES PER WEEK)	1.6	2.3	..	-3.49	***
RAINY SEASON					
SOURCES OF SUPPLY:					
OWN FARM	98.4%	44.6%			
BOUGHT FROM MARKET	0.0%	23.2%			
BOUGHT FROM NEIGHBORS	1.6%	30.4%			
FREE FROM NEIGHBORS	0.0%	1.8%			
TOTAL	100.0%	100.0%	43.10	..	***
FREQUENCY OF COLLECTION (IN TIMES PER WEEK)	2.4	4.1	..	-5.01	***
COLD SEASON					
SOURCES OF SUPPLY:					
OWN FARM	96.7%	42.9%			
BOUGHT FROM MARKET	1.6%	23.2%			
BOUGHT FROM NEIGHBORS	1.7%	33.9%			
FREE FROM NEIGHBORS	0.0%	0.0%			
TOTAL	100.0%	100.0%	41.11	..	***
FREQUENCY OF COLLECTION (IN TIMES PER WEEK)	2.9	4.4	..	-3.85	***

* significant to 10 percent
** significant to 5 percent
*** significant to 1 percent

trees growing on their own farm, compared with 40 to 45 percent of former woodlot growing households. The balance of the woodfuel supply used by former woodlot growing households is obtained from the market, being mostly purchased from neighbors (30 to 35 percent) or from local markets (20 to 25 percent). Differences in sources of supply are significant to less than 1 percent.

Woodlot growing households consistently make fewer collection trips than former woodlot growing households, regardless of the season. Households make the fewest woodfuel collecting trips during the dry season, more during the rainy

season, and the most collecting trips during the cold season. Former woodlot growing households make 1.4 times as many collecting trips during the dry season, 1.7 times as many trips during the rainy season, and 1.5 times as many trips during the cold season than woodlot growing households. Differences are all significant to less than 1 percent.

Woodfuel scarcity

None of this information by itself tells much about whether or not woodfuel is scarce amongst surveyed households. For the purposes of this discussion, woodfuel is assumed to be scarce when households are unable to obtain the minimum amount of fuel that would be needed to meet some level of basic demand. There is simply not enough information available about whether or not this level of demand (which would, in any event, be rather arbitrarily defined) is being met.

Other researchers have concluded that

-- woodfuel is more scarce amongst households whose stocks last a shorter time;

-- woodfuel is more scarce amongst households which make more frequent collecting trips; and

-- regular household purchases of fuelwood or charcoal are indicators of woodfuel scarcity.

Indeed, other researchers have concluded that all these situations obtain in Murang'a District and consequently, that there are serious woodfuel shortages in the district.[1] I think the conclusions are arguable.

According to the results of this survey the three most significant differences between subsamples with regard to woodfuel use are the facts that woodlot growing households have woodfuel stocks which will last them longer, they make fewer collecting trips, and rely less on the market to provide them with supplies.

The frequency with which households make woodfuel collection trips may

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1. P.N.Bradley (1991). *Woodfuel, Women and Woodlots*. London, Macmillan. p.151.

reflect the availability of labour to collect woodfuel -- as well as the physical scarcity or abundance of woodfuel. For instance, amongst surveyed households, if the number of household collecting trips per week is divided by the number of resident household members, there are *no* statistical differences in the numbers of collecting trips per resident household member between woodlot and former woodlot growing households during the dry and cold seasons (although there are small, significant differences during the wet season).

The length of time woodfuel stocks will last will depend partly on the physical size of these stocks, as well as on household size. Rates of energy consumption are less for smaller households, and so, equivalently sized stocks would last longer for woodlot growing households than for others. But this fact bears no relationship to whether or not a household has enough woodfuel. If a household has more labour, which enables it to collect woodfuel more frequently, then there is little need for large stocks. Similarly, woodlot growing households, which have less labour, may take the view that they need to keep larger stocks on hand because of the risk that there may be labour constraints which will prevent them from collecting supplies in the future.

The relationship between a reliance on the market to provide woodfuel, instead of on-farm supplies is a tenuous indicator of woodfuel scarcity. A reliance on the market reflects, in part, the process of specialization and exchange which occurs with the development of labour and other markets. These households may spend capital to buy woodfuel simply because they have more capital to spend, and because labour time is used for other things.

Although the survey identified important differences in the ways households obtain and store woodfuel, there was insufficient information to conclude that one group of households is worse off than the other in terms of the amount and type

of woodfuel which is used. Differences in the strategies which households use to obtain fuelwood reflect more general differences in patterns of labour, land and capital allocation and woodfuel scarcity must be viewed in this context.

Chapter 9. Smallholder Behaviour, Tree Planting, and Land-use Change

Summary of Survey Results

Chapters 6, 7, and 8 reviewed some of the main findings of the household survey with regard to household composition, land-use, cash crop production, savings and investment, and woodlot management. Households which operate woodlots are clearly different from households which operate parcels which have been cleared of their woodlots in terms of the ways in which they use their available land, labour and capital. This chapter summarizes some of these differences, and then describes how data was further analyzed.

One of the important points that emerged from the household data with respect to household composition was the difference in the age of the head of the household, and the relative rates of residence and non-residence of the children of the head of the household. A crucial question is one of causation: whether or not household composition is a function of an older household age structure and that this leads to the adoption of patterns of land, labour and capital use (including woodlot establishment) which are more common amongst older aged households, or whether the adoption and maintenance of woodlots amongst particular households means that these households require less labour, and so household members migrate elsewhere in search of employment. Much of the analysis in this chapter lends strong support to the first hypothesis: that woodlot establishment becomes more common as households age, and is consistent with other resource

allocation strategies which accompany this process. These strategies may well have little to do with labour or capital scarcities *per se*, but may instead reflect lower requirements for capital amongst older households.

Differences in household composition

Households which operate plots which were formerly used for growing woodlots support more residents than households which currently operate woodlots. The difference in the numbers of residents is accounted for by a greater number of resident children -- around 1 extra resident child per household. While the *total* number of children per household, both resident and non-resident, is on average the same amongst all households, the numbers of non-resident children per woodlot growing households is significantly greater than amongst former woodlot growing households.

Differences in the numbers of resident and non-resident children may be an outcome of differences in the age structure of the respective households. Heads of woodlot growing households are generally older than the heads of former woodlot growing households. Children in these households are older, as well, and the result is that more of them are old enough to have moved away from home on marriage.

Around 30 percent of the households in both samples are headed by women. The absence of any significant difference in the numbers of women-headed households or in the ratios of women-to-men between samples in the working age groups suggests that labour migration amongst these age groups is not particularly different.

Small proportions of resident household members in both sets of sampled households engage in some sort of temporary or permanent wage employment, but there are no significant differences between households.

Even though there are no clear differences in rates of waged employment amongst working age residents, differences in the numbers of non-resident relatives

of resident household members in wage employment suggest that participation in the formal wage economy may be playing an important role in the household dynamic.

Woodlot growing households have nearly twice as many sons and daughters no longer in residence as former woodlot growing households and a greater proportion of these non-residents are in the working age groups. Similarly, a larger number of non-resident daughters of woodlot growing households report their primary occupation as operators of their own farms, and the number of non-resident sons of woodlot growing households in urban or public sector wage employment is significantly higher than amongst former woodlot growing households.

Given the differences in the age structure of the respective groups of households, these results would be expected. Because woodlot growing households are generally older, it would be expected that daughters would marry and move away and sons would seek wage employment off the farm. While non-resident sons do not generally participate in the day to day operation of surveyed households, they do maintain rights of tenure and inheritance, and they (or their wives) are expected eventually to return to operate their claim. In contrast, daughters who leave their father's *shamba* on marriage seldom have any explicit subsequent rights of tenure to it and are expected to cultivate their husband's own *shamba*.

This view can be tested by examining differences in household composition in different age groups. In order to do this, the sample was divided into five 10-year age groups, defined by the age of the head of the household: 25 to 35 years, 36 to 45 years, 46 to 55 years, 56 to 65 years, and 66 to 75 years. When examining the proportionate numbers of residents and non-resident relatives of resident household members, per household, in each age group, there were no differences

found between subsamples.

For example, for all woodlot growing and former woodlot growing households where the head of the household was between 56 and 65 years old, there were found to be, on average, 6.41 resident household members and 3.47 non-resident relatives of resident household members per household, and there were no statistical differences between subsamples.

The key differences, then, are in the *total* number of residents and non-residents per household across *all* age groups. Because former woodlot growing households are younger, there are more residents and fewer non-residents. Because woodlot growing households are older, there are fewer residents and more non-residents.

Differences in land-use

Woodlot growing households generally operate larger holdings than households which are operating holdings which have been cleared of their woodlots. Differences are accounted for by the area of woodlots and by the area under fodder crops or pasture (which is greater amongst woodlot growing households). Other land-uses occupy roughly equivalent areas.

The cultivation of multiple parcels was relatively common amongst sampled households. Each household cultivated an average of 1.63 parcels. There were no significant differences between samples. Homestead parcels were generally larger than other parcels.

Amongst woodlot growing households with multiple parcels, the likelihood was greater that the woodlot would be established on a remote parcel, rather than on the homestead parcel. Further, crops with the largest labour requirements (particularly tea) are more likely to be established on the homestead parcel rather than on remote parcels.

Differences in agricultural conditions

There are fundamental differences in the quality of the basic land endowment operated by the respective households. Altitude and slope of the respective subsamples were significantly different in a number of key respects. Parcels which are used for growing woodlots are generally lower in altitude than parcels which have been cleared of their woodlots. The slope of parcels which are used for growing woodlots is generally greater on the woodlot plot itself, as well as on all other plots operated by the household, regardless of their use.

Differences in assets

There were no significant differences in the quality or quantity of assets owned by the respective households, with the exception of cattle. The reported total value of cattle owned by woodlot growing households was around 40 percent greater than that of cattle owned by former woodlot growing households. These households also had a greater area under pasture and fodder crops. Amongst all households, livestock remains an important asset which (much more so than land) can be easily bought and sold.

Differences in input use and income from tea and coffee

With the exception of the use of hired labour for the picking of tea, all characteristics about the cultivation of tea -- input use, output, income, area cultivated, and numbers of bushes cultivated -- were similar amongst sampled households. Former woodlot growing households reported that the frequency with which labourers were hired to pluck tea was significantly greater than amongst woodlot growing households.

With regard to the cultivation of coffee, woodlot growing households reported they cultivated more than twice as many coffee bushes per household member than former woodlot growing households. Net income from coffee

amongst woodlot growing households was greater than amongst former woodlot growing households, which incurred significant losses. Losses by these households were the outcome of higher expenditures on inputs and lower yields.

With regard to the hiring of labour, woodlot growing households hire fewer labourers throughout the year than former woodlot growing households, but during peak periods of demand, they employ them for longer periods. Former woodlot growing households hire labour more frequently for the picking of tea.

Woodlot growing households are more dependent on regular farm income to finance the purchase of inputs for coffee and tea. Former woodlot growing households are more dependent on loans provided by cooperative societies.

Data about crop production and input use suggests that woodlot growing households are more risk averse than other households. Not only were these households less inclined to borrow money to cover either investment or recurrent costs, expenditures on fertilizers and pesticides[1] for coffee were low and were paid for primarily with regular farm income. To some extent these households also rely less heavily on hired labour than former woodlot growing households.

Differences in labour-to-land ratios

The ratios of resident labour-to-land for woodlot growing households are consistently lower than ratios for households which operate parcels cleared of their woodlots. If the ratio of non-resident relatives per ha is considered, the reverse is the case. These differences are consistent with the view that woodlot growing households have relatively limited access to household labour, and indeed have a relatively limited need for labour. The causal question remains of whether labour

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1. It should be pointed out that whether or not a risk averse household uses pesticides is ambiguous at best. On the one hand, there is the fear of losing the coffee crop if pesticides are not used, and the argument could be made that risk averse households would use high levels of pesticides. On the other hand, there is the fear that heavy expenditures on pesticides will not be recouped by higher yields and income from coffee, and so the argument could be made that risk averse households would spend little on pesticides.

migrated, and so woodlots were planted, or whether woodlots were planted, labour was not needed, and so then migrated.

Woodlot management

Woodlots are primarily managed as large areas of uncultivated fallow. Relatively few households regularly harvest their woodlots for bark or for other products which could be sold. The irregular harvesting of trees grown on a short rotation is the standard management practice. Woodlots are being seriously underutilized and could be made much more productive if management was intensified.

Discussion

The picture that emerges from the survey is consistent in many respects with the view that woodlot growing households have both labour and capital constraints. Woodlot growing households have an older age structure, and consequently have fewer children living at home. The fact that there are fewer residents of these households, and that holdings of woodlot growing households are larger has meant that labour-to-land ratios are lower. Non-resident relatives of these households are more involved in the formal wage economy.

Observed patterns of capital, labour and land-use are consistent with the view that woodlot growing households tend to be more risk averse. They have invested more heavily in livestock, and spend relatively little on crop inputs. They depend primarily on regular farm income to cover investment and recurrent costs and are less dependent on cooperatives to provide credit for farm inputs. Urban wage remittances probably help to reduce these households' dependence on cooperatives for loans as non-resident relatives of these households remit income with greater frequency than non-resident relatives of former woodlot growing households.

It is often argued that the maintenance of farm trees, in configurations such as woodlots, is a form of risk management.[1] Unlike virtually any other crop, trees can be harvested whenever the household's needs for cash are the greatest, and they reduce the household's exposure to risk because capital and labour outlays for tree growing are quite low. If one accepts this argument, woodlot establishment would be consistent with other risk averse patterns of land, labour and capital use which seem evident amongst these households.

Why would these households be more risk averse? We return again to the age argument, that older households tend to be more risk averse. These households also have greater labour constraints, because children have left the shamba. So the establishment and maintenance of woodlots is seen by these households to be a low input, risk averting, and labour optimizing land-use strategy.

Woodlots are maintained not so much as a source of income (although income generation from woodlots remains a clear possibility), but because household resources appear not to be adequate for cultivating these areas more intensively. Fundamental differences in the quality of the basic land endowment -- principally that parcels operated by woodlot growing households are more steeply sloping -- have important implications with regard to the intensity with which holdings can be cultivated.[2] Woodlot growing households would require relatively

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1. See for instance, R.J.H.Chambers (1988). *Trees as Savings and Security for the Rural Poor* (Gatekeeper Series Paper No.3). London, International Institute for Environment and Development; and, G.Leach and R.Mearns (1988). *Beyond the Woodfuel Crisis: People, Land and Trees in Africa*. London, Earthscan. pp.82-83.

2. For example, the labour required to harvest tea would be quite different amongst surveyed households. Suppose farmers in the respective subgroups each cultivated parcels of tea which were 30 metres by 100 metres in area (0.3 ha, as in the survey). Suppose also that these parcels were on hillsides with slopes of 18.9° for woodlot growing households and 15.4° for former woodlot growing households (also as in the survey). The difference in total vertical altitude between these parcels is around 6 metres. The 2,500 tea bushes which would be planted on such a parcel, would yield around 3,100 kg of green leaf per year, and would require the removal of 210 basket loads of green leaf per year, probably to the top of the parcel. Clearly, the additional vertical altitude of 6 metres for woodlot growing households would result in a very substantial increase in the amount of work required to harvest tea from the parcel.

larger labour inputs to make their parcels more productive.

Scope for Further Analysis

The decision to establish a woodlot, or to clear a woodlot and to use land for some other purpose reflects multiple household characteristics. It would be difficult to conclude from an observation of any single variable that a household would be more likely to undertake a particular land-use practice.

In order more fully to explore the relationship between factor allocation processes and woodlots, data was further developed through an econometric exercise which related the decision to either establish a woodlot, or to clear a woodlot and to use the land for something else, to particular household characteristics. The objective of the exercise was to explore the likelihood that the willingness of farmers either to adopt or to abandon certain land-use practices is closely linked with particular features of the household economy.

Much of the discussion so far has related to differences in household characteristics amongst households which have made one of two land-use choices: either to maintain a woodlot, or to clear their woodlot and to use their land for something else. Multiple regression analysis and discriminant analysis might be used to predict whether households would choose to alter their land-use in a particular way, say, to establish a woodlot or not. There are problems, however, in using these techniques to predict a binary dependent outcome from a set of independent variables, particularly because predicted values cannot be interpreted as probabilities which are constrained to fall in the interval between 0 and 1.

Logistic regression (logit) analysis is a multivariate technique which allows for estimating the probability of an event occurring or not. Logistic regression models are used to predict a binary dependent outcome from a set of independent variables. The model seeks to fit probable outcomes on a logistic probability curve,

such as that shown in Figure 9.1. For more than one independent variable, the model can be written as

$$P(Z) = \frac{1}{1 + e^{-Z}}$$

where $P(Z)$ is the probability of the event and Z is the linear combination:

$$Z = B_0 + B_1 X_1 + B_2 X_2 + \ldots + B_p X_p$$

X_0 , X_1 , X_2 , ... and X_p are independent variables and B_0 , B_1 , B_2 , ... and B_p are coefficients estimated from the data. Similarly, from this equation,

$$e^{-Z} = \frac{1}{P(Z)} - 1 \quad or \quad \frac{1 - P(Z)}{P(Z)}$$

$$\text{so} \quad Z = \log \frac{P(Z)}{1 - P(Z)}.$$

The outcome is simply that the dependent variable in the regression equation is equal to the logarithm of the odds that a particular choice will be made. As a multivariate technique, logistic regression analysis is superior to the use of descriptive statistics by themselves because it incorporates rigorous checks for the relative significance of multiple variables.

In practice then, data for individual households is coded as either 0 or 1, depending on whether or not it has adopted the practice in question. Parameters of a logistic regression model are estimated and the model is fit by evaluating the maximum likelihood that particular independent variables, and coefficients estimated for these variables, make the observed outcome (0 or 1) more likely. The algorithm for estimating model parameters is non-linear and iterative.

The use of logistic regression to relate household characteristics to tree planting practices has been limited to analyses of Non-Industrial Private Forests

(NIPFs) in North America. Schuster[1] and Romm *et al.*[2] used logits to predict the probability of NIPF management in Montana and California. Binkley[3] used logistic regression to develop a timber supply model for New Hampshire. Clements and Jamnick[4] used logits to relate woodlot owner and ownership characteristics to forest management decisions in New Brunswick. These types of analyses do not incorporate panel data to explore temporal differences amongst surveyed households, but rather use static characteristics of the household to predict the likeliest outcomes.

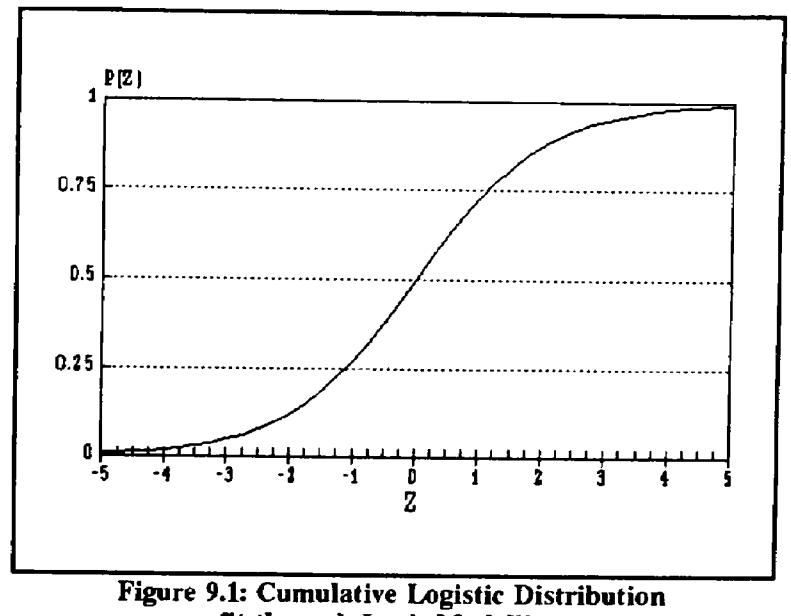


Figure 9.1: Cumulative Logistic Distribution fit through Logit Modelling

Development of Logits

Selection of variables

Using the results from the household survey, a set of variables was assembled for use in the construction of the logits. The variables tested for inclusion in the models reflected features of household composition such as numbers of resident household members, numbers of non-resident relatives, age structure, and features of the holding such as area, slope, and altitude and the length of time the holding had been operated by the household. Labour-to-land

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1. G.E.Schuster (1983). *Evaluating non-industrial private landowners for forestry assistance programmes: a logistic regression approach.* (Forestry Research Paper INT-320). Washington, D.C., U.S.D.A. Forest Service.

2. J.Romm, R.Tuazon, and C.Washburn (1987). "Relating forestry investment to the characteristics of non-industrial private forestland owners in Northern California," *Forest Science* 33:197-200.

3. C.S.Binkley (1981). *Timber supply from non-industrial private forests*. Yale University Bulletin No.92. New Haven, Yale University.

4. S.E.Clements and M.S.Jamnick (1989). "Forest Management on Private Woodlots in New Brunswick," *Journal of Environmental Management* 29:391-398.

Table 9.1: VARIABLES USED IN THE CONSTRUCTION OF LOGIT MODELS

VARIABLE NAME	DEFINITION	MODEL/DATA AGGREGATIONS A	B	C	D	E
MALEH	1 if male headed household; 0 if not	■	■			
WIFE	number of resident wives of head	■	■			
SON	number of resident sons of head	■				
DAUGH	number of resident daughters of head	■				
OLD	number of resident adults over 70 years of age	■	■			
OTHRE	number of other residents (parents, labourers, etc.)	■	■			
NRHUS	number of non-resident husbands	■				
NRWIF	number of non-resident wives	■				
NRSON	number of non-resident sons	■				
NRDOT	number of non-resident daughters	■				
AGEHH	age of the household head	■	■			
ALTIT	altitude of sampled parcel	■	■	■	■	■
AREA	corrected reported area of the household's holdings	■	■	■		
SLOPE	aggregate slope of the measured parcel	■	■	■	■	■
YEARS	number of years household has operated holding	■	■	■	■	■
KIDS	SON+DAUGH		■			
NRSPO	NRHUS+NRWIF		■			
NRKID	NRSON+NRDOT		■			
TOTRE	HEAD+WIFE+SON+DAUGH+OTHRE			■		
TNONR	NRHUS+NRWIF+NRSON+NRDOT			■		
LLHEA	number of household heads/AREA (1/AREA)				■	
LLKID	KIDS/AREA				■	
LLOTH	OTHRE/AREA				■	
LLRES	TOTRE/AREA					■
LLNRE	TNONR/AREA				■	■
COFFEE	Coffee price in constant 1987 KSh per kg	■	■	■	■	■
TEA	Tea price in constant 1987 KSh per kg	■	■	■	■	■

LOGITS WERE TESTED BOTH WITHOUT COFFEE AND TEA PRICES (TABLES 9.1 AND 9.4) AND CONTROLLING FOR COFFEE AND TEA PRICES (TABLE 9.7, DISCUSSION FROM PAGE 173)

ratios were also calculated for different categories of residents and non-residents. Variables were grouped and tested in 5 different aggregations, labeled A through E, which are summarized with their definitions in Table 9.1.[1]

Development of the data set

The first set of logits were derived from data collected during the household survey, reflecting the household's current composition and patterns of land and labour use. This approach is fundamentally a static one as it relies on cross-sectional data, and does not reflect how *changes* in household composition or in the household's endowments may influence the decision to change land-uses. Households which currently operate a woodlot were coded as 0 and households which operate parcels which were used for growing a woodlot in 1967, but which have since been cleared and are being used for something else, were coded as 1.

1. In testing different groups of variables, the objective is to construct logits using the most significant variables. Disaggregated variables which are found not to be significant by themselves may, when aggregated with other similar variables, be significant. Aggregations A through C test basic household characteristics through increasing levels of aggregation. For example, variables SONS and DAUGH in A are aggregated as KIDS in B and

There were 63 and 60 households in these subsamples, respectively. For the purposes of this discussion, these logits are referred to as the *current land-use* logits.

The principal limitation of the use of this data set is that, because it takes only a cross sectional view, it does not allow for the attribution of causality -- for examining why households have or haven't woodlots. In order to do this, a logit analysis must consider characteristics of the household both *before* and *after* a land-use choice was made.

The decision to alter an existing land-use practice by establishing a permanent crop such as a woodlot (or by clearing a permanent crop such as a woodlot) is made by a household in consideration of its immediate and future needs. To capture temporal changes which influence the decision to establish a woodlot, logits must include household information for the years before a woodlot was established, and then again for the same household in the year a woodlot was established and in subsequent years. Similarly, logits which consider the decision to clear a woodlot and to use a parcel for another crop must include household information before and after the land-use change is taken.

In order to construct logits which reflected temporal changes in household characteristics, the original data set was expanded quite considerably to comprise reconstructed household information for each year back to 1975 or to the year the household began operating the holding, whichever was most recent. Data about past household composition was reconstructed using age and residence information and information about the holding (and changes in the holding) which was collected during the survey.

Many households reported that they had undertaken a land-use change by establishing or clearing their woodlots prior to 1975. These households were excluded from the sample because of the problem of recalling accurate household

information over such long periods. Reconstructed household data for each of multiple years, dating back to 1975, was considered as if it represented an entirely new household.

The *woodlot clearance* logits were constructed using reconstructed data from households for each year a woodlot was operated, for the year a household cleared its woodlot, and, for these households, all subsequent years. Households which operated a woodlot at any time whatsoever were coded as 0 for every year the woodlot was operated. Households which cleared their woodlots were coded as 1 in the year of clearance and in all subsequent years. There were 345 and 160 households in these subsamples respectively.

Similarly, *woodlot establishment* logits were constructed using reconstructed household data for all households which had established a woodlot since 1975, for each year before the woodlot was established, for the year the woodlot was established and for all subsequent years. Reconstructed household data was coded as 0 for every year a household did not establish a woodlot, and was coded as 1 in the year a woodlot was established and maintained in all subsequent years. This reconstructed subsample comprised multi-year data in which 289 of these "new" households were coded as 0 and in which 157 households were coded as 1.
The three groups of logits are described in general terms in Table 9.1A.

Construction of Logits

Logits were constructed using the SPSSPC (Version 3.1) software package and its LOGISTIC REGRESSION routine. The FSTEP and BSTEP subroutines were used to iteratively remove and add variables using the likelihood-ratio test, which assesses the change in the log likelihood when each variable is added or deleted from the equation in turn. Variables were deleted which failed to improve the log likelihood ratio to any significant extent.[1]

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1. SPSS Inc. (1989). *SPSS/PC+ Update for V3.0 and V3.1.* Chicago, SPSS Inc.

Table 9.1A: DESCRIPTION OF TEMPORAL CHARACTERISTICS AND DICHOTOMOUS VARIABLE ASSIGNMENTS FOR TESTED LOGITS, AND POSSIBLE LOGIT OUTCOMES

Logit Name	Numbers	Data Included for which Years	Temporal Characteristics of Data	Dichotomous Variable Assignments: 0	Dichotomous Variable Assignments: 1	Logits seek to model:
Current Land-Use Logits	1A through 1E	1990	Static	Households which currently operate parcels with woodlots on them.	Households which operate a parcel which was used for growing a parcel in 1967, but which has since been cleared and is being used for something else.	the likelihood that, given particular characteristics of sample households at the time the survey was undertaken, it could be predicted whether or not households operate a woodlot or operate a parcel used for a woodlot in 1967, but since cleared.
Woodlot Clearance Logits	2A through 2E	1975 to 1990	Time Series	Data for households for all years during which they have operated a woodlot.	Data for households which have cleared their woodlot, for the year of clearance and for all subsequent years.	the likelihood that a sample household would operate a woodlot for a time, and then clear it to use the land for something else. Tests the impact of temporal changes in household characteristics on the decision to clear a woodlot.
Woodlot Establishment Logits	3A through 3E	1975 to 1990	Time Series	Data for households which have established a woodlot, but only for those years before the woodlot was established.	Data for households which have established a woodlot, but only for the year of establishment and for all subsequent years.	the likelihood that a household would establish a woodlot. Tests the impact of temporal changes in household characteristics on the decision to establish a woodlot.

The use of time series data was possible by reconstructing household characteristics, such as household composition, using data collected during the survey. In the Current Land-use logits, a single household would be represented by one record of data, while in the Clearance and Establishment logits, a single household could be represented by up to 16 data records, each describing the household during a different year. Logit construction however would consider each record as if it represented a unique household.

Woodlot Clearance and Woodlot Establishment logits were tested again for price effects. The data set was in all respects the same, except that coffee and tea prices were added to the time series household data, and dichotomous variables controlling for year were added. See the discussion following from page 173.

The Box-Tidwell transformation was used to test for non-linearity,[1] and yielded no evidence for non-linearity amongst any of the variables in any of the models. Once 'main effects' models had been constructed, they were tested for possible interaction effects between variables. Interaction terms were not found to be significant.

Logistic Regression Results

Current land-use logits

Fitness, the values of coefficients for significant variables (and their standard errors) for the current land-use logits are summarized in Table 9.2. The models are grouped in Table 9.2 by the sets of variables which were aggregated and tested for significance, shown in Table 9.1. Table 9.3 shows the signs of the coefficients for the current land-use logits, and summarize possible reasons why different variables affected the outcome positively or negatively.

For these logits, coefficients for all significant variables representing numbers of non-resident relatives of resident household members are negatively signed. Models 1A, 1B and 1C show that the likelihood a surveyed household had cleared its woodlot decreases as the numbers of nonresidents increase. There are clear labour implications of this difference in household composition, as less labour is available for the cultivation of more labour-intensive crops such as coffee or tea. Importantly, Model 1A suggests that this labour would have otherwise been provided by women -- daughters and wives of the head of the household.

Models 1D and 1E, which assess the importance of labour-to-land ratios in determining the likelihood of woodlot clearance, show quite clearly that as the ratio of residents per unit area of the household's holding increases, the likelihood that

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1. G.E.P.Box and P.W.Tidwell (1962). "Transformation of the independent variables," *Technometrics* 4:531-550; and, D.W.Hosmer Jr. and S.Lemeshow (1989). *Applied Logistic Regression*. New York, Wiley and Sons.

Table 9.2: LOGIT MODEL DEFINITIONS, SPECIFICATIONS, COEFFICIENTS AND FITNESS, FOR MODELS OF CURRENT LAND-USE PRACTICES

MODEL SPECIFICATIONS

MODEL	VALUES OF COEFFICIENTS AND STANDARD ERRORS CONSTANT	β_1	β_2	β_3	β_4	FITNESS Chi-Square	° OF FREEDOM	SIGNI-FICANCE
1A	-23.40	-9.16	-0.58	0.01	-0.12	138.3	118	0.10
	(8.7)	(22.3)	(0.2)	(0.0)	(0.0)			
1B	-17.31	-0.34	0.01	-0.11	..	144.1	119	0.06
	(8.0)	(0.1)	(0.0)	(0.0)	..			
1C	-17.27	-0.33	0.01	-0.11	..	144.4	119	0.06
	(8.0)	(0.1)	(0.0)	(0.0)	..			
1D	-24.98	0.23	0.48	0.01	-0.12	132.4	118	0.17
	(8.6)	(0.1)	(0.3)	(0.0)	(0.0)			
1E	-21.73	0.17	-0.21	0.01	-0.12	131.8	118	0.18
	(8.5)	(0.0)	(0.1)	(0.0)	(0.0)			

MODEL DEFINITIONS

MODEL	VARIABLE X_1	X_2	X_3	X_4
1A	NRWIF	NRDOT	ALTIT	SLOPE
1B	NRKID	ALTIT	SLOPE	..
1C	TNONR	ALTIT	SLOPE	..
1D	LLKID	LLOTH	ALTIT	SLOPE
1E	LLRES	LLNRE	ALTIT	SLOPE

Table 9.3: LOGITS OF CURRENT LAND-USE PRACTICES, SIGNS OF COEFFICIENTS

P(WOODLOT CLEARED) = 1
P(WOODLOT MAINTAINED) = 0

VARIABLE	SIGN OF COEFFICIENT	RATIONALE
NRWIF	-	Labour supplies are less when wives live away amongst households with woodlots.
NRDOT	-	Labour supplies are less when daughters live away, amongst households with woodlots.
NRKID	-	As for NRDOT.
TNONR	-	As for NRDOT and NRKID.
LLKID	+	Higher population densities suggest possibly greater access to labour amongst households which have cleared their woodlots.
LLOTH	+	Possibly reflects higher numbers of resident permanent labour amongst households which have cleared their woodlots.
LLRES	+	As for LLKID.
LLNRE	-	Opposite of LLRES.
ALTIT	+	As altitude increases, chances of woodlot clearance increase because of higher altitudes are better for growing tea.
SLOPE	-	Woodlots growing households operate parcels which are more steeply sloping.

one of the sampled households would have cleared its woodlot increases. Model 1D suggests that these residents are largely children and "other residents," a category which includes permanently employed resident labourers. Model 1E shows that if the ratio of total residents per unit area is greater, the likelihood a surveyed household would have cleared its woodlot increases, and as the ratio of total non-resident relatives per area increases, the likelihood a surveyed household had cleared its woodlot decreases.

Higher population densities may mean that there is greater access to household labour, while lower densities suggest that access to labour may be constrained. This analysis of differences in labour-to-land ratios of residents and nonresidents lends support to the view that the decision to continue maintaining trees as a labour-extensive part of the farming system in the face of potentially more lucrative land-uses may be a function of important labour constraints.

The design of the sampling frame was intended to control for the impacts of differences in agricultural conditions (particularly altitude) on the propensity of a household to either clear or to establish a woodlot. Even so, in every model, the altitude of the sampled parcel was a significant variable.

The positive sign of the altitude coefficients in these logits suggests that as altitude increases, the likelihood a surveyed household would have cleared its woodlot also increases. This is somewhat surprising, as wattle grows particularly well at higher altitudes. Wattle woodlots become an extremely common form of land-use at higher altitudes in Murang'a District, and one would expect to find that households at higher elevations would maintain their woodlots.

This outcome is likely related to potential alternative land-uses. Tea, for instance, is most commonly found at higher altitudes. As the altitude increases, it is likely that woodlot clearance precedes the establishment of a tea plot. Wattle

is maintained in woodlots at lower altitudes because alternative land-uses at these altitudes -- smallholder coffee, maize, and other subsistence crops -- are not as lucrative as smallholder tea grown at higher altitudes.

The final important variable, which was significant in most of the models tested was the slope of the sampled parcel. The negative sign of the slope coefficient in the current land-use logits suggests that, amongst surveyed households, those which operate more steeply sloping parcels are more likely to have maintained their woodlots. This is an intuitively satisfying outcome because of the widely-expressed interest of farmers in maintaining trees on steeply sloping hillsides for soil conservation purposes. There are also labour implications of the decision to maintain trees on steep slopes because of the greater difficulty involved in cultivating hillsides.

Woodlot clearance logits

The results of the woodlot clearance logits are summarized in Table 9.4, in Models 2A through 2E. The signs of the coefficients, and a discussion of how these signs could be interpreted are included in Table 9.5. The structure of these logits is somewhat more complex than the current land-use logits because of the greater number of variables that were significant. In general, there is good consistency between these sets of logits. The current land-use logits show the current relationship between different variables and their relative importance vis-a-vis woodlot clearance, and the clearance logits show how temporal changes in these variables contribute to the decision to clear a woodlot and to use the land for something else.

A number of variables, such as DAUGH and KIDS in Models 2A and 2B, suggest that as the numbers of residents (particularly children) increase, the likelihood of woodlot clearance increases. Similarly, as the numbers of

Table 9.4: LOGIT MODEL DEFINITIONS, SPECIFICATIONS, COEFFICIENTS, AND FITNESS

MODEL SPECIFICATIONS

MODEL	CONSTANT	VALUES OF COEFFICIENTS AND STANDARD ERRORS β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	FITNESS Chi-Square	° of Freedom	Signi-ficance
WOODLOT CLEARANCE LOGITS														
2A	-62.23	4.98	-2.85	0.57	2.39	1.54	-0.17	0.04	-0.31	..	..	290.97	496	1.00
	(9.02)	(1.05)	(0.89)	(0.17)	(0.72)	(0.47)	(0.02)	(0.01)	(0.04)	..	..			
2B	-52.14	4.55	-2.65	0.27	2.58	0.37	-0.14	0.03	-0.31	-0.06	..	295.45	495	1.00
	(8.16)	(1.09)	(0.90)	(0.09)	(0.69)	(0.21)	(0.03)	(0.00)	(0.04)	(0.02)	..			
2C	-38.79	-0.58	0.02	-0.21	-0.10	..	..	..	..	..	..	379.53	500	1.00
	(6.88)	(0.15)	(0.00)	(0.03)	(0.02)	..	..	..	..	..	..			
2D	-43.04	0.09	-0.45	0.03	-0.21	-0.11	..	..	..	..	..	381.75	499	1.00
	(7.31)	(0.04)	(0.14)	(0.00)	(0.03)	(0.02)	..	..	..	..	..			
2E	-38.82	-0.43	0.02	-0.21	-0.11	..	..	..	..	..	..	386.38	500	1.00
	(6.96)	(0.14)	(0.00)	(0.03)	(0.02)	..	..	..	..	..	..			
WOODLOT ESTABLISHMENT LOGITS														
3A	39.69	-10.94	8.30	-0.22	-0.30	-0.89	-3.44	0.12	-0.03	0.21	0.13	302.30	435	1.00
	(6.94)	(11.66)	(11.65)	(0.10)	(0.11)	(0.23)	(0.60)	(0.01)	(0.00)	(0.04)	-0.02			
3B	39.85	-10.94	8.35	-0.26	-0.89	-3.44	0.12	-0.03	0.21	0.13	..	302.58	436	1.00
	(6.94)	(11.64)	(11.63)	(0.07)	(0.23)	(0.60)	(0.01)	(0.00)	(0.04)	(0.02)	..			
3C	20.32	-0.12	0.40	-0.01	0.09	0.10	..	..	..	..	..	436.84	440	0.53
	(4.61)	(0.05)	(0.08)	(0.00)	(0.02)	(0.02)	..	..	..	..	..			
3D	22.73	-0.85	-0.15	0.23	-0.01	0.05	0.11	..	..	..	..	427.84	439	0.64
	(5.03)	(0.33)	(0.07)	(0.07)	(0.00)	(0.02)	(0.02)	..	..	..	..			
3E	21.51	-0.22	0.19	-0.01	0.06	0.10	..	..	..	..	..	439.35	440	0.50
	(4.50)	(0.05)	(0.07)	(0.00)	(0.02)	(0.02)	..	..	..	..	..			

MODEL DEFINITIONS

MODEL	VARIABLE X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
2A	MALEH	WIFE	DAUGH	NRHUS	NRSON	AGEHH	ALTIT	SLOPE	..	..
2B	MALEH	WIFE	KIDS	NRSPO	NRKID	AGEHH	ALTIT	SLOPE	YEARS	..
2C	TNONR	ALTIT	SLOPE	YEARS	..	..	..	..	..	..
2D	LLKID	LLNRE	ALTIT	SLOPE	YEARS	..	..	..	..	..
2E	LLNRE	ALTIT	SLOPE	YEARS	..	..	..	..	..	..
3A	MALEH	WIFE	SON	DAUGH	OTHRE	NRHUS	AGEHH	ALTIT	SLOPE	YEARS
3B	MALEH	WIFE	KIDS	OTHRE	NRSPO	AGEHH	ALTIT	SLOPE	YEARS	..
3C	TOTRE	TNONR	ALTIT	SLOPE	YEARS	..	..	..	..	..
3D	LLHEA	LLKID	LLNRE	ALTIT	SLOPE	YEARS	..	..	..	..
3E	LLRES	LLNRES	ALTIT	SLOPE	YEARS	..	..	..	..	..

nonresidents (TNONR) increases, the likelihood of clearance decreases.

The signs of the coefficients for WIFE, NRHUS, and NRSPO appear to contradict this interpretation unless these coefficients are considered in conjunction with several other variables.

For instance, the negatively-signed coefficients for the variables WIFE and AGEHH suggest that the likelihood of woodlot clearance decreases with an increasing number of wives and as the head of the household gets older. These household characteristics are related i.e. polygamy tends to be practiced in older households, and these are the households which tend to maintain their woodlots.

Table 9.5: LOGITS PREDICTING LIKELIHOOD OF WOODLOT CLEARANCE, SIGNS OF COEFFICIENTS

P(WOODLOT CLEARED) = 1
P(NO WOODLOT CLEARED) = 0

VARIABLE	SIGN OF COEFFICIENT	RATIONALE
MALEH	+	Woodlot clearance is increasingly likely if a household is male-headed.
WIFE	-	Woodlot clearance is less likely as the number of wives increases; probably age-linked outcome; older households are more likely to be polygamous. See AGEHH.
DAUGH	+	Woodlot clearance increasingly likely if a household has more resident daughters, increasing its labour supply. Also a reflection of the younger age structure of these households.
KIDS	+	As in DAUGH. Woodlot clearance more likely as the number of resident children increase.
NRHUS	+	Must be considered in conjunction with MALEH to evaluate greater or lesser likelihood of woodlot clearance.
NRSPO	+	Same as NRHUS.
NRSON	+	Woodlot clearance more likely as sons move off the farm. Problematic outcome.
NRKID	+	As in NRSON.
TNONR	-	Woodlot clearance less likely as non-residents increase.
LLKID	+	Fewer labour constraints increases likelihood of woodlot clearance.
LLNRE	-	Opposite of LLKID.
AGEHH	-	Woodlots are less likely to be cleared as the age of the head of the household increases.
ALTIT	+	As altitude increases, the chances of woodlot clearance increases because higher altitudes are better for growing tea.
SLOPE	-	Woodlots are maintained by households with steeply sloping parcels.
YEARS	-	A household is most likely to clear its woodlot in the years immediately after it has begun to operate the holding, and less likely the longer the holding is operated.

The number of non-resident husbands is significant, and, perhaps counterintuitively, the coefficient is positively signed. This variable has to be considered in conjunction with whether or not a household is male-headed. In

Model 2A, for instance, if a household is male-headed, the number of non-resident husbands will be 0, and the sum of the coefficients (MALEH and NRHUS) multiplied by the values for these households and summed would be equal to 8.45. If a household is female-headed and there are no non-resident husbands, the sum would be equal to 0. If a household is female-headed and there is one non-resident husband, the sum would be equal to 3.61.

From this assessment, all other things being equal, the likelihood of woodlot clearance would be greatest if a household is male-headed. It would be less if it were female-headed with a non-resident husband, and least if it is female-headed with no non-resident husbands. This is an interesting outcome. Labour supervision is gender-related. For cultural reasons, it is less problematic for labour to be supervised by a male household-head than by a female.[1] If the problem of labour supervision is considered, it would be least in the first case and greatest in the last case suggesting that woodlots may be maintained when labour to otherwise cultivate a holding may be difficult to supervise.[2]

An analysis of the effect of changing labour-to-land ratios on the likelihood of woodlot clearance shows that as the number of resident children per unit area increases, the likelihood of clearance similarly increases. As the numbers of nonresident relatives per unit area increase, the likelihood of clearance decreases. The logits support the view that as labour availability increases (as the ratio shifts in favor of more residents per unit area), the likelihood that a woodlot would be cleared to bring more land under production also increases.

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1. See, Fisher (1954), as well as Thomas (1988).

2. A similar conclusion can be reached by comparing the coefficients for variables MALEH and NRSPO in model 2B. As there were no non-resident wives in the sample, NRHUS and NRSPO are equivalent.

The number of years a household had operated a parcel was significant in all but one of the clearance logits, and the coefficient was negatively signed, suggesting that the decision to clear a woodlot is less likely the longer a parcel has been operated.

Finally, as with the current land-use logits, the altitude of the sampled parcel and its slope were significant variables in all the woodlot clearance logits. The altitude coefficient is positively signed, suggesting that the likelihood a woodlot would be cleared is greater at higher altitudes, presumably for replanting with tea or another crop. The negative sign of the slope coefficient similarly confirmed that households with more steeply sloping parcels are more likely to maintain their woodlots, rather than to clear them.

Woodlot establishment logits

The results from the woodlot establishment logits are summarized in Table 9.4, Models 3A through 3E. The signs of the coefficients for significant variables are given in Table 9.6, which includes a discussion about how the logit outcome is affected by different variables.

In many respects, the results from these logits complement the outcome from the woodlot clearance logits. The characteristics of a household which decides to clear a woodlot are indeed quite the opposite of the characteristics of households which decide to establish woodlots.

For example, whether or not a household is male-headed, or female-headed with or without non-resident husbands, similarly affects the decision to establish a woodlot. While woodlots are more likely to be cleared if a household is male-headed, and less likely to be cleared if they are female-headed, an assessment of the coefficients for MALEH and NRHUS in Model 3A suggests that woodlots are more likely to be established if a household is female-headed, and less likely to be

Table 9.6: LOGITS PREDICTING LIKELIHOOD OF WOODLOT ESTABLISHMENT, SIGNS OF COEFFICIENTS

P(WOODLOT ESTABLISHED) = 1
P(NO WOODLOT ESTABLISHED) = 0

VARIABLE	SIGN OF COEFFICIENT	RATIONALE
MALEH	-	Gender linkage with woodlot establishment. Likelihood of establishment decreases if household is male headed.
WIFE	+	Possibly linked to older age structure. Older households (see AGEHH) more likely to be polygamous. Also, more wives suggest a preference for subsistence rather than cash crops.
SON	-	Likelihood of woodlot establishment decreases as household labour supply increases.
DAUGH	-	Same as in SON.
OTHRE	-	Same as in SON. OTHRE includes resident hired labourers.
KIDS	-	Same as in SON.
NRHUS	-	Must be evaluated in conjunction with MALEH.
NRSPO	-	Same as NRHUS.
TOTRE	-	Likelihood of woodlot establishment decreases as total numbers of residents increases.
TNONR	+	Likelihood of woodlot establishment increases as total numbers of nonresidents increase.
LLHEA	-	Inverse of AREA. As area gets smaller, LLHEAD increases, and likelihood of establishment decreases.
LLKID	-	Larger numbers of children on smaller holdings suggest larger labour supplies, and less likelihood of woodlot establishment.
LLRES	-	Same as LLKID
LLNRE	+	Larger numbers of non-residents suggest households have constrained labour supplies, increasing the likelihood of woodlot establishment.
AGEHH	+	Woodlots are more likely to be established as the age of the household head increased.
ALTIT	-	Likelihood of wattle establishment decreases as altitude increases. Other crops better suited for higher altitudes.
SLOPE	+	Woodlot establishment more likely on more steeply sloping parcels.
YEARS	+	Households are more likely to establish a woodlot the longer they have operated a holding. Possibly linked to AGEHH.

established if it is male-headed.

As the numbers of resident sons, daughters, and other residents increases, the likelihood a woodlot will be established decreases. This relationship holds for increasing levels of aggregation when the total number of children and the total number of household residents is considered. Conversely, as the total numbers of nonresidents increase, the likelihood of woodlot establishment increases.

The variables for the numbers of wives and the age of the head of the household are also significant, and the coefficients are positively signed. Woodlots are more likely to be established as the numbers of wives increase. These households are more likely to have older heads because these are the mostly likely to practice polygamy.

An analysis of the effect of labour-to-land ratios on the likelihood of woodlot establishment shows that as the numbers of residents, particularly children, per unit area increase, the likelihood of woodlot establishment decreases. As numbers of residents increase, there is a greater dependence on cash and food crops to support a larger household, and the chances that a household would choose to establish a woodlot -- instead of cultivating other crops -- decrease. Labour availability is also greater, making it possible for the household to adopt other more labour intensive land-uses. The converse also holds true: as the ratio of nonresidents per unit area increases, the likelihood of woodlot establishment also increases.

The number of years a holding has been operated was also significant. Households are more likely to establish a woodlot the longer they have operated a holding. This outcome may also be linked to the age of the head of the household, and the processes which occur as households age: children move away, there is no longer enough labour to cultivate the holding, and trees are planted instead of other crops because they take little labour.

Finally, as with most of the other logits tested, altitude and slope were also significant variables. The likelihood of woodlot establishment decreases at higher altitudes, suggesting other crops may be favored at these altitudes. Woodlot establishment is also more likely on holdings which are more steeply sloping.

Price effects

Smallholders who decide to establish a woodlot, or to clear a woodlot and to use their land for something else, must partly base their decision on expectations of future prices. In order to test the sensitivity of the farmer's decision to change land-uses as a response to price, producer price series were developed and logits were re-estimated after this data had been included.

Woodlot operators generally reported that the best crops to plant on old woodlot sites would be tea or coffee, and that the worst crops to plant would be food crops. Operators who had cleared their parcels of woodlots evidently shared this view. Around 70 percent of the parcels which had formerly been used for growing a woodlot had been planted with tea, and 19 percent had been planted with coffee. Only 9 percent had used former woodlot sites for growing food crops. Because of the importance of coffee and tea vis-a-vis wattle, producer price series for these crops were developed for inclusion in the logits. Series of producer prices, export prices and exported quantities of coffee and tea are included in Appendix 5.

Other price series, particularly for tanning extracts, for wattle bark, and for charcoal were also collected, but these were not included in the logits. Tanning extract prices reflect international prices and demands for extracts and are marginally reflected in producer prices for wattle bark, which are set by the two tanning extract manufacturers operating in Kenya. Although wattle bark and charcoal were for many years the primary commodities produced by wattle woodlots in Murang'a, this is no longer the case. Fewer than 11 percent of woodlot growing households surveyed reported that they sold bark from their woodlot the last time it was harvested. Only 3 percent of the woodlot growing households surveyed reported they sold charcoal from their woodlot the last time it was harvested. Because of this, pricing series for these commodities were not included in the logits.

The problem with using price series data is that periods of peak pricing could be correlated with the structure of the household data set, i.e., peak coffee prices in 1977 and low coffee prices in 1990, modelled in conjunction with household data reconstructed for each year from 1975 to 1990, would show that any land-use changes took place in conjunction with declining coffee prices. A more

complete reconstructed household data set and price series, including data for 10 or 15 years before 1977, would reduce these problems.

In the absence of this data, time-trended data was controlled by adding dummy variables to the data set. For instance, a new variable (YR75) was created, and all household records for the year 1975 was coded as 1, while all other data was coded as 0. Additional dummy variables were created for each year of the reconstructed data set.

When the reconstructed household data was run with pricing data and dummy variables, the results were intuitively satisfying, and are summarized in Table 9.7. The likelihood of woodlot clearance increases as the prices of coffee and tea increase, and the likelihood of woodlot establishment decreases with increased coffee prices.

Fixed-effects

In evaluating panel data of the type which comprised the reconstructed household data set, the fixed-effects of individual households on the outcome should be tested. To do this, additional independent dichotomous dummy variables should be created, one to represent each household in the sample (for a total of 123 additional variables) and the logits should be constructed again with the dummy variables included to see if the outcome is affected, or if data for any individual household is significant. The algorithm which the current version of SPSSPC uses in its LOGISTIC REGRESSION routine is not computationally efficient enough to allow for the construction of logits using dummy variables in this way.

Other software packages and mainframe statistical routines allow for the testing of fixed-effects, but in programming steps which are not compatible with the data sets or programming routines used in this analysis. It would have been desirable to test the logits for fixed-effects, but given the computational problems

Table 9.7: LOGIT MODEL DEFINITIONS, SPECIFICATIONS, COEFFICIENTS, AND FITNESS, CONTROLLING FOR YEAR AND TEA AND COFFEE PRICES

MODEL SPECIFICATIONS

MODEL	CONSTANT	VALUES OF COEFFICIENTS AND STANDARD ERRORS β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	COEFFICIENTS FOR CONTROL VARIABLES β_{11}	β_{12}	β_{13}	β_{14}	β_{15}	β_{16}	FITNESS Chi-Square	° of Freedom	Signi-ficance
WOODLOT CLEARANCE LOGITS																				
2A*	-77.20	8.45	-4.72	0.64	3.61	2.28	-0.27	0.05	-0.46	..	..	-6.19	-3.50	-2.71	-1.90	0.11	..	195.18	491	1.00
	(12.89)	(2.55)	(2.37)	(0.23)	(0.93)	(0.62)	(0.04)	(0.01)	(0.06)	..	..	(1.26)	(1.04)	(0.80)	(0.74)	(0.02)				
2B*	-58.43	6.02	-3.35	0.18	3.23	0.41	-0.20	0.04	-0.41	-0.11	..	-5.56	4.12	1.44	2.13	0.26	0.08	198.32	489	1.00
	(10.85)	(3.02)	(2.90)	(0.12)	(0.84)	(0.24)	(0.04)	(0.01)	(0.06)	(0.03)	..	(1.29)	(1.46)	(0.72)	(0.70)	(0.04)	(0.03)			
2C*	-44.18	-0.80	0.03	-0.26	-0.16	..	..	..	..	..	..	-3.93	3.13	1.50	0.18	0.04	..	300.15	495	1.00
	(8.27)	(0.16)	(0.00)	(0.03)	(0.02)	..	..	..	..	..	..	(1.17)	(1.18)	(0.51)	(0.03)	(0.02)	..			
2D*	-45.39	0.21	-0.61	0.03	-0.25	-0.17	..	..	..	..	..	-3.82	3.04	1.47	0.18	0.04	..	307.85	494	1.00
	(8.57)	(0.05)	(0.15)	(0.00)	(0.03)	(0.02)	..	..	..	..	..	(1.17)	(1.16)	(0.50)	(0.03)	(0.02)	..			
2E*	-44.29	-0.60	0.03	-0.26	-0.17	..	..	..	..	..	..	-3.88	3.04	1.48	0.18	0.04	..	308.12	495	1.00
	(8.28)	(0.15)	(0.00)	(0.03)	(0.02)	..	..	..	..	..	..	(1.17)	(1.16)	(0.50)	(0.03)	(0.02)	..			
WOODLOT ESTABLISHMENT LOGITS																				
3A*	40.95	-12.09	9.40	-0.31	-0.28	-0.81	-3.66	0.12	-0.03	0.17	0.14	-8.21	..	..	..	..	..	245.81	358	1.00
	(7.83)	(21.57)	(21.56)	(0.12)	(0.12)	(0.27)	(0.67)	(0.02)	(0.00)	(0.04)	(0.03)	(24.44)	..	..	..	..	..			
3B*	40.86	-12.09	9.39	-0.29	-0.81	-3.67	0.12	-0.03	0.17	0.14	..	-8.20	..	..	..	..	..	245.84	359	1.00
	(7.80)	(21.58)	(21.57)	(0.07)	(0.27)	(0.67)	(0.02)	(0.00)	(0.04)	(0.03)	..	(24.44)	..	..	..	..	..			
3C*	19.43	-0.14	0.43	-0.01	0.07	0.10	..	..	..	..	..	-7.25	..	..	..	..	..	355.02	363	0.61
	(5.09)	(0.06)	(0.10)	(0.00)	(0.02)	(0.02)	..	..	..	..	..	(16.01)	..	..	..	..	..			
3D*	22.60	-0.98	-0.16	0.21	-0.01	0.03	0.11	..	..	..	..	-7.56	-0.04	..	..	..	..	339.77	361	0.78
	(5.65)	(0.36)	(0.08)	(0.08)	(0.00)	(0.03)	(0.02)	..	..	..	..	(16.08)	(0.02)	..	..	..	..			
3E*	21.54	-0.27	0.16	-0.01	0.04	0.09	..	..	..	..	..	-7.67	-0.04	..	..	..	..	347.96	362	0.69
	(5.09)	(0.05)	(0.08)	(0.00)	(0.02)	(0.02)	..	..	..	..	..	(16.21)	(0.02)	..	..	..	..			

MODEL DEFINITIONS

MODEL	VARIABLE X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	CONTROL VARIABLES X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
2A*	MALEH	WIFE	DAUGH	NRHUS	NRSON	AGEHH	ALTIT	SLOPE	..	..	YR75	YR76	YR78	YR79	COFFEE	..
2B*	MALEH	WIFE	KIDS	NRSPO	NRKID	AGEHH	ALTIT	SLOPE	YEARS	..	YR75	YR77	YR83	YR86	COFFEE	TEA
2C*	TNONR	ALTIT	SLOPE	YEARS	..	..	..	..	..	..	YR75	YR77	YR86	COFFEE	TEA	..
2D*	LLKID	LLNRE	ALTIT	SLOPE	YEARS	..	..	..	..	..	YR75	YR77	YR86	COFFEE	TEA	..
2E*	LLNRE	ALTIT	SLOPE	YEARS	..	..	..	..	..	..	YR75	YR77	YR86	COFFEE	TEA	..
3A*	MALEH	WIFE	SON	DAUGH	OTHRE	NRHUS	AGEHH	ALTIT	SLOPE	YEARS	YR75	..	..	..	..	..
3B*	MALEH	WIFE	KIDS	OTHRE	NRSPO	AGEHH	ALTIT	SLOPE	YEARS	..	YR75	..	..	..	..	..
3C*	TOTRE	TNONR	ALTIT	SLOPE	YEARS	..	..	..	..	..	YR75	..	..	..	..	..
3D*	LLHEA	LLKID	LLNRE	ALTIT	SLOPE	YEARS	..	..	..	..	YR75	COFFEE	..	..	..	..
3E*	LLRES	LLNRES	ALTIT	SLOPE	YEARS	..	..	..	..	..	YR75	COFFEE	..	..	..	..

involved, these tests were omitted from this analysis. Because of this, the results discussed here must be treated with some caution and must be closely considered in conjunction with the descriptive statistics discussed in Chapters 6, 7, and 8.

Model fitness

Table 9.4 and Table 9.7 report model goodness-of-fit statistics, which have chi-square distributions. Fitness of the woodlot clearance logits is quite good, while fitness of the woodlot establishment logits is less so. The fitness of the current land-use logits is relatively poorer, but it is still good enough to use them for predictive purposes.[1] The interpretation of goodness-of-fit statistics for logistic regression models is highly problematic.[2]

Discussion

Farmers in Murang'a District of Kenya are engaged in parallel processes of new woodlot establishment and in the clearance of old woodlots so land can be used for alternative purposes. Logit modelling of household data has shown that the likelihood that a household will clear its woodlot increases as the numbers of residents in the household increase, and decreases as the numbers of non-residents increase. Higher labour-to-land ratios amongst households which have cleared their woodlots suggest that the decision to maintain trees as a labour-extensive part of the farming system may be a function of an important labour constraint.

Altitude and the slope of the sampled parcels are significant variables affecting the decision to clear or to establish a woodlot. Woodlot clearance is more likely and woodlot establishment less likely at higher altitudes. In the first instance, this may be linked to the better quality of land at higher altitudes for growing tea. In the second instance, although wattle woodlots tend to grow much better at

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1. SPSS, Inc. (1989).

2. Hosmer and Lemeshow (1989). pp.136-141.

higher altitudes, it may be that these areas have already been widely planted and that new establishment is confined to lower altitudes.

Woodlots are more likely to be maintained on holdings which are more steeply sloping, and new woodlot establishment also appears to be more likely on steeper holdings. These logit outcomes have important implications for labour use, as hillsides are more labour-intensive to cultivate with other annual or perennial crops than with wattle.

Labour availability

Amongst both groups of households, labour availability appears to be playing a key role in the decision of a household to either maintain an existing woodlot or to establish a new woodlot. Labour availability as a determinant of land-use change, however, affects the household decision making process somewhat differently.

Increased labour supplies produce different outcomes, increasing the likelihood of woodlot clearance and decreasing the likelihood of woodlot establishment. Households which clear their woodlots are able to allocate labour supplies, either from family sources or from the market, to cultivate more labour intensive crops on the former woodlot site. Households which establish woodlots are somehow less able to allocate these labour supplies in this way, principally because household labour supplies are inadequate and because there are no mechanisms for hiring enough labour to bring woodlot sites under production with other crops.

Gender relationships and the problem of labour supervision also appear to be playing an important role in the decision to establish or clear a woodlot. Woodlot establishment is more likely amongst female-headed households, and less likely if the household is male-headed. Woodlot clearance is more likely if the

household is male-headed and less likely if it is female-headed. Norms of behaviour in Kikuyu society make labour more responsive to the instruction of male heads of household. The establishment and maintenance of woodlots appears to be more likely when there are difficulties in labour supervision.

What other factors account for differences in patterns of labour and land-use in rural Kenya? Collier and Lal explored the problem of skewed factor proportions in Kenya, and suggested that, in addition to the problem of labour availability, the use of land for cultivating labour extensive crops is related to the problem of a limited access to capital and to risk aversion.[1]

Households may not have the capital to invest in the establishment and maintenance of potentially more lucrative cash crops. Even when capital *is* available through credit markets, it is generally used for the purchase of inputs and cannot be used to hire labour. If there are labour constraints in the household, capital constraints (as well as the problem of a poorly functioning rural wage labour market) limit the household's ability to hire outside labour to fill the gap.

Risk aversion plays a role because of the tendency of smallholders to use their land for meeting subsistence needs in the event of uncertainty about future markets and prices for cash crops. Cash crops are only of use to the household if they can generate enough of an income to obtain household goods, such as food, fuel, and building poles. Uncertainty about pricing trends and future income makes this production possibility sometimes problematic. In the middle coffee zones of Murang'a District, the tendency to reduce risk is partly expressed in cash and subsistence cropping patterns: 13 percent of the land area is used for growing smallholder coffee while nearly 29 percent is used for growing maize and maize intercrops. Woodlots fill a similar niche for some households: they can produce

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1. Collier and Lal (1986).

goods for subsistence uses while requiring few labour inputs.

Evidence from the household survey suggests as well that woodlot growing households may be more risk averse, using lower levels of inputs, lower levels of hired labour, and being more dependent on regular sources of farm income to pay for both investment and operating costs rather than loans from cooperative societies. These households may also have greater access to other sources of capital through wages remitted by non-resident relatives engaged in urban wage or public sector employment.

While many of these processes could be interpreted to be a function of risk aversion, they are also processes which accompany the aging of households. For instance, older households may be interested in woodlot establishment to provide a source of capital for their children on inheritance. Older households have lower requirements for capital, and so would be less inclined to operate their holding intensively.

Altitude and slope

The fact that households which clear woodlots, and households which establish them, operate in fundamentally different ways with regard to the allocation of labour, land and capital resources is even clearer if we consider that the likelihood of woodlot clearance increases at higher altitudes. Some households are able to take advantage of higher altitudes and better growing conditions to cultivate alternative cash crops such as tea.

Other households, at lower altitudes, are constrained from doing so, and establish woodlots instead. These constraints may be related to both capital and labour availability, but may also be a function of fundamental differences in the quality of the basic land endowment.

It could be expected that woodlots would be maintained on steeper slopes to limit soil erosion problems and because it is more difficult to cultivate other crops on steep slopes. These households, however, may have few other options: poorer overall site quality may be acting as a constraint, along with access to capital and labour supplies, in preventing some households from using their land for more highly-valued crops.

The differential use of steeply sloping land for tree growing may in part be an outcome of colonial land-use legislation and its post-Colonial successors such as the Agricultural Act and the Agricultural (Basic Land Usage) Rules which regulate hillside cultivation. The Land Usage Rules prohibit the cutting of trees and the grazing of livestock on hills with slopes of greater than 35 percent (19°). Amongst surveyed households, the average slope of plots used for growing woodlots was nearly 22°. For most land-uses, the slopes of plots for all crops grown on parcels used for growing woodlots are consistently greater than on parcels which were formerly used for growing woodlots (in aggregate, 17° and 14° respectively, significant to less than 1 percent), indicating a very basic difference in site quality.

Gender issues

In some areas of Kenya, tree planting has very strong gender associations. In parts of Kakamega District, for instance, Chavangi has reported that there are influential cultural restrictions against the planting of trees by women.[1] There is little explicit evidence for these types of restrictions amongst the Kikuyu. As early as the 1950s, Fisher reported that while the decision to plant wattle was often the man's, women were seldom discouraged or otherwise prevented from planting it.[2] Wattle did, however, fill a special niche within the farm economy which had important gender associations, and it is perhaps useful to speculate on how this niche may continue to influence the decision to establish a woodlot, evident in the woodlot establishment logits.

Traditionally, women's crops were labour intensive seasonal crops (*irio cia īmera* -- "sprouting foods") such as cereals and legumes while men's crops were less labour intensive perennial crops (*irio cia menja* -- "digging foods") such as

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1. Chavangi (1987).

2. Fisher (undated). p.231 and p.241.

yams, taro, cassava and bananas. Men's crops were also more commonly used as famine foods which could be harvested during times of greatest need.[1]

Colonial labour policies strongly encouraged men to seek wage employment in urban areas and on European plantations, skewing gender ratios in rural areas so there were far more women than men of working ages. Patterns of labour availability in rural areas remain skewed in this way. The outcome in Colonial times would have been an emphasis on the production of women's crops, or some alternative to men's perennial crops, in the absence of male labour.

Wattle, as a perennial crop, emerged as an important crop with a similar role as men's traditional perennial crops. Both the planting of perennial crops as famine foods and participation in the migrant labour economy were somewhat gender specific. This made wattle the ideal crop for filling a particular niche: wattle would be planted on holdings if men planned to seek wage employment elsewhere *and* could provide a source of income during times of environmental or economic stress. Indeed, these types of benefits were widely thought to account for wattle's early popularity.

Logit results are consistent with these findings. The likelihood of woodlot establishment decreases if a household is male-headed, and the likelihood of woodlot clearance increases if a household is male-headed. The likelihood of woodlot establishment is greater if the household is female-headed with a non-resident husband, and greatest if it is female-headed with no non-resident husbands.

Wattle and income generation

Very little wattle in the study area is regularly harvested to generate income, and in this respect, current wattle planting practices are quite different from practices before Independence. This is not to say that there is *no* potential for

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1. Fisher (undated). pp.183-184.

income generation -- just that regular income generation is no longer a key consideration. Indeed, a hectare of mature wattle when harvested after 8 years could still produce around KSh 3,870 for its bark and KSh 28,810 for charcoal at the roadside.[1] Even if a household split the earnings with charcoal burners and bark strippers, as is the practice, net income would still total over KSh 16,000 per ha.

One view of woodlots is that they are the cash crop of the rural poor, and are primarily planted by households with little opportunity for investing in other cash crops. The survey presented little opportunity for testing this hypothesis, as in comparison with other parts of the country, Murang'a continues to be a relatively affluent district. Low levels of woodlot management and utilization suggest wattle growing households are not particularly pressed for income -- if they were, it would be expected they would be more intensively managed. Western Kenya, particularly Kakamega District, would be better suited for testing this view, as eucalyptus woodlots occupy large areas of farmland, even on the smallest holdings.

Policy Implications

Over the last 15 years or so, there have been numerous publicly-supported or aid-financed efforts to encourage farmers in Kenya to grow more trees. These efforts have seldom taken account of the extent of existing farmer tree growing activities. Plans for future efforts have the same disregard for the obvious and widespread local knowledge and awareness about tree growing.

From a policy perspective, it is critically important that efforts to introduce tree planting innovations are put into a context which more accurately reflects local farmer ability and knowledge. Further, this ability and knowledge must be understood within the historic and cultural setting. The appeal of many tree establishment and maintenance practices often has strong local roots. Conventional approaches toward rural forestry extension which have ignored these factors have been expensive and often ineffective, particularly in light of what farmers have been able to accomplish in the absence of these types of inputs.

Importantly, this study has suggested that initiatives which have been intended to encourage farmers to cultivate and manage trees on smallholder farms in Kenya cannot be undertaken without an understanding of the impact of these practices on the whole of the farming system. To the farmer who must devote land,

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1. Woodlot operators were questioned about the value of bark and charcoal at the roadside. Mean reported roadside bark prices were KSh 0.45 per kg ($\sigma = 0.43$) and mean reported charcoal prices were KSh 2.82 per kg ($\sigma = 0.51$). Total value of woodlot production is estimated from these reported prices.

labour and capital to such an effort, land-use changes involving trees may make little sense vis-a-vis alternative land and labour-uses.

From a policy perspective, only one or two of the significant variables in the logit analyses are of direct relevance to the various forestry extension agencies and organizations which operate in Kenya. For example, the findings with regard to slope and altitude could be helpful for targeting specific types of extension activities with regard to woodlot establishment.

Most of the variables discussed here however are of relevance within a much broader policy context. The findings suggest, for instance, that agricultural expansion is still quite possible in some areas of extremely good agricultural potential, but that wattle woodlots are being maintained in these areas as extensively managed fallow because of household capital and labour constraints which prevent them from being cultivated.

Indeed, logit modelling suggests that policies regarding tree planting on small farms and employment policies may be incompatible. Policies relating to both rural and urban employment may ultimately have an effect on the willingness of a household to adopt or to maintain particular tree growing practices.

In the case of woodlots, for instance, if employment policies are undertaken which seek to improve the operation of the rural labour market, it can be anticipated that farmers who maintain woodlots will clear them and plant more labour-intensive crops. If policies are supported to improve prospects for employment in urban areas and in commercial agriculture, it can be anticipated that households will increasingly use their land for less labour-intensive crops such as trees.

If the government concludes that the environmental benefits of maintaining tree cover on small farms outweigh the benefits of increased agricultural production

and rural employment generation, then it must explore alternative ways of generating rural income which encourage the protection and management of these trees.

One option would be to improve and intensify the management of wattle woodlots, but this would be dependent on there being good markets for tree products. While the wattle bark market has virtually collapsed since its peak in the early 1950s, the urban charcoal market is robust as ever and will stay so long into the future (see Appendix 8). Charcoal prices have reached historic highs, and the urban population which depends on regular charcoal supplies continues rapidly to expand.

The principal reason why wattle woodlots in Murang'a are *not* managed to produce charcoal in any quantity for the urban market is because of restrictions on the transport of charcoal across district boundaries (limiting supplies and contributing to significant price increases for charcoal) and because of price controls. Should controls on transport be rationalized, farmers in Murang'a would find ready markets for their charcoal in Nairobi.

Indeed, wattle charcoal production is perhaps the only sustainable system of producing charcoal in Kenya. Charcoal produced as a by-product of land clearance operations -- or as the *sole objective* of land clearance operations -- is being mined. Should the appropriate policy initiatives be undertaken, production from land clearance operations could be increasingly shifted to sustainable wattle production in Murang'a and other areas.

Certainly, Murang'a's wattle farmers have, in the past, been an important source of charcoal for urban markets. Recorded exports of charcoal from Murang'a in 1960 totalled nearly 10,000 tons. Under intensive management and with good charcoal conversion efficiencies, Murang'a District's 6,000 ha of woodlots could

sustainably produce nearly 15,000 tons of charcoal annually, with a 1990 roadside value of nearly KSh 42 million.

The policy and planning challenges in Kenya are enormous. So much of the debate and discussion in Kenya with regard to its development path has been based on an assumption that there are few prospects and little hope of meeting the demands of a rapidly expanding population. Particularly amongst development practitioners, the bias inherent in most analyses is that aid-financed project interventions are the solution. I have attempted to show here that, indeed, rural people are *already* meeting the challenge in Kenya, and that they are quite capable of responding to emerging demands in ways which are both imaginative and innovative and which involve far lower costs to the economy and greater benefit to the environment than many project interventions. The real challenge for planners is to find ways of capturing this potential through policy change and through positive initiatives.

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APPENDIX 1:
The Woodfuel Crisis Reconsidered:
Observations on the Dynamics of Abundance and Scarcity[1]

Introduction

This paper was written to stimulate a more thoughtful debate about the impact and importance of the emergence of woodfuel scarcities in developing countries. It was especially written to question our understanding of the dynamics of woodfuel supply and demand and discusses the need for a more comprehensive and objective view of energy scarcity. It suggests that rural people seldom view woodfuel scarcities in isolation from the household's other constraints, and that because of this, from the farmer's perspective, tree planting is not usually the most rational way to respond to woodfuel scarcities. It questions the mechanisms which have been taken to alleviate perceived scarcities, and, finally, suggests that the singular focus on woodfuel production in many aid projects has obscured more fundamental issues relating to household resource allocation and factor endowments.

From the outset, it should be emphasized that it is *not* an objective here to imply that there are not serious woodfuel scarcities in some areas, or that woodfuels are somehow no longer a basic human need for the great majority of rural people who rely on them as a source of household energy. Rather, it is to suggest that the problem is fundamentally quite different from the way it has generally been perceived. Consequently, the range of responses to emergent scarcities on the part of development assistance agencies has been, in large

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1. This appendix is a revised form of an article published in August, 1989. See, P.A.Dewees (1989). "The woodfuel crisis reconsidered: Observations on the dynamics of abundance and scarcity," *World Development* 17(8):1159-1172.
Sources cited in this and in subsequent appendices are given in their entirety in the relevant footnote and are not included in the bibliography (pp.187-192) unless they are also referred to in the main body of the text.

measure, inappropriate.

The "Woodfuel Gap"

Anyone who tries to understand the nature of woodfuel scarcities by playing the numbers game comes very quickly up against the inevitable: the population driven demand for woodfuel cannot possibly be met by the sustainable management of existing tree resources. The conclusion is unavoidable. If these demands are to be met, vast areas of forested lands must be cleared in the immediate future, or a massive programme of reforestation must be undertaken.

The FAO estimated that more than 100 million people already face acute woodfuel scarcities, and that nearly 1.3 billion people live in woodfuel deficit areas.[1] While it is generally agreed that the data on which the FAO study was based were incomplete, and that it was unclear and poorly understood how people are able to respond to woodfuel scarcities, the analysis suggested that the underlying trends are inescapable: for huge numbers of people, woodfuels will become increasingly scarce and expensive.[2]

Estimates of the rates of reforestation which would be needed to meet future woodfuel demands are staggering. A widely-cited World Bank study suggested, for instance, that the rate of tree planting in Africa would have to be increased 15-fold if year 2000 demands for woodfuel were to be met.[3] In Malawi, a recent review concluded that around 800,000 hectares of fast growing trees would have to be planted to meet estimated 1990 "deficits" of 8 million cubic metres at a

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1. FAO (1981). *The Fuelwood Situation in the Developing Countries* (map prepared by the Forestry Department). Rome, FAO. See also the analysis in, M.R. de Montalembert and J.Clement (1983). *Fuelwood Supplies in the Developing Countries* (Forestry Paper No. 42). Rome, FAO.

2. This conclusion has been reached in many studies, such as in, E.Eckholm, G.Foley, G.Barnard, and L.Timberlake (1984). *Fuelwood: the energy crisis that won't go away*. London, Earthscan.

3. D.Anderson and R.Fishwick (1984). *Fuelwood Consumption and Deforestation in African Countries* (Staff Working Paper No. 704). Washington, D.C., World Bank.

phenomenal cost of well over US$ 360 million.[1]

In the absence of any intervention, it is generally accepted that the "woodfuel gap" between supply and demand will widen considerably. As used and expressed by policy makers, the gap has provided much of the rationale for many of the woodfuel project interventions of the last 15 years.

In some cases, the woodfuel gap has formed the basis for comprehensive energy policy and planning activities. In Kenya, for instance, household energy surveys in the late 1970s were used as the basis for a complex computerized energy information model, the LDC Energy Alternatives Planning system (LEAP). This model was developed to provide a means for evaluating the impact of different energy policy and planning initiatives.[2] The Kenya "Base Case" analysis of woodfuel supply and demand, reflecting the outcome "if prevailing conditions and practices remain unaltered for the remainder of the century," are summarized in Figure 1.[3]

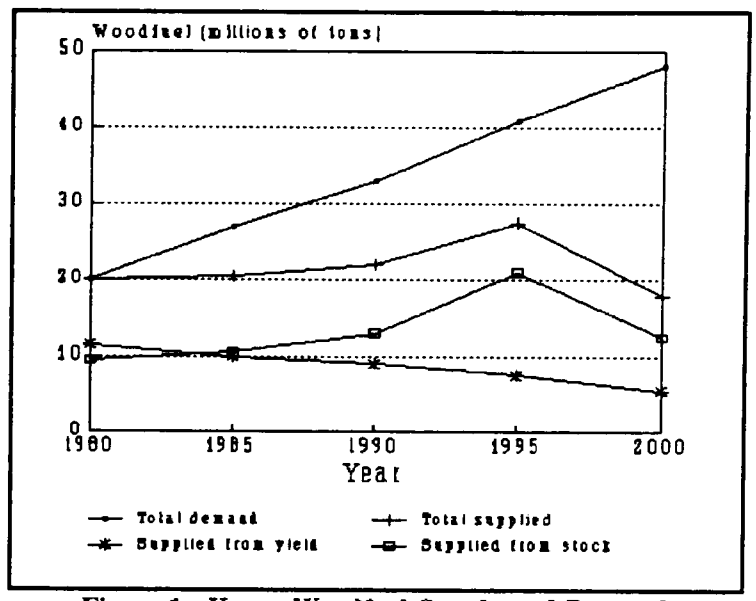


Figure 1: Kenya Woodfuel Supply and Demand Projected by LEAP Model

Projections of energy supply and demand allow policy makers and planners to create alternative woodfuel futures by assessing the outcome of different project and energy policy initiatives. Planners can hypothetically attempt to close the gap

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1. D.French (1986). "Confronting an unsolvable problem: Deforestation in Malawi," *World Development* 14(4):531-540.

2. P.Raskin (1986). *LEAP: A Description of the LDC Energy Alternatives Planning System*. Stockholm and Uppsala, Beijer Institute and the Scandinavian Institute of African Studies.

3. P.O'Keefe, P.Raskin, and S.Bernow (eds.) (1984). *Energy and Development in Kenya: Opportunities and Constraints*. Stockholm and Uppsala, Beijer Institute and the Scandinavian Institute of African Studies.

through these initiatives. By justifying specific proposals on the basis of their impact on closing the gap, aid agencies can be drawn into the scheme of things by providing finance for these initiatives. In Kenya, the hypothetical "policy case" which closed the woodfuel gap through different project interventions, described woodfuel planting and tree management activities targeted for around 3.6 million hectares, as well as a range of demand management strategies.

There are admittedly serious woodfuel shortages in some areas of Kenya, and responses to scarcity may involve very high economic costs. Analyses of the woodfuel gap, however, tend to greatly exaggerate and to obscure the scope of the problem. Indeed, the LEAP analysis leaves more questions than it answered. What is the basis, for instance, for concluding that woodfuel supply equaled demand in 1980? What indicators of scarcity did LEAP researchers use? Could there in fact have been a woodfuel gap in 1980? Conversely, is there the possibility that woodfuel-use in 1980 was *far greater* than that which would have been necessary to meet basic human needs?

Woodfuel supply/demand analyses are generally quite misleading because they fail to distinguish between demand, latent demand, consumption, and the extent to which current demands (or year 1980 demands in the Kenya analysis) can be acceptably moderated without seriously affecting the household's access to basic human needs: adequate food, warmth, housing, clean water, education, and so on. LEAP projected a woodfuel gap based almost exclusively on current consumptive trends. Indeed, rather than suggesting that people in Kenya would moderate their demands for woodfuel as a response to scarcity, the LEAP "base case" analysis projected that demands for woodfuel would actually *increase* from 1.3 tons per capita in 1980 to 1.5 tons per capita in the year 2000. Compared with current rates of consumption in other countries, this must surely be amongst the

highest rates of per capita consumption. This Malthusian woodfuel gap perhaps best represents the chasm in our thinking about the dynamics of woodfuel supply and demand, and about the ways rural people go about responding to woodfuel scarcities. The bias inherent in most analyses is that aid-financed project interventions are the solution. In many areas, however, rural people are *already* responding to increased woodfuel demands in ways which are innovative and imaginative and which involve far lower economic costs than many project interventions.

Measures of Woodfuel Scarcity and Abundance

One of the things which should be manifestly evident from the "conventional" Energy Crisis of the 1970s was that there was tremendous scope for reducing the consumption of fossil fuels. In 1984, for instance, energy consumption amongst the industrialized countries was *still* considerably less than it was before the 1973 oil price shocks.[1] Few people would argue that this reduction in consumption has been achieved at any great long-term social or economic cost. Many would argue that the level of energy consumption remains unacceptably high.

In the mid-1970s however, the "present trends" sort of analysis of conventional energy supply and demand (a type of analysis which has continued to characterize the woodfuel debate) obscured the likely demand response to changing prices. As Singer, in his critique of *Global 2000's* estimates of conventional energy demand suggested:

> "The projection of future energy demand has become a popular pastime, consuming much effort and resources. It is, of course, motivated by people's desire to know whether there will be a 'shortage,' i.e. whether 'demand will exceed supply.' To those who believe that prices in a free market can allocate available fuels efficiently, and bring forth the necessary resources, the idea of a long-term shortage makes no sense whatsoever; the projection of energy demand without considering price changes should be viewed as an academic exercise without much policy content... (Energy projections) have been misused by politicians to create the spectre of a 'crisis,' and

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1. Consumption of oil in North America and Western Europe in 1984, totalling 2,194.3 million tons, was less than it was in 1973, when consumption totalled 2,330.1 million tons. See, G.Jenkins (1986). *Oil Economist's Handbook*. London, Elsevier Applied Science Publishers.

> have served to involve the government in dubious interventions into the energy market."[1]

Similarly, it is a fallacy to suggest, particularly in global analyses, that present trends in woodfuel consumption are likely to continue, or that policy and planning initiatives should be geared to maintaining these sometimes quite high levels of consumption. In the broadest sense, woodfuel consumption is closely linked to its economic cost, and possibly radical changes in patterns of consumption can be anticipated as its cost increases. Indeed, woodfuel consumption is quite dynamically related to its economic cost and to supply. It is not a static variable which can be extrapolated from population growth rates.

Consider, for instance, data from woodfuel surveys carried out in the late 1970s. Woodfuel consumption in Papua New Guinea was reported to be around 1.8 cubic metres of woodfuel equivalents per capita. In Nepal, the figure was estimated to be around 0.9 cubic metres per capita, while in Afghanistan, it was estimated to be around 0.3 cubic metres per capita.[2]

These data suggest the not-surprising conclusion that woodfuel consumption is a function of the cost of obtaining it. In arid Afghanistan, woodfuel consumption is likely constrained because it is difficult to obtain. It *can* be obtained, but at some economic cost: perhaps by spending additional time in collecting it, perhaps through the marketplace, perhaps from farm trees or the use of agricultural residues, or by deferring consumption to the future through changed cooking and heating habits. Data from Papua New Guinea and from Nepal suggests that woodfuel is more available there, and that its economic costs to the household are

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1. S.F.Singer (1984). "World demand for oil", in: J.L.Simon and H.Kahn (eds.) (1984) *The Resourceful Earth: A Response to Global 2000.* Oxford, Basil Blackwell. Singer was responding to estimates contained in the report,
Council on Environmental Quality and the Department of State (United States) (1982). *The Global 2000 Report to the President* (Summary, Volume I). London, Penguin.

2. B.Agarwal (1986). *Cold Hearths and Barren Slopes*. London, Zed Books.

much lower than in Afghanistan. If woodfuels were seriously scarce, people would not be burning nearly as much as they are.

Even this approach is misleading, as it obscures the impact of other variables on the essentially dynamic relationship between supply and demand, and on the household's need for energy. Fisher pointed out that an adequate measure of resource scarcity should have the property of being able to summarize "the sacrifices, direct and indirect, made to obtain a unit of resources".[1] While this notion suggests several admittedly more accurate measures of resource scarcity, the problem of measurement for woodfuels becomes difficult for a variety of reasons. These are associated with their often common property nature, the cost of alternatives (both in terms of capital, labour, and land-use), and possible improvements in woodfuel harvesting, extraction, and delivery.

Energy constraints to development must be evaluated by balancing energy consumption with other variables and costs which influence demand. There may be, for instance, income effects: per capita woodfuel consumption may increase (or decrease) as the household's endowments of physical -- and human -- capital increase. There are likely price effects: as the price of woodfuel increases, demand may decrease (or it may increase if, as economists say, it is a "Giffen" good). Finally, there may be substitution effects: as the price of woodfuels increase, cheaper substitutes may be found; conversely, as the prices of alternative fuels increase, demands for woodfuels may increase.

Impacts of Woodfuel Scarcity

It is generally accepted that, as a result of woodfuel scarcities, the consumption of a marginal unit of woodfuel will entail sometimes quite considerable costs. The outcome of woodfuel scarcities include:

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1. A.C.Fisher (1979). "Measures of natural resource scarcity", in: V.K.Smith (ed.) (1979). *Scarcity and Growth Reconsidered*. Baltimore, Johns Hopkins.

-- increased time for woodfuel collection;

-- a deterioration in the quality, and in the type, of domestic energy used, and an increase in the use of agricultural residues and animal dung for household cooking and heating;

-- an increase in deforestation because more trees have to be felled to meet greater woodfuel demands;

-- changes in cooking and heating habits;

-- the emergence of woodfuel markets; and where there are already markets, increases in the prices of woodfuels.

This paper questions whether or not these impacts are clearly the outcome of woodfuel scarcities, or whether or not they are the outcome of much more fundamental issues related to labour use, land endowments, the transition from subsistence to market economies, and cultural practices. If indeed these more fundamental issues are involved, then the conventional response of development planners to perceived domestic energy shortages -- support for tree planting interventions -- may have little or no impact.

Where there *are* clear woodfuel scarcities, manifested by these types of impacts, tree planting as a mechanism for responding to them may entail particularly high costs for farmers. Without negating the clear impact on the poor of changes in rural factor endowments, brought about by woodfuel scarcities, rural people sometimes view the impacts of scarcities from a fundamentally different perspective than the way development planners perceive them. The objective here is to suggest that the maintenance of adequate levels of domestic energy consumption can be (and indeed often is) achieved at particularly low cost.

Indeed, farmers are often able to adapt to scarcities of different resources in "positive-functioned" sorts of ways. As Dirks pointed out in his study of human responses to food shortages, adaptation to deprivation can involve both "progressive" and "recursive" changes.[1] In cases where there may be risks of food

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1. R.Dirks (1980). "Social responses during severe food shortages and famine," *Current Anthropology* 21(1):21-44.

shortages, these progressive responses include food sharing, shared cooking, increased labour use for food production, rationing, the use of famine-foods, and migration.

People who depend on woodfuel have developed similar types of responses when it has become scarce. These responses include fuel sharing, shared cooking, increased labour-use for fuel collection, the use of other fuels when desired types of woodfuel are scarce, and migration and nomadism.

Where woodfuel scarcities are in evidence, much debate has been initiated about the impact of urban and industrial woodfuel markets on increased scarcity in rural areas. Urban woodfuel markets, though, are a special case and few generalizations about their impact on woodfuel scarcity can be made because painfully little is know about how they work. Planners often forget, as well, that woodfuel markets often provide a critical source of employment and income. In Kenya, for instance, studies have suggested that (in 1985) urban charcoal markets provided full-time jobs for around 30,000 people as charcoal burners, transporters, and retailers.[1]

It is also sometimes argued that cash crop farm forestry contributes to rural woodfuel shortages and to increased disparities in labour use and poverty.[2] It is, however, as likely that farmers undertake to supply markets for woodfuel and for other tree products as a response to much more serious constraints, such as the need for rural housing, capital constraints, the failure of rural labour markets, and distortions in rural land markets.

Evaluating the extent to which woodfuel may have become more scarce

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1. P.A.Dewees (1985). *Commercial Fuelwood and Charcoal Production, Marketing, and Pricing in Kenya* (mimeo). Washington, D.C., Joint UNDP/World Bank Energy Sector Management Assistance Programme.

2. V.Shiva, H.C.Sharatchandra, and J.Bandyapadhyag (1982). "Social forestry: No solution in the market," *The Ecologist* 12(14):158-168.

requires a dynamic view. Saying that women spend, say, 3 hours a day collecting woodfuel is entirely different from saying that women are spending 3 hours a day collecting woodfuel, but that 10 years ago, they only spent 1 hour per day (or possibly 5 hours per day!). The essential improvement or worsening of the woodfuel situation must be measured within some objective time horizon.

Woodfuel Scarcities and Labour

It is hardly arguable that levels of woodfuel consumption are greatly dependent on the amount of labour which is available to collect it. As competing constraints are placed on the household's available supply of labour, woodfuel consumption can decline. These constraints become greater as woodfuel becomes more scarce because farther distances have to be traveled to collect it. They perhaps become most serious when, as Cecelski points out, fuel gathering can no longer be combined with other work (such as the collection of medicinal herbs, or as an activity on returning from the fields), but instead has to be the object of a separate trip.[1]

The question here, however, is not clearly one of fuel availability, but one of *labour* availability. Even if fuel is available in abundance, if there are constraints to the household's supply of labour, the cost of burning woodfuels can be quite high and, consequently, consumption can be quite low. Conversely, if labour is abundant, the time spent on fuel collection and the level of woodfuel consumption can be quite high. In Zimbabwe, for instance, it has been found that the frequency of woodfuel collection, as well as the time spent for collection, increases during the dry season primarily because households are freed from

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1. E.Cecelski (1987). "Energy and rural women's work: Crisis, response and policy alternatives," *International Labour Review* 126(1):41-64.

agricultural labouring.[1] During the planting season, households spend around 3 hours a week in firewood collection; during times of lowest labour demand, they spend around 10 hours a week.

In the Sudan, there are indications that competing demands for labour may have some impact on the price of charcoal delivered to urban markets. Labour costs typically account for around a fifth of the delivered price of charcoal. Agricultural labour and labour for charcoal burning are nearly perfect substitutes. Because of the far greater demand for agricultural labour, however, the price of farm labour dictates the wage of charcoal burners.[2] An analysis of charcoal prices in Khartoum over the last 10 years suggests that charcoal prices are indeed highest when demands for agricultural labour are highest, for instance, during years when there have been particularly good harvests. In constant prices, charcoal prices in Khartoum showed peaks during the 1977 and 1981 harvests, but bottomed out during the 1984 drought.[3]

The lack of adequate on-farm labour can be an important incentive for farmers to plant trees. In Machakos District of Kenya, smallholdings headed by very young or very old women face serious labour constraints. Households headed by mothers of very small children and older infirm women have expressed particular interest in concentrating fodder and fuel resources on or around the farm

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1. R.F.du Toit, B.M.Campbell, R.A.Haney and D.Dore (1984). *Wood Usage and Tree Planting in Zimbabwe's Communal Lands*. Harare, Forestry Commission of Zimbabwe and the World Bank.

2. G.El Faki Ali (1985). *Charcoal Marketing and Production Economics in Blue Nile*. Khartoum, National Council for Research (Energy Research Council).

3. P.A.Dewees (1987). *Charcoal and Gum Arabic Markets and Market Dynamics in Sudan* (mimeo). Washington, D.C., Joint UNDP/World Bank Energy Sector Management Assistance Programme. A range of other variables influence the price of charcoal as well. In Sudan, these have included changes in seasonal demands and supplies which have been influenced by the price of alternative fuels, prices for agricultural crops (which influence the rate of land clearance), pressures on capital markets, efforts at price control, collusion among producers and dealers, and competing demands for charcoal in export markets. In any event, on average, real prices have shown little change over time. The most dramatic price changes have been seasonal ones, and have not been sustained over the long term.

so they are more accessible to the household.[1] These kinds of constraints in other areas of Kenya have led to initiatives which have increased the household's access to woodfuel. In some areas of Kisii District of Kenya where there are agricultural labour shortages, woodfuel collection requires a relatively small proportion of the household's time because woodfuel supplies are obtained from planted and managed on-farm trees.[2]

Studies of household labour-use differentiated by task, sex, and age in Java and Nepal provide startlingly different information about the role of men, women, and children in fuelwood collection. In villages surveyed in Java, children under the age of 15 provided nearly 70 percent of all the labour required for woodfuel collection, while in Nepal, they provided only 30 percent of the total labour required. In Java, men and boys provided 74 percent of the labour required for woodfuel collection, while in Nepal,they provided 57 percent. Finally, in Java, fuelwood collection accounted for 3.5 percent of all work done, while in Nepal, it accounted for only 1.5 percent. In absolute terms, around twice as much labour was used for woodfuel collection in Java, across all age groups, than in Nepal.[3]

Clearly, the issues surrounding labour use and woodfuel scarcity are far more complex than most analyses would suggest. Labour constraints to woodfuel collection are labour constraints to the farm. Where farm labour is scarce, woodfuel collection may be costly; where farm labour is abundant, woodfuel collection may involve very low costs.

Without comparing labour use for woodfuel collection with labour use on

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1. D.Rocheleau (1985). *Criteria for Re-appraisal and Re-design: Intra-household and Between-Household Aspects of FSRE in Three Kenyan Agroforestry Projects* (Working Paper No. 37). Nairobi, International Council for Research in Agroforestry.

2. S.Orvis, personal communication. (Research Associate, Institute for Development Studies, University of Nairobi).

3. M.Nag, B.N.F.White, and R.C.Peet (1978). "An anthropological approach to the study of the economic value of children in Java and Nepal," *Current Anthropology* 19(2):293-306.

the farm as a whole, it is inaccurate to imply that increased use of time for woodfuel collection necessarily reflects woodfuel scarcities. If labour is abundant, how much of a problem is it, really, if the household is spending three times as much labour in woodfuel collection than it otherwise would (as in Zimbabwe)? If labour is scarce, the impacts of scarcity are felt in all farming activities. The question perhaps becomes one of whether or not the household's access to woodfuel can be increased by reducing its labour requirements for other farming activities.

Woodfuel Scarcity and the Quality of Alternative Fuels

It is usually argued that, as woodfuels become more scarce, households are forced to rely on low quality fuels: sticks, twigs, agricultural residues, and animal dung. While a shift to lower quality fuels can indeed reflect the fact that particular types of woodfuel are becoming more scarce, this is not always the case. Even when this is the case, it often represents the least-cost option to the farmer, and entails lower overall costs to the household.

When tree planting is encouraged as a response to fuel scarcities in these situations, trees often assume much higher economic values to the farmer; consequently, tree planting may have little or no impact on reducing the household's reliance on agricultural residues. Trees which produce "high quality" fuelwood may be more highly-valued in the rural economy, for instance, as sources of building timber, or as sources of fruit and fodder. Project interventions which have the objective of producing high quality woodfuels may be frustrated in achieving this objective because of the economically low value of woodfuels vis-a-vis its alternative uses.

In Gujarat in Western India, for instance, the Forestry Department's efforts at increasing supplies of woodfuel basically resulted in the establishment of huge

areas of eucalyptus woodlots for building poles. The objectives in the original project documents were clearly to produce fuelwood. Perhaps it would have been more appropriate to encourage farmers to grow scrubby little plants, which would produce low quality woodfuels. In fact, woodfuel is being produced in Gujarat, but as a byproduct of building pole production. As much as 30 percent of the increment is non-marketable as construction poles, and is ultimately used under the pot.[1]

Although twigs and sticks are not, in the usual view, high quality woodfuels, from the perspective of the farmer who must rely on them, because of their abundance, they can be highly valued. In Indonesia, it has been estimated that low quality fuels are around 4 times more available than high quality stemwood.[2] Indeed, in some areas, crop residues are a preferred type of fuel, both because of their availability and because of the quality of the flame. In China, for instance, straw (which accounts for over 40 percent of domestic energy used in rural areas) produces a hot flame appropriate for frying foods quickly.[3]

Amongst the Khan Magar of north-west Nepal, Molnar suggested that the use of agricultural residues as a household fuel was not necessarily related to physical woodfuel shortages.[4] She noted that stalks of *puwa*, a nettle which is stripped for its fiber, are commonly used for fuel. Despite a heavy reliance on this sub-standard fuel, she observed that the forest resource base was reasonably intact,

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1. P.A.Dewees (1983). *Wood Balance and Market Studies: a preliminary assessment* (mimeo prepared for the World Bank Gujarat Community Forestry Project). Washington, D.C., International Institute for Environment and Development.

2. W.P.Weatherly (1980). *Environmental Assessment of the Rural Electrification I Project in Indonesia* (mimeo). Washington, D.C., Agency for International Development.

3. W.Wu and E.Chen (1983). "Our views on the resolution of China's rural energy requirements," *Biomass* 3:287.

4. A.Molnar (1981). "Economic strategies and ecological constraints: The case of the Khan Magar of north west Nepal," in: C.von Furer Haimendorf (ed.) (1981). *Asian Highland Societies*. New Delhi, Sterling.

and that in the short term at least, it would be sufficient for providing adequate woodfuel and building materials.

Pant however observed that in the Kumaon Himalayas of Nepal, fodder and fuel were in seriously short supply, and that households had to rely on stalks of amaranth, hemp, and chili for fuel. He noted that these scarcities were most serious in irrigated valleys and required periodic, lengthy travel to distant forests in search of fuel and fodder.[1] It is interesting to note that his observations were made over 50 years ago at a time when the government of Nepal was actively encouraging the conversion of forested lands into farmlands.[2] If there were shortages of woodfuels in this area 50 years ago, one could anticipate that responses to scarcities have, since then, become integrated into the local social and economic fabric.

Sometimes farmers manage woody biomass *specifically* to produce low-quality woodfuel. In Western Kenya, for instance, a woody shrub (Tithonia diversifolia) which is widely found on verges and along paths is managed on a sustained yield basis to produce large quantities of woodfuel. The bushes are cut just above the ground, and the branches are left to dry for a few days before collection. Although the productivity of these bushes has never been measured, yields are clearly quite high. In some areas of India, similar types of shrubs are grown for woodfuel, for fodder, and for their soil restoring abilities. Sesbania aculeata, for instance, is a leguminous shrub which is grown as a fallow crop primarily for woodfuel.[3]

In the Philippines, smallholders were encouraged through project

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1. S.D.Pant (1935). *The Social Economy of the Himalayas*. London, George Allen and Unwin.

2. P.Blaikie and H.Brookfield (1987). *Land Degradation and Society*. London, Methuen.

3. B.S.Pathak (1980). *Energy Balances and the Use of Agricultural Waste on a Farm* (mimeo). Ludhiana (India), Punjab Agricultural University.

interventions to grow Leucaena leucocephala to provide fuelwood for the local tobacco curing industry and were provided loans and seedlings to enable them to do so. In the first three years of the project, less than 40 people had signed up for the programme, and planting achievements were less than 6 percent of targets.[1] Closer examination revealed that farmers were *already* growing very large quantities of woodfuel in small, very intensively managed woodlots of Gliricidia sepium. These woodlots were hardly noticed by project planners, probably because they produced a tangled, dense mass of "low quality" woodfuel. When farmers were given the opportunity and were encouraged to grow high quality woodfuel, they chose to stay with their traditional and effective tree management practices.[2]

The burning of agricultural residues is generally thought to contribute to declining soil productivity. This is not clearly the case. Some agricultural residues which make perfectly good woodfuels cannot be dug back into the soil in a way which improves the soil structure or fertility. Stalks from cotton, cassava, pigeon peas, and chick peas, for instance, are much too woody to decompose sufficiently in a way which would improve soil productivity, and in many areas, they are used as a valuable source of fuel.[3] Indeed, there are cases where, by digging in residues, the farmer can encounter serious constraints to crop production. As residues decompose, crops and micro-organisms compete for the same nutrients (particularly phosphorus and manganese) which sometimes results in lower yields than if residues had not been dug in.[4] Residues with a high carbon-to-nitrogen ratio can

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1. E.L.Hyman (1982). *Loan Financing of Smallholder Treefarming for Woodfuel Production in the Province of Ilocos Norte, Philippines*. Honolulu, East-West Centre.

2. K.F.Wiersum and C.P.Veer (1983). "Loan financing of smallholder treefarming in Ilocos, a comment," *Agroforestry Systems* 1(4): 361-365.

3. G.Barnard and L.Kristoferson (1985). *Agricultural Residues as Fuel in the Third World*. London, Earthscan.

4. G.J.Benians and D.A.Barber (1974). "The uptake of phosphate by barley plants from soil under aseptic and non-sterile conditions," *Soil Biology and Biochemistry*. 6:195-200; and

(continued...)

bring about the depletion of soil nitrogen as a result of decomposition. Consequent shortages of nitrogen, while causing lower crop productivity, can also aggravate the severity of various plant diseases.[1]

In some tropical areas, particularly where farmers are unable to practice crop rotation, plant diseases can be spread by digging in crop residues. Fungal decomposers of crop residues, for instance, can produce substances which are phytotoxic to crops. Garret concluded that the most successful way of limiting the spread of pathogens is by the destruction of infected crop residues after harvest.[2]

Related arguments can be made about the link between woodfuel scarcity and the use of animal dung as fuel. There is only limited evidence which suggests that if woodfuels were more available, the use of animal dung for fuel would decline. Animal dung is most widely used as fuel in India. In many areas of Latin America, Asia, and Africa its use is virtually unheard of. Even in Nepal (where the opportunity cost of using dung as fuel was used as the basis for the economic justification of the World Bank's forestry project investments there), the use of dung as fuel is the clear exception, even in the most woodfuel scarce areas, rather than the rule.[3]

Dung is clearly used for cooking in other areas (Ethiopia, Pakistan, Yemen, and Turkey, for instance), but the underlying issue is whether or not its use is

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4.(...continued)
M.W.Loutit and R.R.Brooks (1970). "Rhizopore organisms and molybdenum concentration in plants," *Soil Biology and Biochemistry*. 2:131-135.

1. J.M.Lynch and N.J.Poole (eds.) (1979). *Microbial Ecology: A Conceptual Approach*. Oxford, Blackwell Scientific Publications.

2. As Garret points out, however
"Decomposing plant residues have many and diverse effects upon soil and the plants growing therein, but in general the beneficial greatly outweigh the harmful effects of these decompositions on crop growth."
Many of the negative impacts of digging in crop residues can be overcome by composting. See, S.D.Garret (1970). *Pathogenic Root-Infecting Fungi*. Cambridge, Cambridge University Press.

3. J.G.Campbell, personal communication. (USAID, New Delhi).

increasing as a result of scarcities of other fuels. If instead it has been a long-term feature of household fuel use, preferred over other fuels, it may well have been integrated into the cultural tradition. The question is fundamental, because it suggests that tree planting in these situations would have little impact on reducing the use of dung as fuel.

Particularly in India, many people feel that dung has qualities as a fuel which are not shared by woodfuels. It is slow burning and produces a hot flame. It is easily transported, and is easily collected in areas where zero-grazing has become the norm for livestock management. It is often more accessible to the landless than woodfuel. Some observers have stressed the special appropriateness of dung for the preparation of ghee, and for the efficient deployment of female household labour.[1]

Cow dung has broad significance in Hindu tradition. Its smoke is thought to be cleansing, and it is a feature of purification rituals which involve the "five products of the cow."[2] Harris suggested (probably incorrectly) that wood resources

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1. O.Lewis and V.Barnouw (1958). *Village Life in Northern India*. Urbana, University of Illinois Press.

2. F.J.Simoons (1974). "The purificatory role of 'the five products of the cow' in Hinduism," *Ecology of Food and Nutrition*. 3:21-34. The economic and religious role of the sacred cow in India has been the subject of much intense debate. Harris maintains that the protection of the sacred cow is an example of "positive-functioned technoenvironmental determinism" while researchers like Heston point out that India would be much better off with far fewer cattle. The use of dung as fuel, and the impact of its diversion on agricultural production, is in some senses a moot point considering the fact that anywhere between 5 and 20 percent of arable land is used for growing fodder crops for cattle, and that livestock are far more responsible for desertification than is fuelwood collection. The issue is not clearly one of planting trees for fuelwood, but of limiting the access of livestock to regenerating trees. An interesting literature summarizes some of the features of dung use, cooking, and the sacred cow. See for instance: W.N.Brown (1957). "The sanctity of the cow in Hinduism," *Madras University Journal* 28:29-49; P.Diener, D.Nonini, and E.E.Robkin (1978). "The dialectics of the sacred cow: Ecological adaptation vs. political appropriation in the origins of India's cattle complex," *Dialectical Anthropology* 3:221-241; M.Harris (1978). "India's sacred cow," *Human Nature* 1(2):28-36; A.Heston (1971). "An approach to the sacred cow of India," *Current Anthropology* 12:191-209; D.C.Lodrick (1981). *Sacred Cows, Sacred Places*. Berkeley, University of California Press; F.J.Simoons (1979). "Questions in the sacred cow controversy," *Current Anthropology* 20:467-493; and, D.Srinivasan (1979). *Concept of Cow in the Rig Veda*. Delhi, Motilal Barsidass.
A fine overview of the anthropology of food is found in, P.Fieldhouse (1986). *Food and Nutrition: Customs and Culture*. London, Croom Helm.

in India were potentially adequate for replacing dung as a household fuel, but pointed out that this would negate the fundamental religious, economic, and environmental relationship between Hindus and sacred cattle.[1]

In light of the strong religious and cultural significance of the use of cow dung in India, it can indeed be argued that even if woodfuels were more widely available as a result of tree planting interventions, households would continue to rely on the use of dung as a domestic fuel.

Woodfuel Scarcities and Deforestation

Links between woodfuel use and deforestation are usually discussed from two perspectives: firstly, woodfuel consumption is often identified as an underlying cause of deforestation; and secondly, in areas which have been deforested, woodfuels are thought to have become increasingly scarce. Neither of these observations clearly describe the norm, although they have been widely accepted and form the rationale for many tree planting project interventions.

Despite a continuing emphasis on the contribution of woodfuel consumption to deforestation, it is becoming increasingly accepted that the primary causes of deforestation are more closely related to land clearance to support agricultural expansion.[2]

Livestock pressures, as well, may limit the regenerative capacity of dryland forests. Where livestock grazing has intensified, and where traditional strategies of communal lands management have broken down, soil and rangeland degradation has sometimes been accompanied by a deterioration in the stock and quality of woodfuel. Tree planting however, begs the question. The problem is more

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1. M.Harris (1966). "The cultural ecology of India's sacred cattle," *Current Anthropology*. 7:51-66.

2. D.Bajracharya (1983). "Deforestation in the food/fuel context: historical and political perspectives from Nepal," *Mountain Research and Development* 3(3):227-240.

fundamentally related to range management than it is to a shortage of trees.[1]

Woodfuel harvesting by itself is not necessarily a destructive form of tree management. The problem with agricultural expansion and with land clearance is usually that whole trees are uprooted. Woodfuel collection, on the other hand, may involve hacking off a few branches from a live tree, or the collection of dead wood. As long as the root stock is not destroyed, the productivity of woodlands under this type of stress, brought about as a result of woodfuel harvesting, can be significantly higher than woodlands which are not stressed this way.[2] Woodfuel collection, rather than having a serious and destructive impact on tree cover, can often be a productive tree management strategy.

Sometimes tree management is passive. Farmers may make few conscious choices about the ways trees are used for woodfuel production. As pressures on the remaining resources become more intense, management strategies may become much more active. Active management strategies include rotational harvesting, the protection of naturally-regenerating seedlings, the protection of specific types of valued trees during land clearance, and so on. The most active of tree management strategies involve tree planting and sustained-yield management.[3]

Although woodfuel demands may sometimes contribute to deforestation, woodfuel scarcity (and the need for responding to scarcity) can become most critical as an outcome of deforestation. As some observers have noted:

> "(Fuelwood) scarcity is as much a consequence as a cause of deforestation. First, the widespread clearing of lands for agriculture severely reduces the available forest area.

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1. I am indebted to the anonymous reviewer who pointed out that "the entry of livestock into forested areas has virtually eliminated the regeneration of species suitable for use as fuelwood -- prompting some foresters to claim that forestry, in many countries, is inseparable from range management."

2. Little information is available about the productivity of dry woodland forests when they are regularly coppiced or pollarded. Most analysts of the woodfuel situation fail to point out that woodland productivity could perhaps be greatly increased as a result of regular harvests.

3. G.A.Klee (1980). *World Systems of Traditional Resource Management*. London, Edward Arnold; and, FAO (1986). *Tree Growing by Rural People* (Forestry Paper No.64). Rome, FAO.

> At that point, the gathering of fuel from the remaining woodland may well begin to exceed the sustainable harvest."[1]

Can it be concluded that farmers in areas which are heavily deforested are likely suffering from serious woodfuel shortages? Not necessarily. Indeed, the extent of deforestation may be a particularly poor indicator of the severity of woodfuel scarcities, simply because farmers may well have developed sophisticated tree management strategies, as well as cultural responses, to enable them to deal with scarcities.

In Zimbabwe, recent studies have indicated that, despite rapid rates of deforestation, residual woodlands and other tree resources are being managed to meet local needs. Even in the most heavily deforested areas, where remaining tree resources are essentially confined to non-cultivable locations (particularly hilltops), the clearance of residual woodlands over the last 15 to 20 years has been insignificant, despite rapidly increasing demands for these resources. In fact, some areas of residual woodland appeared to be more densely forested now than before, possibly because of coppice regrowth.[2]

Over half of the respondents interviewed in field surveys in Zimbabwe reported that fuelwood was easy or fairly easy to obtain, while nearly 70 percent believed there is currently enough fuelwood to meet household demands (an interesting distinction between *economic* and *physical* scarcity).[3] Despite the fact that the deforestation of savannah bush has clearly accelerated over the last 20 years, farmers noted that, even in the most heavily deforested areas, firewood is not necessarily difficult to obtain.

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1. Eckholm, et.al., *op.cit.*

2. du.Toit, et.al., *op.cit.*; and, B.M.Campbell and R.F.du Toit (1987). "Relationships between wood resources and use of species for construction and fuel in the Communal Lands of Zimbabwe," *Monographs of the Missouri Botanical Society* (in press).

3. These surveys were carried out as part of a Baseline Study for the Zimbabwe Forestry Commission's Rural Afforestation Project. A total of 1,829 households were surveyed.

Similar findings with regard to the consumption of wild fruit in Zimbabwe are reported by Campbell.[1] Deforestation does not appear to affect the availability of wild fruit, because people tend to protect preferred fruit trees while land is being cleared for cultivation. Indeed, in some agricultural areas forest cover has been manipulated to such an extent that fruit trees have become the dominant type of tree. Other researchers have since confirmed that in some areas of Zimbabwe, farmers have a very sophisticated notion of the interactions between trees and crops and are clearly aware of a broad range of management possibilities.[2]

In West Africa, tree management is believed to have been one of the earliest types of farming practices amongst settled agriculturalists. Evidence of the manipulation of forest cover dates back some 5,000 years. In Southeastern Nigeria, dense stands of oil palms ("oil palm bush") within tropical rain forests are more recent indications of the earlier integration of trees in farming systems. When the forest was originally cleared for farming, oil palms were left in fields because they were a valued source of cooking oil. After farm sites were abandoned, oil palms became the dominant species in the climax tropical rain forest.[3] The British explorer, Mungo Park, in the 1790s made careful reference to the economic importance of the shea butter tree in Mali, and noted that it was seldom planted, but that "in clearing wood land for cultivation, every tree is cut down but the shea."[4]

Similar types of tree management strategies have been widely reported elsewhere. Even so, many development planners maintain an overwhelming prejudice about the ability of rural people to manage their environment, despite the

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1. B.M.Campbell (1987). "The use of wild fruits in Zimbabwe," *Economic Botany* 41(3):375-385.

2. K. Wilson, personal communication. (Queen Elizabeth House, University of Oxford, Oxford).

3. M.A.Sownmi (1985). "The beginning of agriculture in West Africa: Botanical evidence," *Current Anthropology* 26(1):127-129.

4. M.Park (1799). *Travels into the Interior of Africa*. London, William Bulmer and Company.

fact that environmental management is often fundamental to their survival. These prejudices include the notion that farmers fail to understand the long-term and intergenerational impacts of their choices about resource use.

In his analysis of woodfuel scarcities and abundance in the Sahel, Foley pointed out that although energy planners at the national level often envisage a woodfuel crisis of catastrophic proportions (and respond accordingly), at the village level, farmers seem to have few worries about woodfuel shortages or to show any interest in planting the tree seedlings provided for them.[1] Sometimes local people are blamed for their lack of foresight or their "inability to understand exponential growth". It is more likely that, given the community's land and labour resources, and their access to bush, to managed fallow land, and to on-farm trees, they have developed quite responsive means of dealing with growing demands for tree resources.

The impact that tree planting programmes would have on reducing woodfuel scarcities caused by deforestation is unclear. To begin with, deforestation does not necessarily bring about scarcities of woodfuel, and even when it does, farmers may have alternative and sophisticated means of responding to scarcities through environmental management strategies or through cultural practices which require no project intervention.

A final point should be made about adaptive strategies in areas which have long been deforested (or which perhaps never supported any forests). In a study of energy flows in households on the northeastern shore of Lake Titicaca in Peru, Collins suggested that seasonal migrations are a response to energy scarcities.[2]

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1. G.Foley (1987). *Exaggerating the Sahelian Woodfuel Problem?* (mimeo). London, Panos Institute.

2. J.L.Collins (1983). "Seasonal migration as a cultural response to energy scarcity at high altitude," *Current Anthropology* 24(1):103-104.

Seasonal migration and the development of very low-energy intensive cooking strategies also characterize the cultural and economic practices in energy scarce areas of the Himalayas.

There are interesting migration paradigms in the literature about human responses to the scarcity of other resources. The entire population of the great Moghul sandstone city of Fatepur Sikhri migrated as the result of shortages of water. Dirks noted that migration is often an outcome of food scarcity.[1] Others have noted that the "most obvious pastoral adjustment to a scarcity of resources is to move elsewhere; nomadism itself is created by such a necessity."[2]

Woodfuel Scarcities and Changed Cooking Habits

When woodfuel scarcities have become most serious, woodfuel consumption can be reduced, but sometimes at a very high cost to the household. Woodfuel scarcities may result in the preparation of fewer meals or may bring about changes in the diet which favour fast-cooking, and possibly less nutritious foods. While it is widely argued that changed cooking and dietary habits are an outcome of woodfuel scarcity, studies which have supported this view are scarce and are mostly anecdotal. The issue is somewhat complicated by the fact that changes in food consumption as a result of fuel scarcity may easily be confused with changes in consumption as a result of food scarcity. The vast literature about social and cultural aspects of diet and nutrition suggests that other constraints likely play a far greater role in causing nutritional deficiencies.[3]

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1. R.Dirks (1980). "Social responses during severe food shortages and famine," *Current Anthropology* 21(1):21-44.

2. J.Swift (1977). "Sahelian pastoralists: Underdevelopment, desertification, and famine," *Annual Review of Anthropology* 6:457-478.

3. See for instance, E.Messer (1984). "Anthropological perspectives on diet," *Annual Review of Anthropology* 13:205-249.

There are numerous low-cost strategies for reducing fuel consumption when wood is scarce, and these may involve no change in food consumption. Fire management is the most obvious low-cost means of reducing fuel consumption. Studies have shown, for instance, that the efficiency of a three-stone fire can be quite high, if the fire is closely tended and managed. The first outcome of woodfuel shortages will likely be a change in cooking habits -- a change which can be accomplished at very low cost and which may have no impact on food consumption.

Changed strategies of preparing food can also reduce fuel consumption. The soaking of foods such as beans and lentils can greatly reduce cooking time. In the high altitude Khumbu Valley in Nepal, women quite typically use pressure cookers (left by numerous mountaineering expeditions) to reduce their cooking time. The adoption of metal pots and the abandonment of clay pots in some parts of West Africa was a result of convenience, as well as the fact that food can be cooked more quickly in metal pots.

In the Sudan, one outcome of growing demands for woodfuel is the "shared pot" where women from several households may cook together, to reduce their individual woodfuel requirements. Communal cooking has become an important social focus for women in small communities.[1] Household size can greatly influence levels of per capita woodfuel consumption. As household size increases, consumption per capita will decrease.

The concept of the communal sharing of woodfuel resources has similarities to other cultural responses when food scarcities threaten. At the prospect of having to deal with food shortages after a typhoon, villagers on the island of Tikopia in Micronesia increased the extent of food sharing, and developed the

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1. T. Hammer, personal communication. (Department of Geography, University of Bergen, Norway).

concept of the "linked stove."[1]

A comprehensive review of wood conserving stove programmes concluded that the role of improved stoves was limited.

> "(Because) stoves are inefficiently used and deteriorate, because wood is burnt for reasons other than cooking, and because improved stoves cannot be got to everyone, national wood savings through stove programmes can never be significant. However, though improved stoves may not save trees or forests, they can improve the daily lives of human beings."[2]

Similar conclusions can be reached about the role of tree planting programmes with respect to human nutrition. There are likely lower-cost ways of creating additional energy supplies by conserving woodfuel. When conservation is no longer an option, other strategies can be undertaken to augment supplies. At that point, tree planting may make a great deal of sense to the household, but for entirely different reasons: because of the potential for producing construction timber, fruit, fodder, shade, and so on.

Woodfuel Scarcities and the Emergence of Woodfuel Markets

It is widely argued that the emergence of woodfuel markets is an indicator of scarcity and that where there are woodfuel markets, increasing prices are a further indication of scarcity. Both of these arguments seem to be based on misconceptions about the role of trade and exchange in the transition from subsistence to market economies.

The presence of woodfuel markets is no indicator of widespread physical scarcity and is a tenuous indicator of economic scarcity. The emergence of markets for woodfuels, and for other commodities, is an outcome of the process of specialization and exchange. As Brumfiel pointed out in a review of markets in the Aztec state,

> "Specialization allows for exploitation of differences in the natural abilities of individuals and in the natural resources of geographic regions. It permits economies

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1. D.M.Schneider (1957). "Typhoons on Yap," *Human Organization* 16:10-15.

2. G.Foley, P.Moss, and L.Timberlake (1984). *Stoves and Trees*. London, Earthscan.

> of scale and minimizes investments in duplicating the tools of production. Exchange provides for the transfer of goods and services. . . (Exchange) is therefore essential if the benefits of specialization are to be realized."[1]

In the Valley of Mexico, environmental diversity was associated with a degree of economic specialization. Many communities were supplementing subsistence agricultural activities with other activities which produced surpluses for the market.

Similarly, the emergence of woodfuel markets is an outcome of the need for greater degrees of economic specialization and exchange. Woodfuel markets may become a feature of the economy, for instance, when there is wage employment. This type of specialization means that some households may not be able to collect fuelwood, and may have to rely on the market to provide it for them. The fact that there are woodfuel markets gives little indication of its *economic* costs, which may be exactly the same in the absence of markets: it may still take, say, a half day to collect and chop a load of fuelwood, regardless of whether or not there are markets.

Using the "food/fuel" paradigm, one could argue that the presence of markets means that woodfuel-selling households are generally having their needs met. In the Tudu region of Niger, for instance, no grain enters the market until households have 18 months supply in reserve.[2] Similarly, a household which is selling woodfuel must be confident that it has an economic surplus: the value of surplus woodfuel to the household is greatest only if it is sold, and the household would otherwise have a means of doing without.

Woodfuel pricing trends are similarly unconvincing indicators of physical scarcity. An analysis of longer term woodfuel pricing trends in urban markets in

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1. E.M.Brumfiel (1980). "Specialization, market exchange, and the Aztec state: A view from Huexotla," *Current Anthropology* 21(4):459-478.

2. R.Faulkingham (1978). "Where the lifeboat ethic breaks down," *Human Nature* 1:32-39.

South Asia indicated there were no convincing links between the extent of physical tree resources and market prices.[1] In the Sudan, there are large seasonal price fluctuations, but over the last 10 years, real prices have shown no long term increases.[2]

This is not to say that there are not growing physical scarcities of woodfuel in these areas, but only to point out that pricing trends provide us with little information about the extent of these scarcities. The data instead suggests the lack of an *economic* scarcity of woodfuels. In Kenya, for instance, woodfuel prices have been kept low because of improvements in the transportation infrastructure, because of an extremely competitive market, and because of the continuing clearance of agricultural land.

In Sudan, charcoal markets have become extremely sophisticated and show a high degree of vertical integration. A few entrepreneurs, for the most part, control the major aspects of production, transport, distribution, and sale, thus keeping overheads low, and allowing them to maintain their margins in the face of increasing physical scarcity.

Increases in relative prices indicate economic, and not physical scarcity. The passenger pigeon, for instance, was first commercially harvested in the 1840s, but became extinct in the 1890s. Market prices showed little tendency to increase over time, even in the face of extinction. Prices failed to rise (and hence we can argue passenger pigeons were not economically scarce) because they were a common property resource, because there were cheap substitutes, and because there were improvements in harvesting technologies.[3] It can be convincingly shown that

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1. G.Leach (1987). *Household Energy in South Asia*. London, Elsevier Applied Science.

2. Dewees (1987), *op.cit.*

3. C.W.Howe (1979). *Natural Resource Economics*. New York, John Wiley and Sons.

woodfuel pricing trends similarly give no adequate indicator of physical scarcity for precisely the same reasons.

Until conventional measures of economic scarcity more accurately reflect the physical scarcity of woodfuels, the augmentation of woodfuel supplies for the market through tree planting project interventions will be problematic. In the absence of any market intervention, it is unlikely that sustainably-produced woodfuel will be able to compete in the marketplace with nonsustainable production, unless it is produced as a byproduct of other more lucrative tree growing practices. Otherwise, tree growing solely for woodfuel production will only become profitable vis-a-vis alternative land and labour uses as absolute physical scarcities emerge, and as prices for conventional fuels become too high.

This is not an argument for intervention in woodfuel markets. Good market intelligence about woodfuel markets is limited to a handful of studies, and most of these were one-off efforts which fail to capture the long-term supply/demand dynamic. It would be fatuous to suggest that they could form the basis for realistic and effective interventions.

Responding to Tree-Based Constraints to Development

There is a huge gap in our understanding about the difference between the *economic* scarcity of woodfuel and its *physical* scarcity. Even when woodfuels have become physically scarce, households have a great deal of latitude in developing adaptive responses (which may include tree growing or management); from the farmer's perspective, the impacts of economic scarcity may not be nearly as serious as the extent of physical scarcity might suggest. It would be unrealistic, for instance, for a household to use kerosene or other fossil fuels as woodfuels become physically scarce as long as there is a broad range of much lower-cost options open to it, such as conservation. Eventually, as the economic cost of these other options

increases, scarce household income may well have to be spent on kerosene.

Even in the absence of physical scarcity, there may be an economic scarcity of woodfuel, defined by the household's access to labour, income, or land. If the household has no surplus labour to collect fuel, even if tree resources are abundant, woodfuels will be economically scarce.

The "woodfuel crisis" was a powerful catalyst in the late 1970s for focusing the attention of development planners on some of the more fundamental requirements of the rural poor. Too often, this myopic focus was the driving force behind project investments. Even though planners would claim that they were also interested in food, fodder, housing, and so on, an overwhelming emphasis on woodfuel emerged, probably because it seemed so much more tangible than other aspects of tree resource use. It is difficult to imagine, for instance, that much excitement could have been generated over a "fodder crisis" or over a "fruit crisis".

Even much more obvious constraints such as rural housing have often been ignored during the design of forestry project interventions because of a focus on fuelwood. When projects have the objective of providing the resources to enable farmers to produce fuelwood, and they instead grow building poles, project planners are often loudly criticized because the project had not met its original objectives. The point is, from the farmer's perspective, building poles make much more sense. No one thought to ask if there were rural housing shortages.

Tree resources are of fundamental importance to farming systems, and rural people may become much more involved in tree planting or management when trees become scarce. Woodfuel scarcity in the economic sense, however, cannot always be equated with tree scarcity. So tree planting interventions which are intended to be responsive to woodfuel scarcities will likely miss the point. Even an abundance of trees may obscure more fundamental tree-related resource

constraints.

Tree planting and management interventions must be more responsive to the much broader range of the needs of the farming system. Some aid agencies, governments, NGOs, and local organizations have of course done better than others in adopting a broader view of trees within development projects. The experience of programmes which have encouraged tree growing to provide multiple outputs has reinforced the assessment that farmers widely value trees for a variety of inputs into their household and farming systems, and will pursue tree growing strategies which provide as large an aggregate as possible of multiple benefits.

The obvious point is that forestry programme planners must have an idea of what the farmer's tree-based constraints are before responsive interventions can be developed. It is counterproductive to undertake a baseline survey during the design of a "woodfuel programme" because there is the presupposition (no doubt reinforced by a yawning "woodfuel gap") that woodfuel is the problem. It would indeed be an institutional dilemma if an agency which had been given the mandate to develop a woodfuel project intervention discovered that in fact woodfuel was not a serious constraint in the proposed project area.

It is becoming a much more critical feature of successful programme design that other less value-laden, but more comprehensive, exercises are undertaken, such as Rapid Rural Appraisals, participatory programme design, Agroecosystem Analysis, baseline surveys, and Diagnosis and Design studies. Particularly where issues such as land and tree tenure and usufruct complicate the dimensions of project design, these approaches are crucial. The problem is that many aid agencies (or forest departments) are ill-equipped to carry out these types of exercises without significant training and retraining.

The "woodfuel crisis" served a valuable and useful function as a political tool which successfully raised the awareness of development planners about the interdependencies between trees and people in developing economies. As long as aid agencies and governments downplay this interdependence, the "crisis" will not go away. But the issues are much farther reaching. Trees are fundamental for truly sustainable development, but for a range of reasons: for building timber, fodder, fruit, fiber, soil conservation and improvement, shade and enjoyment, and income generation, as well as for fuel. Can we afford to continue to limit our view of trees primarily as sources of energy?

APPENDIX 2:
Questionnaire Used in the Household Survey

The questionnaire used in the household survey was prepared along the lines of a number of other household surveys which had been carried out by the Central Bureau of Statistics of the Ministry of Planning and National Development. Four enumerators and one supervisor from CBS were employed to help implement the field survey. Enumerators worked in teams of 2. Depending on the household, the survey required anywhere from 20 minutes to 1 hour to administer. Because of the length of time which was required to carry out area measurements, because of the distances between the aerial flight transects, and because of the large number of recalls which were required, it was unusual for a team of enumerators to complete more than one household in a day. The entire questionnaire is reproduced here. The form used for recording the area measurement data is reproduced in Appendix 3.

CONFIDENTIAL

MOI UNIVERSITY
Department of Forest Resources
and Wildlife Management
Eldoret, Kenya

OXFORD FORESTRY INSTITUTE
University of Oxford
Oxford
United Kingdom

INTERVIEW REPORTING FORM

Survey Number _____ Location _____

Photograph Number _____ Sub-location _____

Cluster Number _____ Altitude _____

Interviewer's Initials _____

Date of first visit _____ Date of second visit _____

Status, First Visit	Status, Second Visit
____Farmer available for survey	____Farmer available for survey
____Farmer not in	____Farmer not in
____Farmer asked us to return	____Farmer asked us to return
____Farmer unwilling to participate	____Farmer unwilling to participate
____Woodlot is not black wattle woodlot	____Woodlot is not black wattle woodlot
____Woodlot belongs to government or institution	____Woodlot belongs to government or institution
____Two sample plots were operated by the same person	____Two sample plots were operated by the same person

Time Interview Began _____ Time Interview Completed _____

Total Time of Interview _____

DID YOU HAVE PROBLEMS OR COMMENTS ABOUT ANY SPECIFIC QUESTION?

CONFIDENTIAL
Form 1

1. Household Composition. Survey Number _____

Locate the parcel marked on the aerial photograph. Then identify the household (or households) with an economic interest in that parcel. If multiple households have an economic interest in a parcel, the responding household should be the most economically active household.

A. Household members who are RESIDENT. List all members of the household (or households) who are living in the household at the time of the interview. Include any guests who have been staying for more than 2 weeks, all polygamous wives and their children, and domestic servants or other workers living in the household. Do not include anyone who is temporarily home or on leave from full-time employment or children who are normally in boarding school. Sons or daughters or husbands or wives of resident household members WHO DO NOT LIVE HERE should be listed on Form 2.

Serial Number of Resident Household Member	Name of Resident Household Member (This column is for the enumerator's use only. It is not required for statistical analysis.)	Relationships within the household: What is the relationship of this person to the resident head of the household (a)	Relationships within the household: Who is this person's mother? (Give her Serial Number from the first column. Code=00 if mother is not resident or is deceased.)	Relationships within the household: Is this person a married woman? If yes, who is husband? (Give Ser. number. Code=00 if not resident or deceased.)	Age (years)	Education: Highest level completed (b)	How does this person normally spend most of their time?: Main activity (c)	How does this person normally spend most of their time?: Any other activity? (c)
01								
02								
03								
04								
05								
06								
07								
08								
09								
10								

(a) 1 = person is male head
2 = person is female head (husband is away)
3 = person is female head (is a widow or is unmarried)
4 = wife of head, or co-wife to female head
5 = son of head
6 = son-in-law
7 = daughter of head
8 = daughter-in-law
9 = father of head
10 = mother of head
11 = other male
12 = other female

(b) 0 = none
1 = standard 1
2 = standard 2
3 = standard 3
4 = standard 4
5 = standard 5
6 = standard 6
7 = standard 7
8 = standard 8/Form 1
9 = Form 2
10 = Form 3
11 = Form 4 or 5
12 = College, Polytechnic, or through Form 6
13 = University

(c) 0 = looking for waged work
1 = works on this or another family farm (not hired)
2 = hired labour working for this household
3 = works on another small farm (hired)
4 = works on an estate/large farm (hired)
5 = works for a rural business
6 = has own rural business or works as a local craftsman
7 = works for an urban business
8 = has own business (urban)
9 = working for government or parastatal
10 = teacher
11 = student in school
12 = not in labour force (such as elderly parents, the disabled, young children)

CONFIDENTIAL
Form 2

1. Household Composition (continued) Survey Number _____

B. NON-RESIDENT RELATIVES OF RESIDENT HOUSEHOLD MEMBERS. Are there any sons, daughters, or husbands or wives of any of the resident household members who are not living here now?

		DO NOT FILL IN THESE COLUMNS FOR RELATIVES OF NON-FAMILY RESIDENT HOUSEHOLD MEMBERS										
Serial Number of Non-Resident Relative	Name of Non-Resident Relatives of Resident Household Members (This column is for the enumerator's use only. It is not required for statistical analysis.)	Household member to whom related (Serial number from Form 1)	Relationship (a)	Age (years)	Education: Highest level completed (b)	How does this person normally spend most of their time?: Main activity (c)	How does this person normally spend most of their time?: Any other activity? (c)	Where is he/she living now? (d)	How long ago did he/she leave the household? (in years)	Why did he/she go? (e)	Does he/she ever send money or gifts back to the family? (f)	If yes, about how often? (g)	What are the money or gifts usually used for? (h)
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													

(a) 1 = husband
2 = wife
3 = son
4 = daughter

(b) 0 = none
1 = standard 1
2 = standard 2
3 = standard 3
4 = standard 4
5 = standard 5
6 = standard 6
7 = standard 7
8 = standard 8/Form 1
9 = Form 2
10 = Form 3
11 = Form 4 or 5
12 = College, Polytechnic, or through Form 6
13 = University

(c) 0 = looking for waged work
1 = works on this or another family farm (not hired)
2 = hired labour working for this household
3 = works on another small farm (hired)
4 = works on an estate/large farm (hired)
5 = works for a rural business
6 = has own rural business or works as a local craftsman
7 = works for an urban business
8 = has own business (urban)
9 = working for government or parastatal
10 = teacher
11 = student in school
12 = not in labour force (such as elderly parents, the disabled, young children)

(d) 1 = Nairobi
2 = other major town (specify)
3 = other rural, near here (less than 20 km away)
4 = other rural, but far from here (more than 20 km away)

(e) 1 = to look for work
2 = to take up a job offer
3 = marriage
4 = land shortage
5 = school
6 = other

(f) 0 = no
1 = yes

(g) 0 = not applicable
1 = more often than once a month
2 = about once a month
3 = about once every 6 months
4 = less often than once every 6 months

(h) 0 = not applicable
1 = investment in farm
2 = investment in business
3 = to pay household expenses
4 = to repay other debts
5 = school fees
6 = dowry or other ceremonial

CONFIDENTIAL
Form 3
Survey Number _________

2. Employment of RESIDENT HOUSEHOLD MEMBERS

A. Have any of the people who live on the shamba worked off the farm in the last year? Include ONLY WAGE EMPLOYMENT such as on other farms, plantations, in nearby towns, as a teacher, and so on. DO NOT INCLUDE SELF-EMPLOYMENT OF ANY TYPE. List each job separately, i.e. if one household member worked in 3 different jobs, list each job separately.

Serial Number of Household Member	Over the past 12 months, where have you worked? (a)	What type of work did you do? (Specify, i.e., picking tea or coffee, digging, etc.) (b)	About how far away is that from here? (km)	Did you continue to live on this shamba, or did you live somewhere else? (c)	Over the last year, about how much did you work at this place? (d)	How were you paid (by the day, month or piece work?) (e)	What was the wage rate? (Specify in shillings per unit worked)	About how long was a work day? (hours)	Did you receive any in-kind payments such as clothes, food or housing? (f)	Did you use any of your earnings for your own schooling? (0 if no; how much if yes) (KSh)

(a) 1 = worked on other small farm
2 = worked on an estate/large farm
3 = worked as a craftsman or mechanic
4 = worked for government or parastatal
5 = teacher
6 = other (specify)

(b) 1 = picking tea
2 = picking coffee
3 = digging
4 = weeding
5 = other (specify)

(c) 1 = stayed on this shamba
2 = stayed somewhere else

(d) 1 = less than a week
2 = more than a week but less than a month
3 = more than a month but less than 3 months
4 = more than 3 months but less than 6 months
5 = more than 6 months

(e) 1 = cash at day rate
2 = cash at weekly rate
3 = cash at monthly rate
4 = cash paid by task completed (specify)
5 = other (specify)

(f) 0 = no
1 = meals only
2 = lodging only
3 = meals and lodging
4 = other (specify)

2. Employment of RESIDENT HOUSEHOLD MEMBERS (continued)

C. NON-FARM INCOME
Have any of the people living here made or sold things like ciondo or have otherwise done any work as his or her own boss in the last year in THEIR OWN small business? Examples are handicrafts, a duka, bar, food kiosk, brewing beer, sewing, weaving baskets. Do not include the rental of a household's property as a business. For multiple businesses, list each business separately.

Serial Number of Resident Household Member	Type of business (a)	Typically how many days per month do you work at this business? (number)	Are there other family members who work in this business? 0 if no; if yes, give serial numbers from Forms 1 and/or 2.	How are family members paid? (b)	Do you hire anyone else to work in this business? 0 if no; if yes, how many full-time employees do you hire?	What wage rate do you pay your employees? (In shillings per unit worked)

(a) 1 = handicrafts
2 = market stall/duka
3 = food kiosk
4 = bar
5 = brewing
6 = sewing
7 = Other (specify)

(b) 1 = cash at day rate
2 = cash at weekly rate
3 = cash at monthly rate
4 = cash paid by task completed (specify)
5 = other (specify)

CONFIDENTIAL
Form 4
Survey Number _________

D. OTHER WORK OFF-THE-FARM

Do people in this area ever help each other out by working without wages on other peoples shambas (in ngwatio groups)? (a) ___________
Probe a bit on this question and write details on back.

Have any of the people living here worked in this way WITHOUT WAGES on other family plots or on neighbors' plots, in a women's work group or in some other kind of activity (cooperatives, harambees, DDC, etc.)

Serial Number of Resident Household Member	Where did you work? (b)	Over the last year, about how many times did you do this type of work? (c)	How far away from here was this place? (km)	If this was work on another shamba, what type of work did you do? (d)	Did you work alone or did you work as part of a group? If a group, how large was the group? (e)	Did you expect to receive anything in exchange for this labour? If yes, what? (f)

(a) 0 = no
1 = yes

(b) 1 = other family plot
2 = neighbor's plot
3 = work at cooperative
4 = other (specify)

(c) 1 = once or twice
2 = 5 or 10 times
3 = more than 5 or 10 times

(d) 1 = preparation or planting
2 = weeding
3 = harvesting
4 = terracing
5 = other (specify)

(e) 0 = alone
1 = less than 5 people
2 = more than 5 people but less than 15 people
3 = more than 15 people

(f) 0 = no
1 = exchange of labour
2 = food or lodging
3 = gift
4 = other (specify)

CONFIDENTIAL
Form 5

3. Land and the Household's Holding

Survey Number _____

A. THE HOLDING. How much land does the household operate? In how many different parcels? Include buildings or parcels in local centres, towns, or cities. Also include land which is rented by the household or has been rented to someone else. The "homestead" parcel is the parcel of residence. This may be different from the parcel which is in the aerial photograph.

Parcel Number	ENUMERATOR'S USE: Is this parcel which is marked in the aerial photo? (a)	Area (acres)	About how far is that from here? (km)	Is that in this location? (a)	How many years ago did the household begin operating the parcel? (Code = 99 if a long time ago; 0 if less than 1 year)	How did the household acquire the right to operate the parcel? (b)	Purchased parcels only: If the parcel was bought, where did the cash to buy it primarily come from? (c)	Purchased parcels only: Do you remember about how much the parcel cost? (KSh)	Rented parcels only: Does the household rent the parcel from someone else, or is it rented to someone else? (d)	Rented parcels only: If the parcel is rented, how much is the rent, per year? (KSh)	What is the MAIN use of the parcel? (e)	Is any part of the parcel used for growing a black wattle or eucalyptus woodlot? (f)	Is any part of the parcel kept under pasture? (a)	Is there any part of the parcel which has never been dug and is under bush? (a)
Homestead														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														

(a) 0 = no
1 = yes

(b) 1 = inherited or from consolidation
2 = bought
3 = borrowed
4 = acquired by cooperative or land buying scheme
5 = rental
6 = other (specify)

(c) 1 = income from farm
2 = income from off-farm wages
3 = income from business
4 = loan/borrowing (family)
5 = loan/borrowing (Bank)
6 = loan/borrowing (non-Bank)
7 = sale of livestock
8 = sale of other assets
9 = other (specify)

(d) 0 = no
1 = rented by household
2 = rented to someone else

(e) 1 = permanent cash crops
2 = annual cash crops
3 = subsistence crops
4 = livestock
5 = idle or fallow
6 = buildings
7 = other (specify)

(f) 0 = no
1 = black wattle
2 = eucalyptus

4. General Information

QUESTIONS 1 THROUGH 4 REQUIRE THE ENUMERATOR TO MEASURE DISTANCES ON THE MAP. QUESTIONS 5 THROUGH 13 SHOULD BE SPECIFICALLY ADDRESSED TO THE RESPONDENT.

1. Find the location of the nearest dukas on the map. Then estimate the walking distance from the dukas to the primary parcel and enter it here, in km. _____

2. Find the location of the nearest primary school on the map. Then estimate the walking distance from the school to the primary parcel and enter it here, in km. _____

3. Find the location of the nearest secondary school on the map. Then estimate the walking distance from the secondary school to the primary parcel and enter in here, in km. _____

4. If the household grows coffee or tea as primary cash crops, find the location of the nearest coffee factory or tea buying centre on the map. Then estimate the distance to the parcels where these crops are grown and enter it here.
Distance to coffee factory (km) _____
Distance to tea buying centre (km) _____

5. How are inputs like fertilizers usually brought here? (a) _____

6. How are outputs, like coffee and tea, taken from here? (a) _____

7. Where is the household's main source of water? (b) _____

8. Do you have electricity? (c) _____

9. Do you have any neighbors who rent land? If so, what is the land primarily used for? (0 if no; specify use if yes.) _____

10. If the household were to need cash to pay for a large expense like for a funeral or wedding, or for school fees, where would the money normally come from to pay for something like this? (d) _____

11. If you needed to buy some inputs for your crops, like fertilizer or seed, where would the money for these expenses normally come from? (d) _____

12. Does anyone with the household have an account with a bank, or with the Post Office, or with someone like a building society? (c) _____

13. Description of dwellings. List the number of dwellings by type of roof and wall. Exclude stores.

Type of Roof	Tile	Mabati	Rafuta tins	Thatch	Other
Number of Buildings					

Type of walls	Stone	Timber	Mud/wattle	Mabati	Other
Number of Buildings					

(a) 1 = carried on back
2 = handcart
3 = cycle
4 = donkey
5 = animal cart
6 = matatu
7 = other _____

(b) 1 = on farm piped or well
2 = neighbor's piped or well
3 = river
4 = other _____

(c) 0 = no
1 = yes

CONFIDENTIAL
Form 6

5. Farm Animals

Survey Number _____

List numbers of livestock and poultry OWNED BY MEMBERS OF THE HOUSEHOLD, but not necessarily kept on this shamba.

Type of Cattle	Has 0 = no 1 = yes	Zebu (number)	Grade or Crossbred Dairy (number)	Grade or Crossbred (number)	Owner's Total Valuation (KSh)	Are any of these kept on another shamba? (number)	Is the household keeping any additional livestock for someone who doesn't live here? (number)
Breeding bulls							
Oxen							
Male calves less than 1 year							
Males, 1 to 3 years							
Males, over 3 years							
Female calves less than 1 year							
Heifers (not yet calved)							
Cows							
Totals							

Other farm animals	Has 0 = no 1 = yes	Total Number	Owner's Total Valuation (KSh)	Are any of these kept on another shamba? (number)	Is the household keeping any additional livestock for someone who doesn't live here? (number)
Sheep (meat)					
Sheep (wool)					
Goats					
Pigs					
Donkeys					
Rabbits					
Chickens					
Beehives					

6. Other Assets. How many of each of the following does the household own?

Animal drawn cart	_____	Maize grinder	_____	Car	_____
Wheelbarrow	_____	Water pump	_____	Tractor	_____
Plough	_____	Radio	_____	Other vehicle	_____
Spray pump	_____	Television	_____	Bicycle	_____

(d) 1 = regular farm income
2 = off-farm income
4 = family borrowing
5 = borrowing from friends
6 = cooperative loan
7 = bank loan
8 = other loan
9 = harambee
10 = savings
11 = sale of assets like livestock
12 = other _____

CONFIDENTIAL
Form 7

7. Crops and Land-use

Survey Number _____

List up to ten of the most important crops grown by the household, on all of the household's parcels, OVER THE LAST YEAR. Code = 99 if the respondent doesn't know or can't remember.
Specifically ask about COFFEE AND/OR TEA, HYBRID MAIZE, LOCAL MAIZE, BEANS, AND POTATOES.

What were your main crops? (a) (List other crops besides coffee/tea or use crop codes)	Coffee	Tea							
Was this crop grown by itself or was it grown with other crops in the same plot? (0 if monocrop; Give codes or names of other crops if mixed crop.)									
Over the last year, about how much of this crop did the household harvest? (kg)									
Did the household sell any of its harvest of this crop? About how much? (fraction)	1.00	1.00							
Who was it primarily sold to? (b)	3	3							
Do you remember the price you got for your crop? About how much was it? (Net price in KSh per unit).									
Was that a price for the crop at the farm, or delivered to the market or factory? (c)									
About how much seed or vine stock did you plant for this crop? (kg)	**********	**********							
Was it purchased, or was it from your own supplies or stores of seed or vines? (d)	**********	**********							
If you were to buy seed for this, do you know how much that quantity would have cost? About how much? (KSh per unit)	**********	**********							
Did you use fertilizer for this crop? (e)									
About how much over the last year? (kg)									
Do you remember about how much that cost? About how much? (Total fert. cost in KSh)									
Did you buy this with your own money, or did you use a loan from, say, a neighbor, relative, bank or a Cooperative Society? (f)									
Did you use herbicides or pesticides for this crop? (e)									
Do you remember about how much that cost? About how much? (Total dawa cost in KSh)									
Did you buy this with your own money, or did you use a loan from, say, a neighbor, relative, bank or a Cooperative Society? (f)									
COFFEE AND TEA ONLY: How many bushes do you have? (number)									
About how many of these are of bearing age? (number)									
When was the last time you planted more than 10 new bushes? (year)									
Around how long ago did you plant most of the coffee or tea growing here? (year)									

CONVERSIONS:
Maize and beans: 16 kg per debe
English potatoes and sweet potatoes: 12.5 kg per debe
Coffee weights are in cherry. Tea is green leaf.

(a) 2 = hybrid maize
4 = beans
12 = English potatoes
13 = Sweet potatoes
15 = Arrowroots
17 = tomatoes
18 = onions
20 = cabbages
43 = rodder grass
45 = bananas
50 = passion fruit
52 = fallow
FOR OTHER CROPS, USE THE CODES IN THE ENUMERATOR'S MANUAL

(b) 0 = not sold
1 = to government buying agent
2 = to other buying agent
3 = to cooperative or factory
4 = at the market
5 = direct to other households

(c) 0 = n/a
1 = farm
2 = market
3 = factory
4 = other (give place)

(d) 1 = purchased
2 = from own seed stores
3 = borrowed from neighbor

(e) 0 = no
1 = yes

(f) 1 = own money
2 = friend/neighbor
3 = Cooperative society
4 = bank

CONFIDENTIAL
Form 8

8. Labour Hired in to Work on the Household's Parcels.

Survey Number _____

Does the household ever hire labour to help do the work on the farm or to help with the children or the kitchen? Could you list all the people that have been hired by the household, DURING THE LAST YEAR, to help out in these ways?

Hired labourer Serial Number	Was this person hired permanently, or as a casual? (a)	Male or Female? (b)	Estimated Age (years)	What jobs did this person do? List up to four. (c)				Around what time of the year (or season) did you hire this person? (d)	Around how many weeks did they continue working for you? (number)	About how long was a work day? (hours)	How were they paid? (By the day, worth or by piece work?) (e)	How much were they paid? (KSh per unit worked)	Where did this person stay when he or she worked here? (f)	Did you provide them with meals? (g)	Had this person worked for you before? (g)	Who usually supervised this labourer? Giver serial number of Resident Household Member from Form 1.
01																
02																
03																
04																
05																
06																
07																
08																
09																
10																

(a) 1 = casual
2 = permanent

(b) 1 = female
2 = male

(c) 1 = picked tea
2 = picked coffee
3 = other task, tea
4 = other task, coffee
5 = tended livestock
6 = other crop, digging
7 = other crop, planting
8 = other crop, fertilizer or spraying
9 = other crop, weeding
10 = other crop, harvesting
11 = household or childcare
12 = other

(d) 1 = just before the long rains (end of March)
2 = during the long rains (early April to the end of May)
3 = just after the long rains (early June)
4 = dry season between the long rains and the short rains (end of June until mid-October)
5 = just before the short rains (end October)
6 = during the short rains (November until mid-December)
7 = just after the short rains (end December)
8 = dry season between the short rains and the long rains (January to mid-March)

(e) 1 = cash at day rate
2 = cash at weekly rate
3 = cash at monthly rate
4 = cash paid by task completed
5 = other (specify)

(f) 1 = here
2 = at their own shamba
3 = other

(g) 0 = no
1 = yes
2 = sometimes

CONFIDENTIAL
Form 9

9. USE THIS FORM ONLY FOR HOUSEHOLDS WHICH HAVE BLACK WATTLE WOODLOTS (only plots numbered greater than 100 but less than 200) Survey Number _____

Is the woodlot in the photograph on the main household parcel, or is it on a separate parcel? (a)	
When was the woodlot originally planted? (Give year; Code = 99 if a long time ago)	
When did you last harvest trees from the woodlot? (year)	
Did you cut down the whole woodlot, or only part of it? IF ONLY PART OF IT, about how much of the whole woodlot did you cut down. (In any case, give fraction of woodlot which was last cut down.)	
About how old was the woodlot when you last cut it down? (years)	
When you last harvested the woodlot, did you sell the bark? (b)	
Did you keep any of the wood (kuni, makea, fitus, etc.) for the use of the household or did you sell it all? What did you keep? (c)	
Did you sell any of the wood (kuni, makea, fitus, etc.)? What? (d)	
Do you take thinnings from the woodlot? (b)	
About how old is the woodlot when you take out thinnings? (years after regeneration) — First time / Second time	
What do you use the thinnings for? (c)	
Do you ever sell the thinnings? (b)	
When the woodlot was harvested last, did someone from the household or family cut down the trees or was someone else paid to cut it down? (e)	
If someone from outside the household harvested the woodlot, how were they paid? (Daily, weekly, earnings split, etc.) (f)	
When do you expect to harvest the woodlot again? (in years' time)	
Will you replant this site with another crop, or will you leave it under wattle? (g)	
Do you remember what you did with the income you received when you last harvested your woodlot? (h)	
Do you remember which month(s) you harvested the woodlot (0 if no, month if yes). Is there a particular time of the year which is better? Why? _____	
Have you ever heard of anyone using a woodlot as security for a loan? (b) (If yes, write details on back)	
Does wattle give your other crops problems? (b)	
If you were to clear the woodlot and to plant another crop here, what would do best? What would do worst? (i)	Best: / Worst:
What price can you get for bark now? (in KSh per kg)	
What price can you get for charcoal now if you were to sell around 20 sacks for someone else to transport and sell in Nairobi? (roadside price, in KSh per sack; buyer provides the sacks)	

Questions for the woman	
Do you have a special stock of woodfuel (kuni or makea)? (b)	
How long will the stock you have now last you? (days)	
What types of woodfuel are you primarily using now? (i)	
How often do you get kuni or makea to replenish your stock? (In times per week). In the dry season (January)	
During the rains (long rains and short rains)?	
When it is cold? (June to August)	
Where do you usually get your woodfuel? (k) In the dry season (January)	
During the rains (long rains and short rains)?	
When it is cold? (June to August)	
Is there any particular time of the year when you use makea instead of kuni? Why? Specify time of year, reason.	

(a) 1 = main parcel
2 = separate parcel

(b) 0 = no
1 = yes

(c) 0 = didn't keep any
1 = kept makea
2 = kept kuni
3 = kept poles
4 = 1 and 2
5 = 2 and 3
6 = 1 and 3
7 = 1, 2 and 3

(d) 0 = didn't sell any
1 = sold makea
2 = sold kuni
3 = sold poles
4 = 1 and 2
5 = 2 and 3
6 = 1 and 3
7 = 1, 2 and 3

(e) 1 = household labour only
2 = non-household labour only
3 = household labour and hired labour
4 = other _____

(f) 0 = not paid
1 = daily
2 = weekly
3 = monthly
4 = piece work
5 = proceeds split with workers

(g) 0 = don't know
1 = no, will leave under wattle
2 = yes, tea
3 = yes, coffee
4 = yes, pasture
5 = yes, other _____

(h) 0 = don't remember/or no income
1 = to pay regular household expenses
2 = for a special expense like a radio or refrigerator
3 = to build a house
4 = to pay school fees
5 = to pay dowry, funeral, or other ceremonial
6 = to pay for regular farm inputs, like fertilizer, dawa, etc.
7 = to pay for farm machinery or equipment
8 = to buy livestock
9 = to buy a plot
10 = other _____

(i) 2 = hybrid maize
4 = beans
12 = English potatoes
13 = Sweet potatoes
15 = Arrowroots
17 = tomatoes
18 = onions
20 = cabbages
43 = fodder grass
45 = bananas
50 = passion fruit
52 = fallow
FOR OTHER CROPS, USE THE CODES IN THE ENUMERATOR'S MANUAL

(j) 1 = crop residues
2 = bark
3 = thin twigs
4 = thick branches
5 = split wood
6 = makea
7 = other _____

(k) 1 = own farm
2 = bought from market
3 = bought from neighbors
4 = free from neighbors
5 = sawmill
6 = pitsawyers
7 = other _____

CONFIDENTIAL
Form 10

10. USE THIS FORM ONLY FOR HOUSEHOLDS WHICH HAVE CLEARED AWAY THEIR WOODLOTS, AND ARE USING THE LAND FOR SOMETHING ELSE (Only plots numbered greater than 200) Survey Number _____

Is the plot which is marked on the aerial photograph on the main household parcel, or is it on a separate parcel? (a)	
Do you remember when there used to be a woodlot growing on this plot? (refer the farmer to the plot or to the aerial photograph. Complete the rest of this half of the page ONLY if the farmer remembers when there used to be a woodlot growing here. DO COMPLETE THE WOODFUEL SECTION AT RIGHT) (b)	
How long ago was the plot which is marked on the photograph cleared and planted under another crop (estimate the year).	
What type of trees were growing in this woodlot? (c)	
If this was a black wattle woodlot, before it was finally cleared, did you usually sell the bark from it after it was harvested? (b)	
What did you usually do with the wood? (d)	
What was the income from the woodlot mostly used for then? (e)	
Do you know anyone who ever belonged to one of the wattle bark cooperatives that were around here before Independence? Did you belong to one? (f)	
Why was the woodlot cleared? _____	
Was that before or after this holding was consolidated? (g)	
What is the old woodlot site being used for now? Refer ONLY to the plot which has been marked on the photograph. (h)	

Questions for the woman	
Do you have a special stock of woodfuel (kuni or makea)? (b)	
How long will the stock you have now last you? (days)	
What types of woodfuel are you primarily using now? (i)	
How often do you get kuni or makea to replenish your stock? (In times per week). In the dry season (January)	
During the rains (long rains and short rains)?	
When it is cold? (June to August)	
Where do you usually get your woodfuel? (j) In the dry season (January)	
During the rains (long rains and short rains)?	
When it is cold? (June to August)	
Is there any particular time of the year when you use makea instead of kuni? Why? Specify time of year, reason.	

(a) 1 = main parcel
2 = separate parcel

(b) 0 = no
1 = yes

(c) 1 = black wattle
2 = blue gum
3 = other (specify) _____

(d) 1 = burnt to makea
2 = used as kuni
3 = used as poles/posts
4 = 1 and 2
5 = 2 and 3
6 = 1 and 3
7 = 1, 2 and 3

(e) 0 = don't remember
1 = to pay regular household expenses
2 = for a special expense like a radio or refrigerator
3 = to build a house
4 = to pay school fees
5 = to pay dowry, funeral, or other ceremonial
6 = to pay for regular farm inputs, like fertilizer, dawa, etc.
7 = to pay for farm machinery or equipment
8 = to buy livestock
9 = to buy a plot
10 = other _____

(f) 0 = no
1 = Someone in family belonged to one
2 = Knows someone who belonged to one

(g) 1 = before consolidation
2 = after consolidation

(h) 2 = hybrid maize
4 = beans
12 = English potatoes
13 = Sweet potatoes
15 = Arrowroots
17 = tomatoes
18 = onions
20 = cabbages
43 = fodder grass
45 = bananas
50 = passion fruit
52 = fallow
FOR OTHER CROPS, USE THE CODES IN THE ENUMERATOR'S MANUAL

(i) 1 = crop residues
2 = bark
3 = thin twigs
4 = thick branches
5 = split wood
6 = makea
7 = other _____

(j) 1 = own farm
2 = bought from market
3 = bought from neighbors
4 = free from neighbors
5 = sawmill
6 = pitsawyers
7 = other _____

APPENDIX 3:
Area Measurement Calculations and Data Entry

This Appendix describes the algorithm, and the programme written in BASIC programming language, which was used to calculate plot and parcel areas from field measurements. The programme itself is somewhat disjointed because it was revised and rewritten during the course of the fieldwork to improve it and make it more efficient.

Area Measurement Algorithm and Programme Structure

The Area Measurement algorithm is derived from a standard textbook on surveying.[1] The technique basically involves breaking up a polygon, defined by the X and Y coordinates of each corner, into its constituent polygons, calculating the areas of each polygon, and then summing them up to get the total area.

Let Figure 1 represent a plot laid out on an X-Y axis with corners at ABCDE. The area of the plot is equal to the areas:

$$ABGF + GBCH - (AEJF + EDIJ + DCHI)$$

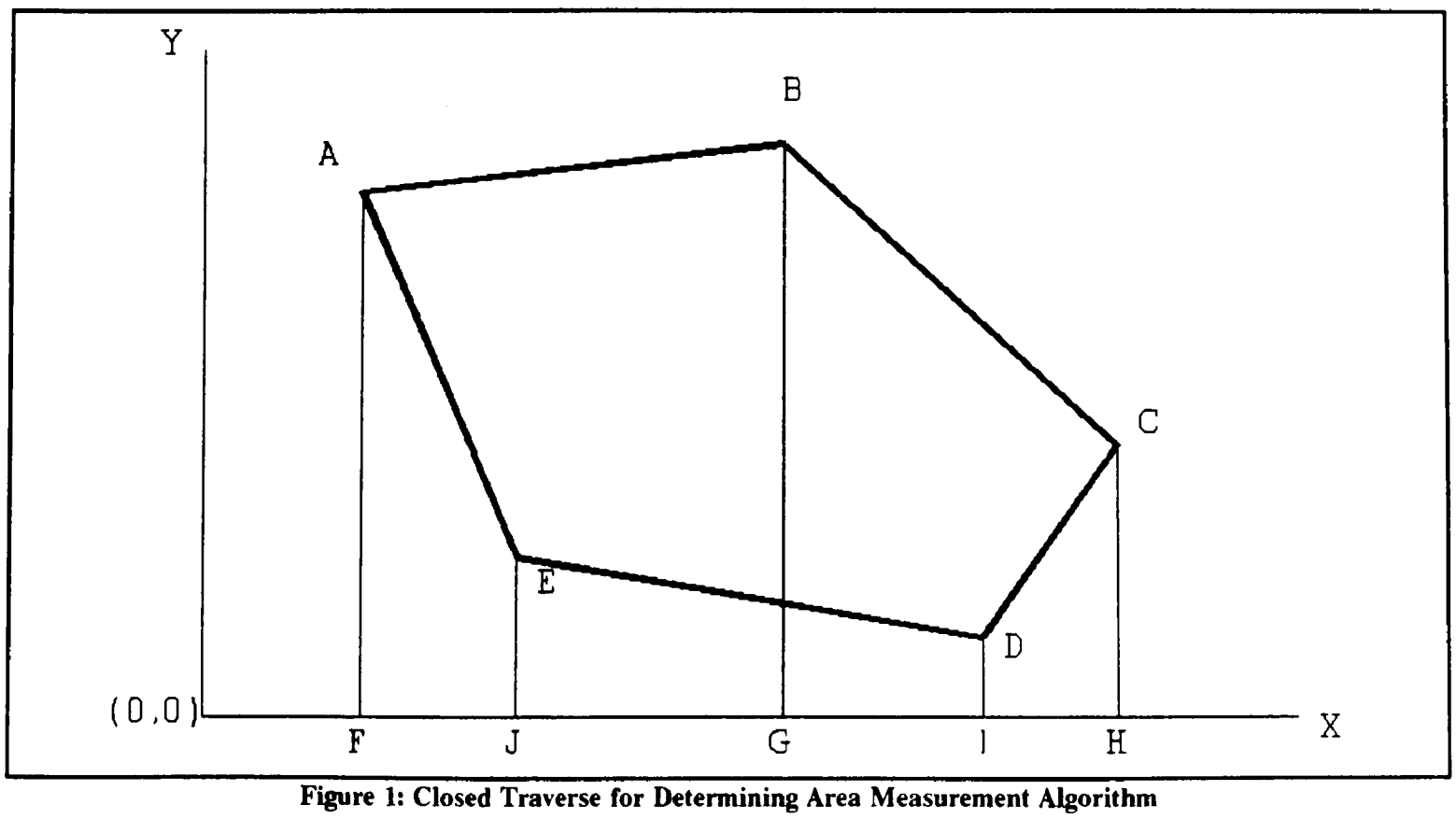


Figure 1: Closed Traverse for Determining Area Measurement Algorithm

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1. A.Bannister and S.Raymond (1984). *Surveying.* Harlow, Longman. pp.262-264.

If any corner, M, is represented by its coordinates (X_M, Y_M), then the area can be determined using the following equation:

$$\text{AREA} = \frac{(Y_A+Y_B)}{2} \times (X_G-X_F) + \frac{(Y_B+Y_C)}{2} \times (X_H-X_G)$$

$$- \frac{(Y_A+Y_E)}{2} \times (X_J-X_F) - \frac{(Y_E+Y_D)}{2} \times (X_I-X_J) - \frac{(Y_D+Y_C)}{2} \times (X_H-X_I)$$

$$= \tfrac{1}{2} [Y_AX_G - Y_AX_F + Y_BX_G - Y_BX_F + Y_BX_H - Y_BX_G + Y_CX_H - Y_CX_G$$

$$- Y_AX_J + Y_AX_F - Y_EX_J + Y_EX_F - Y_EX_I + Y_EX_J - Y_DX_I + Y_DX_J$$

$$- Y_DX_H + Y_DX_I - Y_CX_H + Y_CX_I]$$

Because $X_A=X_F$, $X_B=X_G$, $X_C=X_H$, $X_D=X_I$, and $X_E=X_J$, this equation can be rewritten:

$$\text{AREA} = \tfrac{1}{2} [Y_A(X_B-X_E) + Y_B(X_C-X_A) + Y_C(X_D-X_B) + Y_D(X_E-X_C) + Y_E(X_A-X_D)]$$

In general, then:

$$\text{AREA} = \tfrac{1}{2} \left[\sum_{i=1}^{n} Y_i(X_{i+1} - X_{i-1})\right]$$

If the figure is lettered counter-clockwise, the calculation will give a negative area -- a difficulty which is eliminated if the absolute value of the total is taken.

During the field survey, the compass bearing and the length of each side was recorded. In order for there to be consistency in the measurements, compass bearings were recorded either clockwise around the plot, or counter-clockwise. The data was logged on a laptop computer, areas were calculated, and remeasurements were undertaken if there were data problems.

In order to calculate field areas, the computer programme arbitrarily set the coordinates of the first corner of the field at (0,0). Using basic trigonometric relationships, the coordinates of subsequent corners were calculated. If the traverse had been recorded without errors, the first corner and the final corner could be expected to share the same coordinates (0,0) of the closed polygon. If there were errors in measurement, the polygon would be constructed as an open traverse, with a gap between the first corner and the final corner. If there were gross errors in

measurement, this gap could be quite large. If there were small errors, the area enclosed by the open traverse would closely approximate the true area. The criteria for accepting or rejecting the data depended on the size of the gap. The distance from the first corner to the final corner was calculated. If this distance (the "closing error") was less than 5 percent of the perimetre of the polygon, the measurements were deemed to be acceptable. (This criterion is generally used by the Central Bureau of Statistics for instance in its 1986 Agricultural Production Survey and in other surveys which required the collection of field measurements.) In order to close the polygon, the distance between the first and final corners was logged as the length of an additional -- and final -- side of the plot.

The programme was written to allow the user to accept or reject the measurements for any given plot. If the measurements are not acceptable, the user has the option of logging the coordinates to an ASCII file for graphically plotting them in order to determine if the errors are major ones which require remeasurement, or minor ones which could be rectified without remeasurement.

If the measurements are acceptable, the programme requests other information about the plot: the survey (or parcel) number, the plot number, the altitude of the parcel, whether or not the plot was marked on the aerial photograph, the slope of the plot, the current land-use, the land-use during the last short rains, and the land-use during the last long rains. The user is asked to verify all entries, and a final edit is allowed before the data is logged to an ASCII file.

The survey number, the plot number, and the coordinates for each corner of the plot are also logged to a separate file. This file could be imported into Lotus 1-2-3 and the data would be used to generate a graph of each plot. The routine for doing so is described below. Graphs were generated for every plot for

comparison against the aerial photographs and against the boundaries of each plot which had been marked on transparent overlays.

Finally, the programme includes a subroutine which allows the user to recall data which has been logged for any parcel or plot. The subroutine first requests the parcel number, and then generates a list of the plots for that parcel for which data has been entered. The user is requested to provide the number of the plot of interest. All the data which has been logged for that plot will be printed out. Data confirmation was routinely undertaken for every parcel, and the data was cross-checked against the data on the original Area Measurement Sheet for errors.

Documentation for the Area Measurement Programme

The Programme comprises four subroutines: the Area Measurement Subroutine, the Data Logging Subroutine, Coordinate Logging Subroutine, and the Data Confirmation Subroutine. Data about each plot is logged in ASCII formatted text to the file "AREA". Once that the (X,Y) coordinates of each plot are calculated, they are logged to the file "PLOT.PRN". A list of land-use codes and their definitions is recorded in the file "CROP".

VARIABLE LIST:

SIDES	NUMBER OF MEASURED SIDES OF A SAMPLE PLOT
DEG(I)	MAGNETIC BEARING OF SIDE A (IN DEGREES)
DIST(I)	MEASURED DISTANCE OF SIDE A (IN METRES)
X(I)	CALCULATED X-COORDINATE OF CORNER BETWEEN TWO SIDES
Y(I)	CALCULATED Y-COORDINATE OF CORNER BETWEEN TWO SIDES
XP(I)	VARIABLE USED IN AREA MEASUREMENT ALGORITHM
XM(I)	VARIABLE USED IN AREA MEASUREMENT ALGORITHM
SUM(I)	VARIABLE USED IN AREA MEASUREMENT ALGORITHM
PER	THE SUM OF THE MEASURED SIDES OF A PLOT (PERIMETRE)
DIFF	THE CALCULATED DISTANCE BETWEEN THE FIRST CORNER AND THE FINAL CORNER OF THE PLOT, IN METRES (FOR MEASUREMENTS THAT WERE WITHOUT ERRORS, THIS WOULD BE EQUAL TO ZERO)
CLOSERR	CLOSING ERROR (100*DIFF/PER)
ANSWER	SIZE OF THE PLOT, IN HA
SUR	SURVEY NUMBER
PLOT	PLOT NUMBER
ALTI	ALTITUDE OF THE PARCEL (METRES)
SLOPE	SLOPE (DEGREES)
NOW	CODE FOR LAND-USE OF PLOT AT THE TIME OF THE SURVEY
SHORT	CODE FOR LAND-USE OF PLOT DURING THE LAST SHORT RAINS
LONG	CODE FOR LAND-USE OF PLOT DURING THE LAST LONG RAINS

	BASIC Programming Code	Description of Programming Steps
	AREA MEASUREMENT SUBROUTINE	
60	PRINT:PRINT	Clears screen. Ready to accept data.
80	LET PI = 3.1415926535#	Defines value of Pi.
90	INPUT "HOW MANY SIDES TO THIS FIELD"; SIDES	Requests user to provide information about the number of sides to the plot.
100	DIM DEG(SIDES+1), DIST(SIDES+1), X(SIDES+2), Y(SIDES+2), XP(SIDES+2), XM(SIDES+2), SUM(SIDES+2)	Allocates memory for variables used in calculations according to the number of sides to the plot.
120	IF SIDES=999 THEN GOTO 1190	If user input is 999, branches to the Data Confirmation Subroutine to allow for an inquiry about a specific parcel or plot, for which data has already been entered.
150	FOR I=1 TO SIDES	
160	PRINT "WHAT IS THE ANGLE MEASURE OF SIDE";I	Requests the compass bearing of each side, in degrees.
170	INPUT DEG(I)	
180	PRINT "WHAT IS THE LENGTH OF SIDE";I	Requests the length of each side, in metres.
190	INPUT DIST(I)	
200	NEXT I	
230	FOR I=1 TO SIDES	
240	PRINT "SIDE";I;": ", DIST(I),"ANGLE";I;": ",DEG(I)	Prints to the screen the values which have been entered by the user, to allow for checking.
250	NEXT I	
280	PRINT	
290	X(1)=0	Sets the value of the first corner of the plot at (0,0).
300	Y(1)=0	
310	FOR I=2 TO SIDES	Calculates the (X,Y) coordinates of subsequent corners of the plot using the compass bearings and distances of each side.
320	LET X(I)=DIST(I-1)*SIN(DEG(I-1)*PI/180)+X(I-1)	
330	LET Y(I)=DIST(I-1)*COS(DEG(I-1)*PI/180)+Y(I-1)	
340	NEXT I	
350	LET DIFF=((X(SIDES+1))^2+(Y(SIDES+1))^2)^(.5)	Calculates the distance between the first corner of the plot at (0,0) and the final corner which, if there were no errors in measurement, would be at (0,0) as well.
360	FOR I=1 TO SIDES	Determines the length of the perimetre of the plot.
370	LET PER=DIST(I)+PER	
380	NEXT I	
390	LET CLOSERR=100*DIFF/PER	Calculates the closing error.
400	LET DIST(SIDES+1)=DIFF	Assigns the distance calculated in line 350 to the final side of the polygon.
420	PRINT "CLOSING ERROR IS"; CLOSERR; "PERCENT"	Prints the closing error to the screen to allow user to determine if measurements are within acceptable limits.
430	FOR I=1 TO SIDES+1	Area Measurement algorithm which determines the area by calculating the area of constituent polygons, and then by summing them up for the total area.
440	LET XP(I)=X(I+1)	
450	LET XM(I)=X(I-1)	
460	SUM(I)=Y(I)*(XP(I)-XM(I))	
470	ANSWER=ANSWER+SUM(I)	
480	NEXT I	
490	ANSWER=ABS(ANSWER/2/10000)	Converts area measurements into hectares.
500	PRINT "THE FIELD IS"; ANSWER;"HA IN SIZE.": PRINT:PRINT " I X(I) Y(I) DIST(I)" :PRINT " ----------" ----------	Prints the area of the plot to the screen.
510	FOR I=1 TO SIDES+1	
520	PRINT USING " ######.##";I;X(I);Y(I);DIST(I)	Prints the calculated (X,Y) coordinates for each corner and the distance of each side to the screen.
530	NEXT I	
540	PRINT	
550	PRINT	
560	INPUT "DO YOU WANT TO LOG THIS PLOT"; ANS$	Allows user to decide whether or not to log data about the plot to a data file.
570	IF ANS$="999" THEN GOTO 1190	Allows user to branch to Data Confirmation Subroutine to check data already entered about another plot.
580	IF ANS$="1" OR ANS$="Y" OR ANS$="y" OR ANS$="YES" OR ANS$="yes" THEN GOTO 620 ELSE GOTO 590	Branches to Data Logging Subroutine.
590	IF ANS$="0" OR ANS$="N" OR ANS$="n" OR ANS$="NO" OR ANS$="no" THEN GOTO 1010 ELSE GOTO 560	Branches to Coordinate Logging Subroutine, which logs only the (X,Y) coordinates of the plot, without other data.
600	PRINT " "	
610	PRINT " "	

DATA LOGGING SUBROUTINE

```
620  INPUT "WHAT IS THE SURVEY NUMBER? ", SUR
630  IF SUR<101 OR SUR>180 THEN GOTO 640 ELSE
     GOTO 650
640  IF SUR<201 OR SUR>280 THEN GOTO 620 ELSE
     GOTO 650
650  INPUT "WHAT IS THE ALTITUDE?", ALTI
660  INPUT "WHICH PLOT NUMBER IS THIS ONE? ",
     PLOT
670  INPUT "IS THIS THE PLOT WHICH IS MARKED ON
     THE AERIAL PHOTO?", ANS$
680  IF ANS$="1" OR ANS$="Y" OR ANS$="y" OR
     ANS$="YES" OR ANS$="yes" THEN GOTO 690
     ELSE GOTO 710
690  PHOTO=1
700  GOTO 720
710  IF ANS$="0" OR ANS$="N" OR ANS$="n" OR
     ANS$="NO" OR ANS$="no" THEN PHOTO=0 ELSE
     GOTO 670
720  INPUT "WHAT IS THE SLOPE? ", SLOPE
730  IF SLOPE>90 OR SLOPE<0
     THEN GOTO 720
740  INPUT "WHAT IS NOW ON THE PLOT? ", NOW
750  INPUT "WHAT WAS ON THIS PLOT DURING THE
     LAST SHORT RAINS?", SHORT
760  INPUT "WHAT WAS ON THIS PLOT DURING LAST
     YEAR'S LONG RAINS? LONG
770  PRINT
780  PRINT "SURVEY NUMBER :  ";SUR
790  PRINT "THIS PLOT NUMBER:";PLOT
800  PRINT "ALTITUDE :       ";ALTI
810  PRINT "SLOPE :          ";SLOPE
820  PRINT "AERIAL PHOTO :   ";PHOTO
830  PRINT
840  PRINT "FIELD SIZE (HA): ";ANSWER
850  PRINT "CLOSING ERROR:   ";CLOSERR
860  PRINT
870  PRINT "ON PLOT NOW:     ";NOW
880  PRINT "LAST SHORT RAINS:";SHORT
890  PRINT "LAST LONG RAINS: ";LONG
900  PRINT
910  INPUT "DO YOU WANT TO EDIT ANY OF THESE?";
     ANS$
920  IF ANS$="1" OR ANS$="Y" OR ANS$="y" OR
     ANS$="YES" OR ANS$="yes" THEN GOTO 620
930  IF ANS$="0" OR ANS$="N" OR ANS$="n" OR
     ANS$="NO" OR ANS$="no" THEN GOTO 940 ELSE
     GOTO 910
940  INPUT "DO YOU WANT TO LOG THIS DATA TO A
     FILE?"; ANS$
950  IF ANS$="1" OR ANS$="Y" OR ANS$="y" OR
     ANS$="YES" OR ANS$="yes" THEN GOTO 970
960  IF ANS$="0" OR ANS$="N" OR ANS$="n" OR
     ANS$="NO" OR ANS$="no" THEN GOTO 1070 ELSE
     GOTO 940
970  OPEN "AREA" FOR APPEND AS 1
980  PRINT#1, USING "####.##,";SUR, PLOT, PHOTO,
     ANSWER, CLOSERR, ALTI, SLOPE, NOW, SHORT,
     LONG
990  CLOSE #1
1000 GOTO 1090
```

Requests information about the plot for data logging.
Checks these entries for errors.

Requests altitude (metres)
Requests the number of the plot within the parcel.

Requests whether or not the plot in question was the one marked on the aerial photograph.

Requests the slope of the measured plot, in degrees. Checks that slope falls within acceptable range.

Requests code for current land-use.
Requests code for land-use during the last short rains.

Requests code for land-use during the last long rains.

Prints to the screen all the data which has been calculated and entered by the user for this plot for checking by the user before logging data to a file.

Allows the user to check and recode any of the data which has been input, or to reject the data altogether.
Branches to beginning of Data Logging Subroutine to allow user to re-enter any data.

If there are no corrections to be made, allows the user to decide whether or not to log the data, or to reject it altogether.

Opens file called "AREA" for data logging.
Logs all data about the plot to the file "AREA" and then closes the file.

Branches to Coordinate-Logging Subroutine.

COORDINATE LOGGING SUBROUTINE

```
1010 INPUT "DO YOU WANT TO LOG THIS DATA FOR
     PLOTTING"; ANS$
1020 IF ANS$="1" OR ANS$="Y" OR ANS$="y" OR
     ANS$="YES" OR ANS$="yes" THEN GOTO 1030 ELSE
     GOTO 1060
1030 INPUT "WHAT IS THE SURVEY NUMBER"; SUR
1040 INPUT "WHAT IS THE PLOT NUMBER"; PLOT
1050 GOTO 1090
1060 IF ANS$="0" OR ANS$="N" OR ANS$="n" OR
     ANS$="NO" OR ANS$="no" THEN GOTO 1070 ELSE
     GOTO 1010
1070 CLEAR
1080 GOTO 10
1090 OPEN "PLOT.PRN" FOR APPEND AS 2
1100 PRINT#2, SUR, PLOT
```

If the area measurements are unacceptable, allows the user to log the coordinates of the plot for error checking without logging other data about the plot.

Records survey number and plot number.

If user doesn't want to log any of the data, closes all files and clears memory. Branches to the beginning of the Area Measurement Subroutine.

Opens file "PLOT.PRN" to record the survey number, plot number and the (X,Y) coordinates of the measured plot to allow for

```
1110  FOR I=1 TO (SIDES+1)
1120  PRINT#2, USING "####.##";X(I),Y(I)
1130  NEXT I
1140  PRINT #2, ""
1150  CLOSE #2
1160  CLEAR
1170  GOTO 10
```

graphing.
Records coordinates to file.

Closes files. Clears memory. Branches to the beginning of the programme for new input.

DATA CONFIRMATION SUBROUTINE

```
1180  PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:
      PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:
      PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:
      PRINT:PRINT:PRINT
1190  INPUT "WHICH SURVEY NUMBER DO YOU WANT
      TO KNOW ABOUT"; SURVEY
1200  PRINT "INFORMATION HAS BEEN LOGGED FOR
      THE FOLLOWING PLOTS ON PARCEL"; SURVEY
1210  OPEN "I", #1, "AREA"
1220  INPUT #1, X
1230  IF EOF(1) THEN GOTO 1260
1240  IF X=SURVEY THEN GOTO 1250 ELSE GOTO 1220
1250  INPUT #1, X:PRINT: "PLOT";X:GOTO 1220
1260  PRINT:PRINT:CLOSE #1:INPUT "WHICH PLOT ARE
      YOU INTERESTED IN";PLOT:PRINT
1270  PRINT
1280  OPEN "I", #1, "AREA"
1290  INPUT #1, X
1300  IF EOF(1) THEN GOTO 1520
1310  IF X=SURVEY THEN GOTO 1320
      ELSE GOTO 1290
1320  INPUT #1, Y
1330  IF Y=PLOT THEN GOTO 1340 ELSE GOTO 1290
1340  INPUT #1, PHOTO, AREA, CERROR, ALT, SLOPE,
      NOW, SRAIN, LRAIN
1350  IF PHOTO=0 THEN PRINT "PARCEL";
      SURVEY;"PLOT";PLOT;"WAS MARKED ON THE
      AERIAL PHOTOGRAPH."
1360  PRINT "AREA :";AREA;"HA. CLOSING
      ERROR:";CERROR;"%"
1370  PRINT "ALTITUDE:";ALT;"METRES":
      PRINT "SLOPE :";SLOPE;"DEGS"
1380  OPEN "I", #2, "CROPS"
1390  INPUT #2. CODE, CROP$
1400  IF EOF(2) THEN GOTO 1410 ELSE GOTO 1460
1410  CLOSE #2
1420  PRINT:PRINT:PRINT:INPUT "CHECK ANOTHER
      PLOT? (NUMBER IF YES, 99 IF NO);PLOT
1430  PRINT:PRINT
1440  IF PLOT=99 THEN GOTO 1520
      ELSE CLOSE #1:GOTO 1280
1450  GOTO 1520
1460  IF CODE=NOW THEN PRINT "ON PLOT NOW :
      "CROP$
      ELSE GOTO 1470
1470  IF CODE=SRAIN THEN PRINT "SHORT RAINS :
      ";CROP$
      ELSE GOTO 1480
1480  IF CODE=LRAIN THEN PRINT "LONG RAINS :
      ";CROP$
1490  GOTO 1390
1500  CLOSE #2
1510  GOTO 1420
1520  CLOSE #1
1530  END
```

Clears screen for new subroutine.

Subroutine allows the user to make a query about data which has already been entered for a parcel or a particular plot within the parcel.
Prints the parcel number to the screen and lists all the plots for which data has been logged.

Requests the user to provide the plot number for the plot and parcel in question.

Subroutine calls up "AREA" file and prints to the printer all the information which has been logged in that file for each parcel and plot. A catalogue of land-use codes is recorded in the file called "CROPS" and the subroutine converts the code into the named land-use.

Prints whether the plot was marked in the aerial photograph.

Prints area and closing error of the plot.

Prints altitude of the parcel.
Prints slope of the plot.
Checks in the file "CROPS" for the land-use codes in the "AREA" file.

Allows user to check multiple plots for the parcel in question.

Either ends sub-routine, or branches to beginning of sub-routine to check another plot.

Checks land-use codes against the codes recorded in the file "CROPS", and prints land-use for each code, as recorded.

Crop and Land-Use Codes and Definitions

The following crop codes were recorded in the file "CROP". The file was used by the Data Confirmation subroutine to generate a hard copy of the entered data, using words instead of codes so that entered data could be checked against the original data.

Crop Code	Definition
1	LOCAL MAIZE
2	HYBRID MAIZE
3	YELLOW MAIZE
4	BEANS
5	MILLET
6	SORGHUM
7	GRAMS
8	COW PEAS
9	PIGEON PEAS
10	FIELD PEAS
11	DOLICHOS LABLAB
12	ENGLISH POTATOES
13	SWEET POTATOES
14	CASSAVA
15	ARROWROOT
16	YAMS
17	TOMATOES
18	ONIONS
19	CARROTS
20	CABBAGES
21	PUMPKINS
22	OTHER VEGETABLES (NON-HORTICULTURAL)
23	COFFEE
24	TEA
25	PYRETHRUM
26	SISAL
27	PINEAPPLE
28	SUGARCANE
29	COTTON
30	GROUND NUTS
31	SIM SIM
32	CASTOR
33	TOBACCO
34	SUNFLOWER
35	CHILIES
36	FRENCH BEANS
37	OTHER HORTICULTURE
38	WATTLE
62	WATTLE WOODLOT AND PASTURE
100	WATTLE TREES, PASTURE, BANANAS AND FISHPONDS
101	WATTLE, BANANAS AND ARROWROOT
39	EUCALYPTUS WOODLOT
40	GREVILLEA WOODLOT
98	CYPRESS WOODLOT
41	BUSH, WOODLAND, OR FOREST
42	MULCH GRASS
43	FODDER GRASS
44	PASTURE
45	BANANAS
46	ORANGES
47	MANGOES
48	LEMONS
49	PAW PAW
50	PASSION FRUIT
97	PASSION FRUIT AND YAMS

Crop Code	Definition
51	MACADAMIA NUTS
52	FALLOW
53	HOUSE COMPOUND
86	MAIZE AND BEANS
109	MAIZE, BEANS, BANANAS AND FODDER GRASS
55	MAIZE AND ENGLISH POTATOES
73	MAIZE, ENGLISH POTATOES AND BEANS
59	MAIZE, ENGLISH POTATOES AND SWEET POTATOES
64	MAIZE, ENGLISH POTATOES, SWEET POTATOES AND BANANAS
58	MAIZE, ENGLISH POTATOES AND BANANAS
68	MAIZE, ENGLISH POTATOES AND FODDER GRASS
66	MAIZE AND SWEET POTATOES
74	MAIZE, SWEET POTATOES AND CABBAGES
65	MAIZE, SWEET POTATOES AND BANANAS
112	MAIZE, SWEET POTATOES, BANANAS AND FODDER GRASS
69	MAIZE, SWEET POTATOES, AND FODDER GRASS
87	MAIZE, SWEET POTATOES AND FALLOW
78	MAIZE AND BANANAS
83	MAIZE, BANANAS AND AVOCADOES
111	MAIZE, BANANAS AND CABBAGES
108	MAIZE, BANANAS, ARROWROOT AND FODDER GRASS
72	MAIZE, BANANAS AND FODDER GRASS
57	MAIZE AND SUGARCANE
61	MAIZE AND ARROWROOT
105	MAIZE AND YAMS
75	MAIZE AND CABBAGES
56	MAIZE AND FODDER GRASS
85	MAIZE AND FALLOW
81	SWEET POTATOES, ENGLISH POTATOES AND VEGETABLES
84	SWEET POTATOES AND BANANAS
63	SWEET POTATOES, BANANAS AND YAMS
110	SWEET POTATOES, BANANAS AND AVOCADOES
76	SWEET POTATOES, BANANAS AND FODDER GRASS
96	SWEET POTATOES, BANANAS AND FALLOW
67	SWEET POTATOES AND ARROWROOT
106	SWEET POTATOES, ARROWROOT, SUGARCANE AND FODDER GRASS
104	SWEET POTATOES, FODDER GRASS AND FALLOW
82	SWEET POTATOES AND FODDER GRASS
80	SWEET POTATOES AND FALLOW
88	BANANAS AND SUKUMA WIKI
92	BANANAS, CASSAVA AND FALLOW
89	BANANAS AND YAMS
70	BANANAS, YAMS AND SUGAR CANE
91	BANANAS, YAMS AND FODDER GRASS

99	BANANAS, YAMS, PASSION FRUIT, AVOCADOS AND MACADAMIA NUTS
95	BANANAS AND ARROWROOT
113	BANANAS, ARROWROOT AND TOMATOES
90	BANANAS, ARROWROOT AND SUGAR CANE
94	BANANAS, ARROWROOT AND FODDER GRASS
103	BANANAS, FODDER GRASS AND FALLOW
77	BANANAS AND FODDER GRASS
93	BANANAS AND FALLOW
79	FODDER GRASS AND ARROWROOT
107	FODDER GRASS, ARROWROOT AND SUGARCANE
102	FODDER GRASS, ARROWROOT AND FALLOW
60	FODDER GRASS AND PASTURE
71	FODDER GRASS AND FALLOW

Area Measurement Data Entry and Checking: Sample Run

To show how this set of programmes was used in practice, the raw area measurement data has been reproduced in Figure 2, and a printout of a sample data entry and confirmation run has been generated. Output and input is for Parcel 112, Plot 1. User entries have been underlined.

AREA MEASUREMENT SHEET
Measure the full parcel which appears in the photograph. Then measure each plot within that parcel.

CONFIDENTIAL
Survey Number 112
Date 6/3/98
Enumerator CMG2

This is sheet number 1 of 1 sheets.

1900

PARCEL/PLOT NO. 1	Slope (in °)	A–B F.B.	A–B METRES	B–C F.B.	B–C METRES	C–D F.B.	C–D METRES	D–E F.B.	D–E METRES	E–F F.B.	E–F METRES	F–G F.B.	F–G METRES	G–H F.B.	G–H METRES	H–I F.B.	H–I METRES	What is on the plot now?	What was planted on this plot during the last short rains?	What was planted on this plot during the last year's long rains?
CHECK BLACK NATTLE	19°	033	112	341	043	265	096	175	023	210	085	125	052	094	043			BW	BW	BW
		D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.			
		213		171		85		355		30		345		274						

PARCEL/PLOT NO 2	Slope (in °)	A–B F.B.	A–B METRES	B–C F.B.	B–C METRES	C–D F.B.	C–D METRES	D–E F.B.	D–E METRES	E–F F.B.	E–F METRES	F–G F.B.	F–G METRES	G–H F.B.	G–H METRES	H–I F.B.	H–I METRES	What is on the plot now?	What was planted on this plot during the last short rains?	What was planted on this plot during the last year's long rains?
FALLOW	8°	233	045	528	012	244	013	435	040	070	082	150	033					F	M	M
		D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.			
		53		148		60		145		250		370								

PARCEL/PLOT NO 3	Slope (in °)	A–B F.B.	A–B METRES	B–C F.B.	B–C METRES	C–D F.B.	C–D METRES	D–E F.B.	D–E METRES	E–F F.B.	E–F METRES	F–G F.B.	F–G METRES	G–H F.B.	G–H METRES	H–I F.B.	H–I METRES	What is on the plot now?	What was planted on this plot during the last short rains?	What was planted on this plot during the last year's long rains?
HOMESTEAD	5°	035	012	321	018	215	020	116	018									—	—	—
		D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.			
		215		141		35		296												

PARCEL/PLOT NO 4	Slope (in °)	A–B F.B.	A–B METRES	B–C F.B.	B–C METRES	C–D F.B.	C–D METRES	D–E F.B.	D–E METRES	E–F F.B.	E–F METRES	F–G F.B.	F–G METRES	G–H F.B.	G–H METRES	H–I F.B.	H–I METRES	What is on the plot now?	What was planted on this plot during the last short rains?	What was planted on this plot during the last year's long rains?
BANANAS NAPPIER GRASS	5°	036	143	0	026	205	029	094	024									B NG	B NG	B NG
		D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.			
		216		130		23		274												

PARCEL/PLOT NO	Slope (in °)	A–B F.B.	A–B METRES	B–C F.B.	B–C METRES	C–D F.B.	C–D METRES	D–E F.B.	D–E METRES	E–F F.B.	E–F METRES	F–G F.B.	F–G METRES	G–H F.B.	G–H METRES	H–I F.B.	H–I METRES	What is on the plot now?	What was planted on this plot during the last short rains?	What was planted on this plot during the last year's long rains?
		D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.	D.B.	DIFF.			

Figure 2: Area Measurement Sheet, Parcel 112

AREA MEASUREMENT SUBROUTINE

Programme Output and Input	Explanation
HOW MANY SIDES TO THIS FIELD? 7 WHAT IS THE ANGLE MEASURE OF SIDE 1 ? 33 WHAT IS THE LENGTH OF SIDE 1 ? 112 WHAT IS THE ANGLE MEASURE OF SIDE 2 ? 341 WHAT IS THE LENGTH OF SIDE 2 ? 43 WHAT IS THE ANGLE MEASURE OF SIDE 3 ? 265 WHAT IS THE LENGTH OF SIDE 3 ? 96 WHAT IS THE ANGLE MEASURE OF SIDE 4 ? 175 WHAT IS THE LENGTH OF SIDE 4 ? 23 WHAT IS THE ANGLE MEASURE OF SIDE 5 ? 210 WHAT IS THE LENGTH OF SIDE 5 ? 85 WHAT IS THE ANGLE MEASURE OF SIDE 6 ? 125 WHAT IS THE LENGTH OF SIDE 6 ? 52 WHAT IS THE ANGLE MEASURE OF SIDE 7 ? 94 WHAT IS THE LENGTH OF SIDE 7 ? 43	Data is entered sequentially from the Area Measurement Sheet.
SIDE 1 : 112 ANGLE 1 : 33 SIDE 2 : 43 ANGLE 1 : 341 SIDE 3 : 96 ANGLE 1 : 265 SIDE 4 : 23 ANGLE 1 : 175 SIDE 5 : 85 ANGLE 1 : 210 SIDE 6 : 52 ANGLE 1 : 125 SIDE 7 : 43 ANGLE 1 : 94	The entered data is printed out to allow the user to check for data entry errors.
CLOSING ERROR IS 1.057034 PERCENT THE FIELD IS 1.324808 HA IN SIZE.	Closing error is calculated. The area of the plot is calculated.

I	X(I)	Y(I)	DIST(I)
1.00	0.00	0.00	112.00
2.00	61.00	93.93	43.00
3.00	47.00	134.59	96.00
4.00	-48.63	126.22	23.00
5.00	-46.63	103.31	85.00
6.00	-89.13	29.70	52.00
7.00	-46.53	-0.13	43.00
8.00	-3.64	-3.13	4.80

The X and Y coordinates of each corner of the plot are calculated and printed out. The distance of each side is included in the printout. Corner 8 is the final corner. The distance between this point and (0,0) is used to determine the closing error. The distance is logged as Side 8.

DO YOU WANT TO LOG THIS PLOT? YES	Requests user confirmation to continue with data entry, if closing error is within acceptable limits.
WHAT IS THE SURVEY NUMBER? 112 WHAT IS THE ALTITUDE? 1900 WHICH PLOT NUMBER IS THIS ONE? 1 IS THIS THE PLOT WHICH IS MARKED ON THE AERIAL PHOTO? YES WHAT IS THE SLOPE? 19 WHAT IS NOW ON THE PLOT? 38 WHAT WAS ON THIS PLOT DURING THE LAST SHORT RAINS? 38 WHAT WAS ON THIS PLOT DURING LAST YEAR'S LONG RAINS? 38	Requests user to provide all other information about the plot which was collected by the enumerator. Crop code, 38, is for black wattle.
SURVEY NUMBER : 112 THIS PLOT NUMBER: 1 ALTITUDE : 1900 SLOPE : 19 AERIAL PHOTO : 1 FIELD SIZE (HA): 1.324808 CLOSING ERROR: 1.057034 ON PLOT NOW: 38 LAST SHORT RAINS: 38	Prints out all the information which has been entered for the plot to allow the user to edit any entries before the data is logged.

LAST LONG RAINS: 38

DO YOU WANT TO EDIT ANY OF THESE? NO
DO YOU WANT TO LOG THIS DATA TO A FILE? YES

Requests confirmation from the user before logging the data. Data is logged to the file "AREA". X-Y coordinates are logged to the file "PLOT.PRN".

HOW MANY SIDES TO THIS FIELD? .....

Loops to the beginning of the subroutine for data entry for the next plot.

DATA CONFIRMATION ROUTINE

Programme Output and Input	Explanation
WHICH SURVEY DO YOU WANT TO KNOW ABOUT? 112 INFORMATION HAS BEEN LOGGED FOR THE FOLLOWING PLOTS ON PARCEL 112 PLOT 1 PLOT 2 PLOT 3 PLOT 4	Requests user to provide survey number for parcel and plot data which has already been entered. Generates a list of the plots for which data has been entered.
WHICH PLOT ARE YOU INTERESTED IN? 1	Requests the plot number.
PARCEL 112 PLOT 1 WAS MARKED ON THE AERIAL PHOTOGRAPH AREA : 1.32 HA. CLOSING ERROR : 1.06 PERCENT ALTITUDE : 1900 METRES SLOPE: 19 DEGREES ON PLOT NOW : WATTLE SHORT RAINS : WATTLE LONG RAINS : WATTLE	Generates a table of all the data which has been entered for that particular plot.
CHECK ANOTHER PLOT? (NUMBER IF YES, 99 IF NO) 2	Allows user to request information about multiple plots within the parcel. Typically, data would be printed out for every plot within a parcel to allow for checking.
PARCEL 112 PLOT 2 AREA : .3 HA. CLOSING ERROR : .82 PERCENT ALTITUDE : 1900 METRES SLOPE : 8 DEGREES ON PLOT NOW : HYBRID MAIZE SHORT RAINS : HYBRID MAIZE LONG RAINS : FALLOW	
CHECK ANOTHER PLOT? (NUMBER IF YES, 99 IF NO) 3	
PARCEL 112 PLOT 3 AREA : .03 HA. CLOSING ERROR : .77 PERCENT ALTITUDE : 1900 METRES SLOPE : 5 DEGREES ON PLOT NOW : HOUSE COMPOUND SHORT RAINS : HOUSE COMPOUND LONG RAINS : HOUSE COMPOUND	
CHECK ANOTHER PLOT? (NUMBER IF YES, 99 IF NO) 4	
PARCEL 112 PLOT 4 AREA : .05 HA. CLOSING ERROR : .09 PERCENT ALTITUDE : 1900 METRES SLOPE : 5 DEGREES ON PLOT NOW : BANANAS AND FODDER GRASS SHORT RAINS : BANANAS AND FODDER GRASS LONG RAINS : BANANAS AND FODDER GRASS	

Documentation for the Graphing Macro
Written in Lotus 1-2-3 Command Language

This routine was written to import the X-Y coordinates of each plot calculated in the BASIC programme described above and logged in the file "PLOT.PRN", and to generate a graph showing the location of the corners of each plot. Each graph is stored in a Lotus-formatted "*.PIC" file, where * is in the format, Parcel#_Plot#, for instance, 167_1.PIC.

Raw data is logged in the PLOT.PRN file in the following format. The first row comprises the parcel number and the plot number. Subsequent rows contain paired X and Y coordinates for each of the corners of the plot. There is no limit imposed by the macro to the number of corners that can be graphed for each plot. Subsequent data sets follow each other in the same format, separated by a blank line.

Data is imported to the spreadsheet using the macro \Z, defined below. The cursor should be positioned at any empty point of the spreadsheet, allowing for 8 columns of input, and an unlimited number of rows. If new data is being imported into an empty spreadsheet and if these macros are to be used for the first time, range names M and N have to be defined first. The location and content of these ranges is irrelevant.

Cell C13 has to be defined as range O and Cell C15 has to be defined as range P. Cells A1 through A26 should contain the sequential, capitalized letters of the alphabet, and this range should be named "LETTERS." The macro used to import the raw data has been named \Z, and Cell H15 was named and used for this purpose. The macro which carries out the graphing routine has been named \T, and Cell C1 was named and used for this purpose. The macro should be invoked only on the first cell of the first line of the data set concerned, which should contain the parcel number. Once the macro has worked its way through this

data set, it will begin work on the next data set. If there is no more data, the macro will stop and a series of tones will be generated.

LOTUS 1-2-3 MACRO CELLS AND STEPS

Cell Number	MACRO keys	Description of macro steps.
H15:	'/FIN{ESC}{ESC}C:\PLOT.PRN~	This range is named as the macro \Z. It imports the ASCII file called "PLOT.PRN" created by the Area Measurement Programme which contains the number of each parcel and plot and the XY coordinates of each of the corners of the plot, calculated from the Area Measurement data collected by the enumerators.
C1:	'{WINDOWSOFF}{PANELOFF}/RNDM~/RNCM ~~{R}/RNDN~/RNCN~~	This range is named as the macro \T and is the beginning of the plotting routine. The macro is invoked at the first cell of the first line of data. It deletes range names M and N and relabels this cell as M and the cell to the right as N. M contains the parcel number and N contains the plot number, as imported from "PLOT.PRN." If the macro is being invoked for the first time, an error message will be encountered unless the user has created the M and N range names previously. What and where these ranges are is irrelevant.
C2:	'{IF@N(M)=0}{BEEP 1}{BEEP 2}{BEEP 3} {BEEP 4}{BEEP 1}{BEEP 2}{BEEP 3}{BEEP 4} {BEEP 1}{BEEP 2}{BEEP 3}{BEEP 4} {L}{QUIT}	This line checks the contents of the cell which has been labelled M. If the cell is empty or if there is a label in the cell instead of a number, a series of tones is generated and the macro ends.
C3:	'{EDIT}{HOME}"~{L}{EDIT}&"/"&N{HOME}+ "{R 3}"~{EDIT}{CALC}{HOME}"~	These lines convert the parcel and plot number to a label in the M cell to the form "Parcel#/Plot#". The label is used as the title for each plot which is graphed. The parcel and plot number is converted to a label in the N cell of the form "Parcel#_Plot#". This label is used to name the file which will store the graphing data for the Lotus Printgraph programme.
C4:	'/C~N~{R}{EDIT}{L 2}{DEL}_~{L}	
C5:	'{D}{R 2}@MAX({L 2}.{END}{D})~{D}@MIN ({U}{L 2}.{END}{D})~{D}+((@ABS({U 2} -{U}))/2)+{U}~{END}{U}/C.{END}{D}~{R}~	Establishes the maximum and minimum X and Y values to enable scaling of a non-transposed graph. Calculates the X and Y offsets so that the graph can be transposed. Without being transposed, the first corner would always be at (0,0). With transposition, (0,0) is at the centre of the plot.
C6:	'{R 2}+{L 4}-{L 2}{END}{D}{ABS 2}~	Transposes all X and Y coordinates by the offset determined in line C5. Determines maximum and minimum values of the offset coordinates for scaling, and names the maximum value range A. Returns cursor to the top of the X coordinates.
C7:	'/C~.{L 4}{END}{D}{R 5}~	
C8:	'{U}{END}{L 2}/C.{R}~{R 4}~{R 4}	
C9:	'{R 2}{D}@MAX({L}.{L}{END}{D})~{R} @MIN({L 3}.{R}{END}{D})~	
C10:	'{D}{L}@ABS({U})~/C~{R}~{D}@MAX({U}. {R})~/RNDA~/RNCA~~	
C11:	'{END}{U}{L 2}	
C12:	'/GRGTXX.{END}{D}~A{R}.{END}{D}~	Defines graph type to an X-Y graph. Enters X data in the X graph range and Y data in the A graph range.
	OSXML-A~U+A~QSYML-A~U+A~Q	Manually sets the maximum and minimum values of the graph, using the maximum scaling values determined from the transposed data and labeled as range A.
	FGSQdaLETTERS~AQQQ{PANELON} {WINDOWSON}	Formats data points to appear as symbols without lines. Assigns letter labels to each corner of the plot, starting with A for the first corner, B for the second, and so on. Letters for the labels are in cells A1 to A26 which has the range name of LETTERS.
	{GOTO}O~+"/GOTF"&M{CALC}{HOME}"~	Edits cell C13 of the macro, which has been labeled as range O. The cell is editted so that the label entered in range M (in the format Parcel#/Plot#) is used as the title of the graph.
C13:	"/GOTF161/7	Creates a title for the graph, using the parcel and plot number recorded in range M. In this case, the graph was titled "161/7," referring to Plot 7 of Parcel 167.
C14:	"~QQ{GOTO}P~+"/GS"&N{CALC}{HOME}"~	Edits cell C15 of the macro, which has been labeled as range P. The cell is editted so that the label entered in range N in the format Parcel#_Plot# is used as the name of the name of the file which be used to store the graphing data for the Lotus Printgraph programme.

C15:	"/GS161_7	Saves the graph in a file named after the parcel and plot numbers, in this case, a file named "167_7". If this file name already exists, an error message is generated and the macro aborts.
C16:	"~VQ{GOTO}M~	Shows the graph on the screen, and then returns the cursor to the first cell in this data set, labelled as range M.
C17:	'{END}{D 3}/XG\T~	Moves the cursor to the beginning of the next data set. Starts the macro over again.

A1:	'A	A14:	'N
A2:	'B	A15:	'O
A3:	'C	A16:	'P
A4:	'D	A17:	'Q
A5:	'E	A18:	'R
A6:	'F	A19:	'S
A7:	'G	A20:	'T
A8:	'H	A21:	'U
A9:	'I	A22:	'V
A10:	'J	A23:	'W
A11:	'K	A24:	'X
A12:	'L	A25:	'Y
A13:	'M	A26:	'Z

Cells A1 to A26 contain the letters of the alphabet. The range is named LETTERS and is used for labelling the points of the corners on the graph.

Output from the Graphing Macro

Output from the graphing macro in Lotus 1-2-3 is stored in a *.PIC file. The Lotus Printgraph programme was used to produce hard copies of these files, and the hard copies were compared against the plot's actual boundaries which had been sketched to scale using transparent overlays and the aerial photographs. If the sketch was a reasonable facsimile of the computer generated plot, the area measurements were accepted as valid. If there were significant discrepancies, enumerators were asked to remeasure the plots in question. Figure 3 shows the hard-copy output of parcel 112, plot 1 produced by the Printgraph programme. Figure 4 shows the sketch made using the overlay and the aerial photograph.

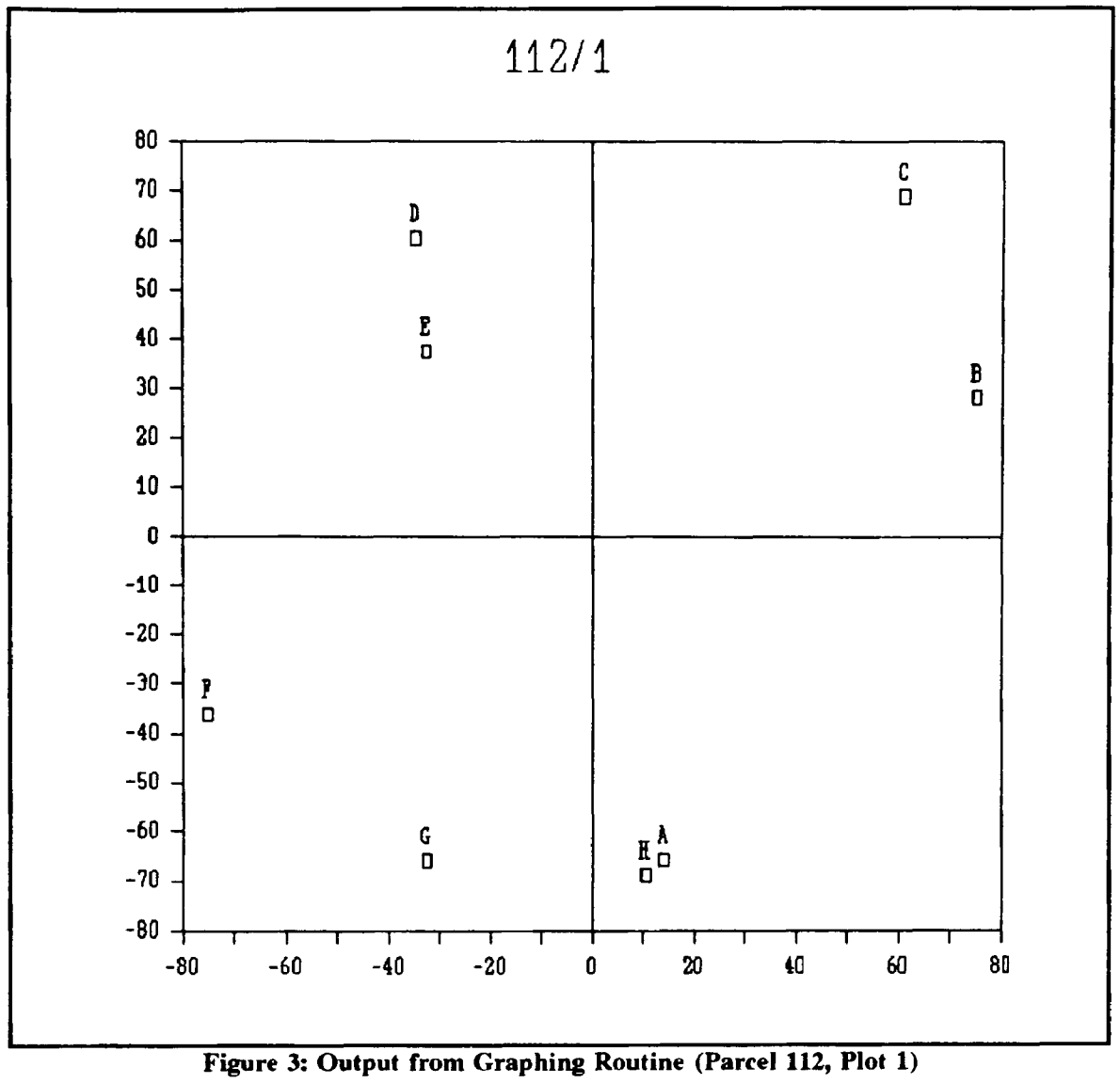


Figure 3: Output from Graphing Routine (Parcel 112, Plot 1)

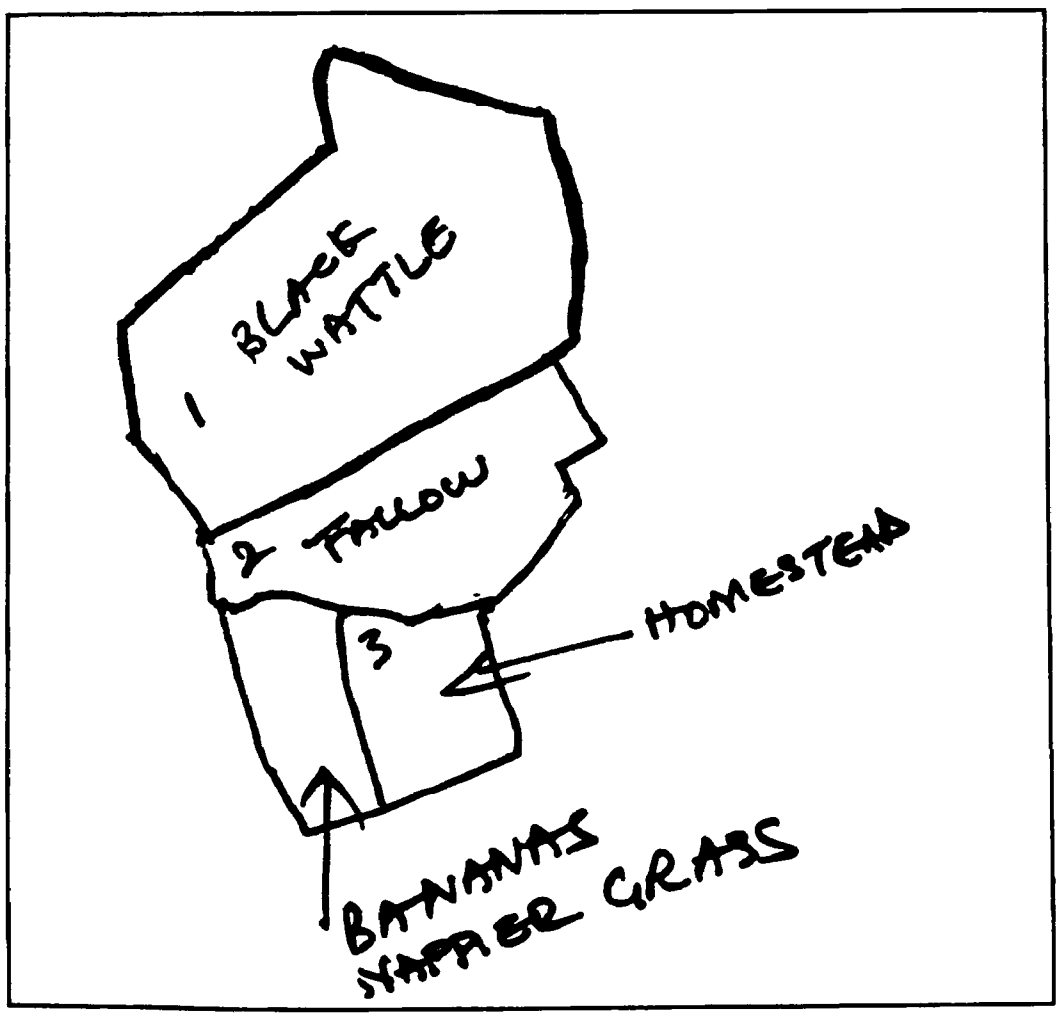


Figure 4: Sketch Made Using Aerial Photograph and Transparent Overlay (Parcel 112)

APPENDIX 4:
Grouping of Land-uses into Different Land-use Categories

Land-uses on each plot within sampled parcels were noted and recorded at the time of the interview. Every different crop combination was recorded as a unique land-use. A total of 74 different crop combinations and land-uses were recorded. The clustering of land-uses into more general categories was undertaken to make the analysis somewhat less cumbersome. The aggregation of land-uses into 8 land-use categories was based on the predominance of particular crops within that category. For instance, a plot used for growing maize, bananas and cabbages (thus being used for 2 annual food crops, and 1 perennial food crop) would be placed in the category "Annual Food Crops (Intercropped)" because there are more annual than perennial, intercropped, food crops. The huge diversity of intercropping strategies was most impressive. This Appendix lists the crop combinations and land-uses which were grouped into the eight primary land-use categories. These categories were,

	GENERAL LAND-USE CATEGORIES
1	MONOCROPPED ANNUAL AND PERENNIAL FOOD CROPS
2	ANNUAL FOOD CROPS (INTERCROPPED)
3	PERENNIAL FOOD CROPS (INTERCROPPED) AND MINOR PERENNIAL CASH CROPS
4	PASTURE AND FODDER CROPS
5	SMALLHOLDER COFFEE
6	SMALLHOLDER TEA
7	WATTLE OR WATTLE/PASTURE
8	HOUSEHOLD COMPOUND, FALLOW, OR OTHER UNCULTIVATED LAND

LAND-USE CATEGORY	*NUMBERS OF CROP AND LAND-USE COMBINATIONS*						
		PERENNIALS					
1. MONOCROPPED ANNUAL AND PERENNIAL FOOD CROPS	ANNUAL FOOD CROPS	FOOD CROP	CASH CROP	FODDER OR PASTURE	PLANTED TREES	FALLOW	OTHER UNCULTIVATED
ARROWROOTS		1					
ENGLISH POTATOES		1					
HYBRID MAIZE	1						
OTHER VEGETABLES (NON-HORTICULTURAL)	1						
PASSION FRUIT		1					
SWEET POTATOES		1					
2. ANNUAL FOOD CROPS (INTERCROPPED)							
BANANAS AND SUKUMA WIKI	1	1					
MAIZE, BANANAS, ARROWROOT AND FODDER GRASS	1	2		1			
MAIZE, BANANAS AND AVOCADOES	1	1			1		
MAIZE, BANANAS AND CABBAGES	2	1					
MAIZE, BANANAS AND FODDER GRASS	1	1		1			
MAIZE, BEANS, BANANAS AND FODDER GRASS	2	1		1			
MAIZE, ENGLISH POTATOES, AND BANANAS	2	1					
MAIZE, ENGLISH POTATOES, SWEET POTATOES AND BANANAS	3	1					
MAIZE, ENGLISH POTATOES AND BEANS	3						
MAIZE, ENGLISH POTATOES AND FODDER GRASS	2			1			
MAIZE, ENGLISH POTATOES AND SWEET POTATOES	3						
MAIZE, SWEET POTATOES, AND FODDER GRASS	2			1			
MAIZE, SWEET POTATOES, BANANAS AND FODDER GRASS	2	1		1			
MAIZE, SWEET POTATOES AND BANANAS	2	1					
MAIZE, SWEET POTATOES AND CABBAGES	3						
MAIZE, SWEET POTATOES AND FALLOW	2					1	
MAIZE AND ARROWROOT	1	1					
MAIZE AND BANANAS	1	1					
MAIZE AND BEANS	2						
MAIZE AND CABBAGES	2						
MAIZE AND ENGLISH POTATOES	2						
MAIZE AND FALLOW	1					1	
MAIZE AND FODDER GRASS	1			1			
MAIZE AND SUGARCANE	1		1				
MAIZE AND SWEET POTATOES	2						
MAIZE AND YAMS	2						
SWEET POTATOES, ENGLISH POTATOES AND VEGETABLES	3						
3. PERENNIAL FOOD CROPS (INTERCROPPED) AND MINOR PERENNIAL CASH CROPS							
BANANAS		1					
BANANAS, ARROWROOTS AND TOMATOES	1	2					
BANANAS, CASSAVA AND FALLOW		2				1	
BANANAS, FODDER GRASS AND ARROWROOT		2		1			
BANANAS, FODDER GRASS AND FALLOW		1		1		1	
BANANAS, FODDER GRASS AND YAMS	1	1		1			
BANANAS, SUGAR CANE AND ARROWROOT		2	1				
BANANAS, SUGAR CANE AND YAMS	1	1	1				
BANANAS, WATTLE TREES, PASTURE AND FISH PONDS		1		1	1		1
BANANAS, WATTLE TREES AND ARROWROOTS		2			1		
BANANAS, YAMS, PASSION FRUIT, AND AVOCADO/MACADAMIA TREES	1	2			2		
BANANAS AND ARROWROOT		2					
BANANAS AND FALLOW		1				1	
BANANAS AND FODDER GRASS		1		1			
BANANAS AND YAMS	1	1					
FODDER GRASS, ARROWROOTS AND SUGARCANE		1	1	1			
FODDER GRASS AND ARROWROOT		1		1			
PASSION FRUIT AND YAMS	1	1					
SUGARCANE			1				
SWEET POTATOES, ARROWROOTS, SUGARCANE AND FODDER GRASS	1	1	1	1			
SWEET POTATOES, BANANAS, AND YAMS	2	1					
SWEET POTATOES, BANANAS AND AVOCADOES	1	1			1		
SWEET POTATOES, BANANAS AND FALLOW	1	1				1	
SWEET POTATOES, BANANAS AND FODDER GRASS	1	1		1			
SWEET POTATOES, FODDER GRASS AND FALLOW	1			1		1	
SWEET POTATOES AND BANANAS	1	1					
SWEET POTATOES AND FALLOW	1					1	
SWEET POTATOES AND FODDER GRASS	1			1			

LAND-USE CATEGORY	*NUMBERS OF CROP AND LAND-USE COMBINATIONS*						
		PERENNIALS					
4. *PASTURE AND FODDER CROPS*	ANNUAL FOOD CROPS	FOOD CROP	CASH CROP	FODDER OR PASTURE	PLANTED TREES	FALLOW	OTHER UNCULTI-VATED
FODDER GRASS				1			
FODDER GRASS AND FALLOW				1		1	
PASTURE				1			
PASTURE AND FODDER GRASS				2			
5. *SMALLHOLDER COFFEE*			1				
6. *SMALLHOLDER TEA*			1				
7. *WATTLE OR WATTLE/PASTURE*							
WATTLE					1		
WATTLE WOODLOT AND PASTURE				1	1		
8. *HOUSEHOLD COMPOUND, FALLOW, OR OTHER UNCULTIVATED LAND*							
BUSH, WOODLAND, OR FOREST							1
CYPRESS					1		
EUCALYPTUS					1		
FALLOW						1	
HOUSE COMPOUND							1

APPENDIX 5:
Exports, Production, and Pricing

Smallholders who decide to establish a woodlot, or to clear a woodlot and to use their land for something else, must partly base their decision on expectations of future prices. In order to test the sensitivity of the farmer's decision to change land-uses as a response to price, producer price series were developed for inclusion in the logits.

Woodlot operators generally reported that the best crops to plant on old woodlot sites would be tea or coffee, and that the worst crops to plant would be food crops. Operators who had cleared their parcels of woodlots evidently shared this view. Around 70 percent of the parcels which had formerly been used for growing a woodlot had been planted with tea, and 19 percent had been planted with coffee. Only 9 percent had used former woodlot sites for growing food crops. Because of the importance of coffee and tea vis-a-vis wattle, producer price series for these crops were developed for inclusion in the logits.

Other price series, particularly for tanning extracts, for wattle bark, and for charcoal were also collected, but these were not included in the logits. Tanning extract prices reflect international prices and demands for extracts and are marginally reflected in producer prices for wattle bark, which are set by the two tanning extract manufacturers operating in Kenya. Although wattle bark and charcoal were for many years the primary commodities produced by wattle woodlots in Murang'a, this is no longer the case. Fewer than 11 percent of woodlot growing households surveyed reported that they sold bark from their woodlot the last time it was harvested. Only 3 percent of the woodlot growing households surveyed reported they sold charcoal from their woodlot the last time it was harvested.

Because of this, pricing series for these commodities were not included in the logits.

Other data about export prices and exported quantities of these commodities and the relative proportion which each commodity contributed to export earnings was also compiled. Two relationships were examined: producer prices were compared with export prices and producer prices were compared with export volumes.

Producer and export prices were deflated using the Middle Income Consumer Price Index. While this was appropriate for deflating producer prices, it would have been preferable to deflate export prices using GDP deflators. These were not available to cover the period for which prices were available, which in some cases dated to 1949.

The complete series of price and export data is shown in Table 1.

Data Sources

Exports, export prices, and the proportion of export earnings accounted for by each commodity were taken from reported annual exports and export earnings listed in the *Statistical Abstract* series published by the Government of Kenya.

Producer prices were compiled from several sources. Coffee producer prices were taken from the Ministry of Agriculture's annual reports for Murang'a District which summarize crop prices and production for the previous season. Where data was missing, prices were estimated by calculating the average proportion of the export price which was paid to the producer for two years before and after the year for which data was missing, and by multiplying this by the export price in that year. Prices for 4 years since 1962 were estimated in this manner.

Producer prices for tea grown by Murang'a farmers were taken from the annual reports of the Kenya Tea Development Authority. KTDA payments come in two tranches: a first payment which stays relatively constant from year to year,

and a second payment (known as the 'bonus' payment), which is paid after tea produced by a particular factory has been auctioned off and after marketing costs have been deducted. A complete series of producer prices was available dating to 1962.

Producer prices for wattle bark were problematic to obtain, as these are not consistently reported in any particular source. Cowen's price series dating from 1949 to 1963 is quite good and is derived from reported prices paid at the Karatina inspection and buying centre.[1] Prices between 1970 and 1980 were derived from the Ministry of Agriculture's annual reports of crop production and prices for Murang'a. Prices since 1980 were estimated from data provided during an interview with the managing director of the East African Tanning Extracts Company, in Eldoret. Current prices between 1963 and 1970 were estimated using an exponential growth curve. Of the three commodities, the producer price for wattle bark is the least affected by fluctuations in the international price of bark or extracts.

Export and Producer Prices

Export prices for coffee, tea, and wattle bark are compared with producer prices in Figures 1, 2 and 3. Producer and export prices for tea and coffee are closely correlated, significant to 1 percent for coffee and tea prices ($t = 14.17$ and $t = 2.70$, respectively). Producer and export prices for wattle bark are not correlated ($t = 1.05$).

These patterns would be expected. One of the primary roles of the coffee and tea marketing parastatals is to pass world prices for these commodities on to the producer. Correlation coefficients confirm that they have been successful in doing this. Although the price of wattle bark was for many years set by the

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1. Cowen (1978), p.325.

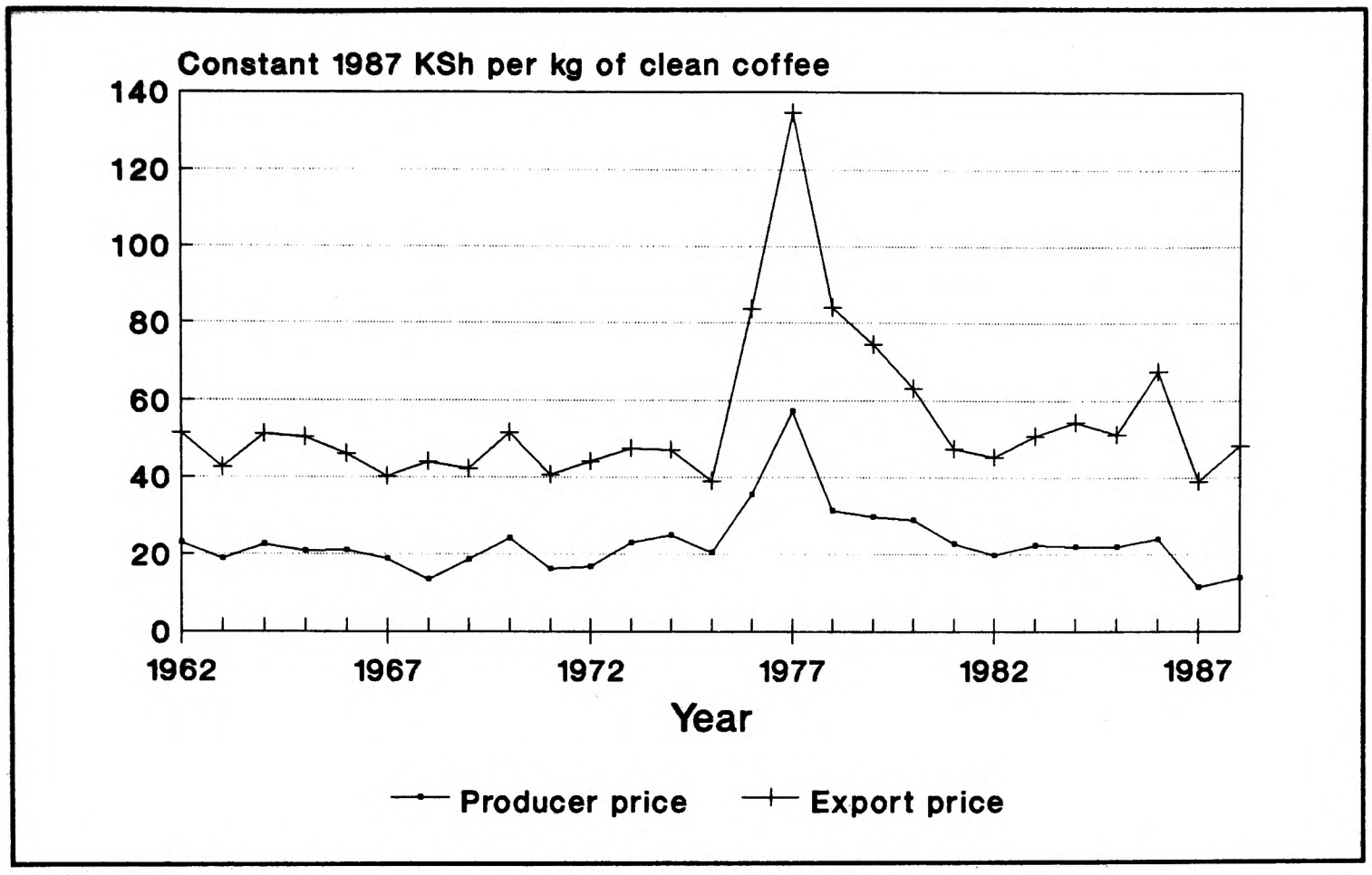


Figure 1: Export and Producer Prices for Coffee

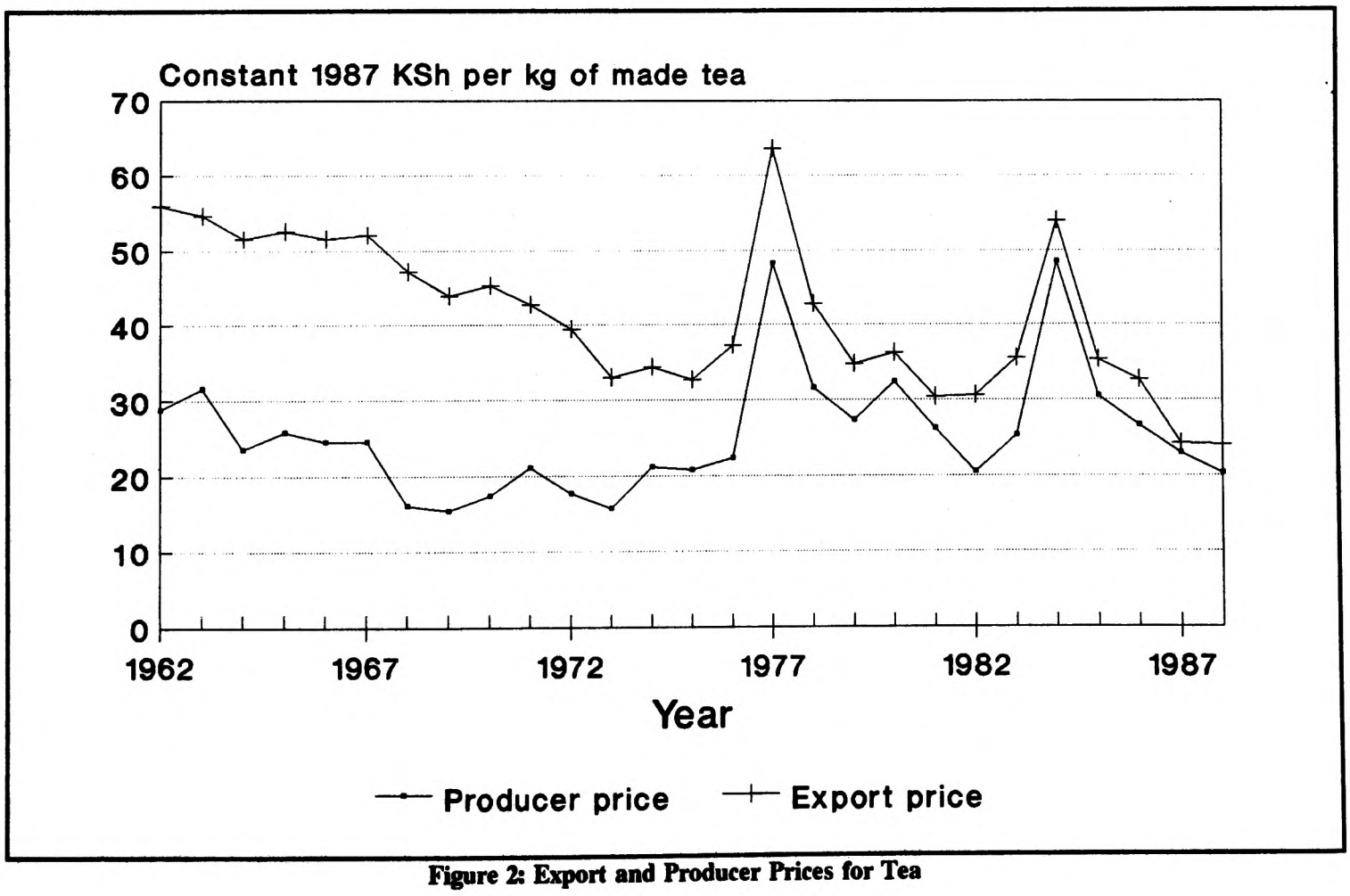


Figure 2: Export and Producer Prices for Tea

Government (in consultation with the Wattle Manufacturers Association), as it became less important to the economy, Government became less involved in the fixing of fair prices. At the same time, Government dropped its system of requiring

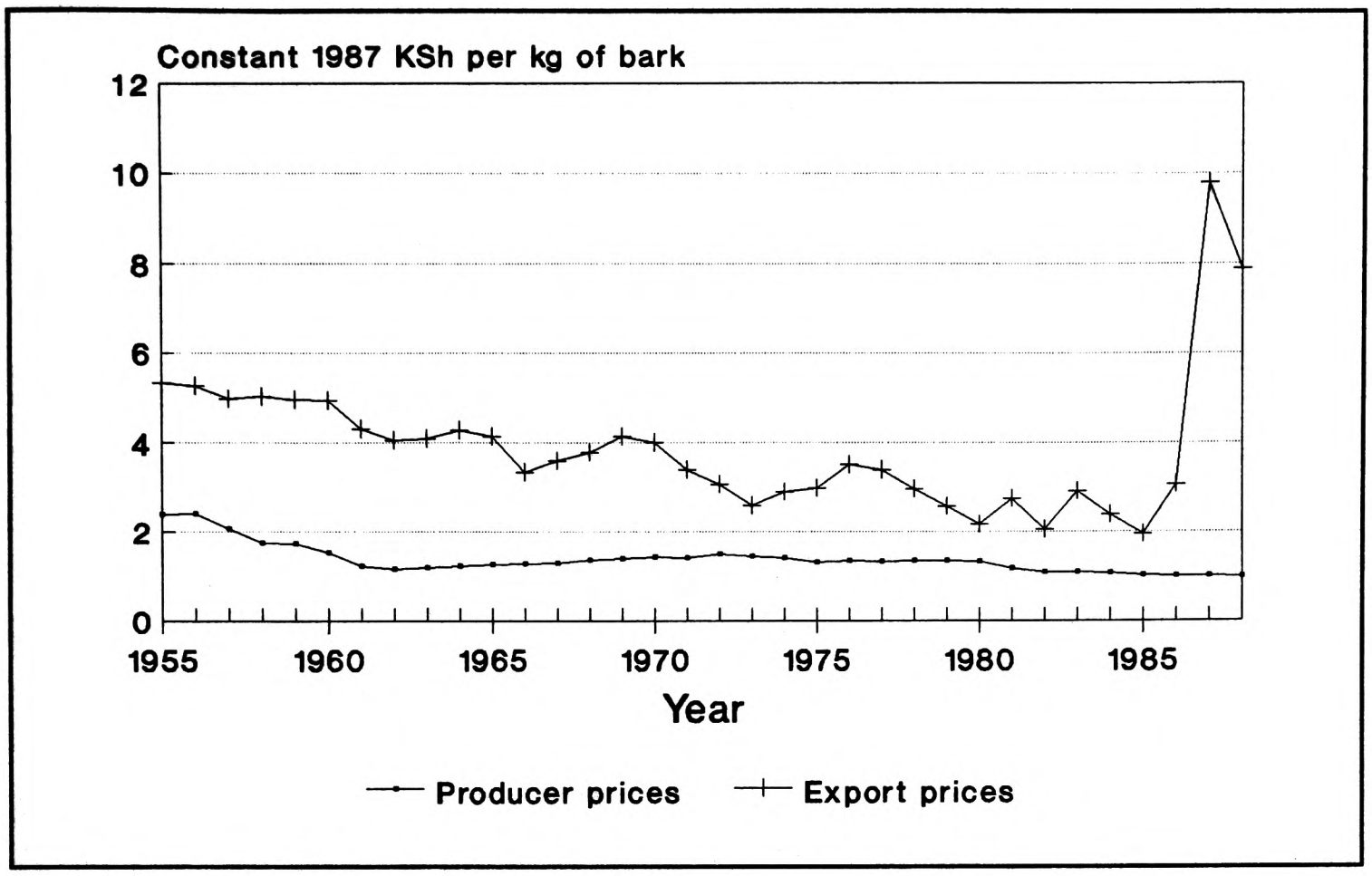


Figure 3: Export and Producer Prices for Wattle Bark

permits for the stripping of bark (in 1977) and for the delivery of bark to the tanning factories (in 1978). Currently, the price of wattle bark is set by a duopsony (Kenya Tanning Extracts Company and East African Tanning Extracts Company). Particularly during the 1987 and 1988 seasons, when export prices were at a peak, the duopsony failed to pass on increased prices to producers.

Exported Quantities and Producer Prices

The relationship between the volume of commodities exported to producer prices was tested to see how responsive producers and marketing agents in Kenya are to changes in international markets. Exports of coffee, tea and wattle bark are compared with producer prices in Figures 4, 5 and 6.

Neither coffee or tea exports were significantly correlated with producer prices ($t = 1.23$ for coffee and $t = 1.14$ for tea). Indeed, production and exports are greatly dependent on input use and rainfall during the previous seasons, and so it could not be expected that short-term output could be greatly increased as a

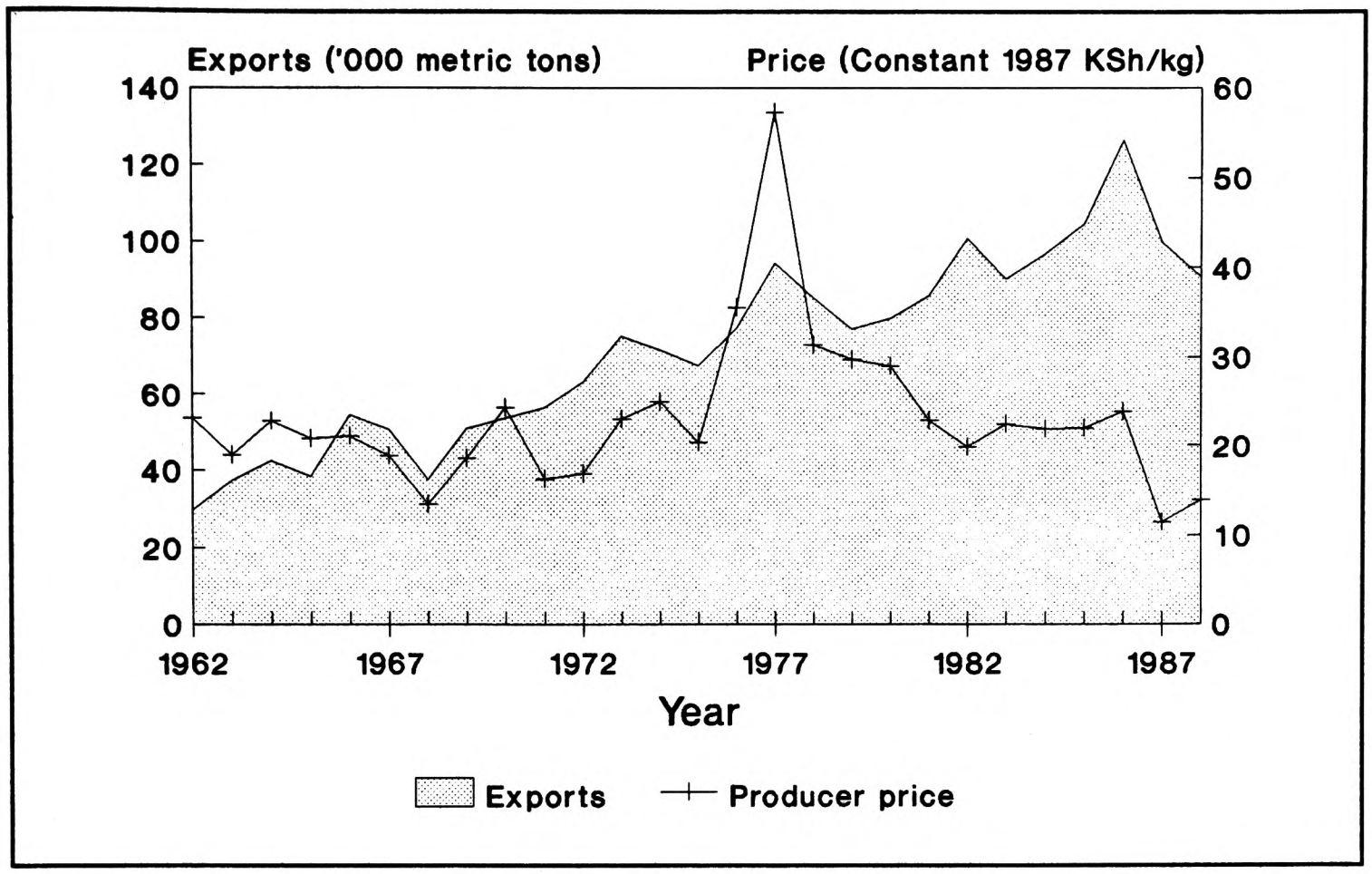


Figure 4: Exported Quantities and Producer Prices for Coffee

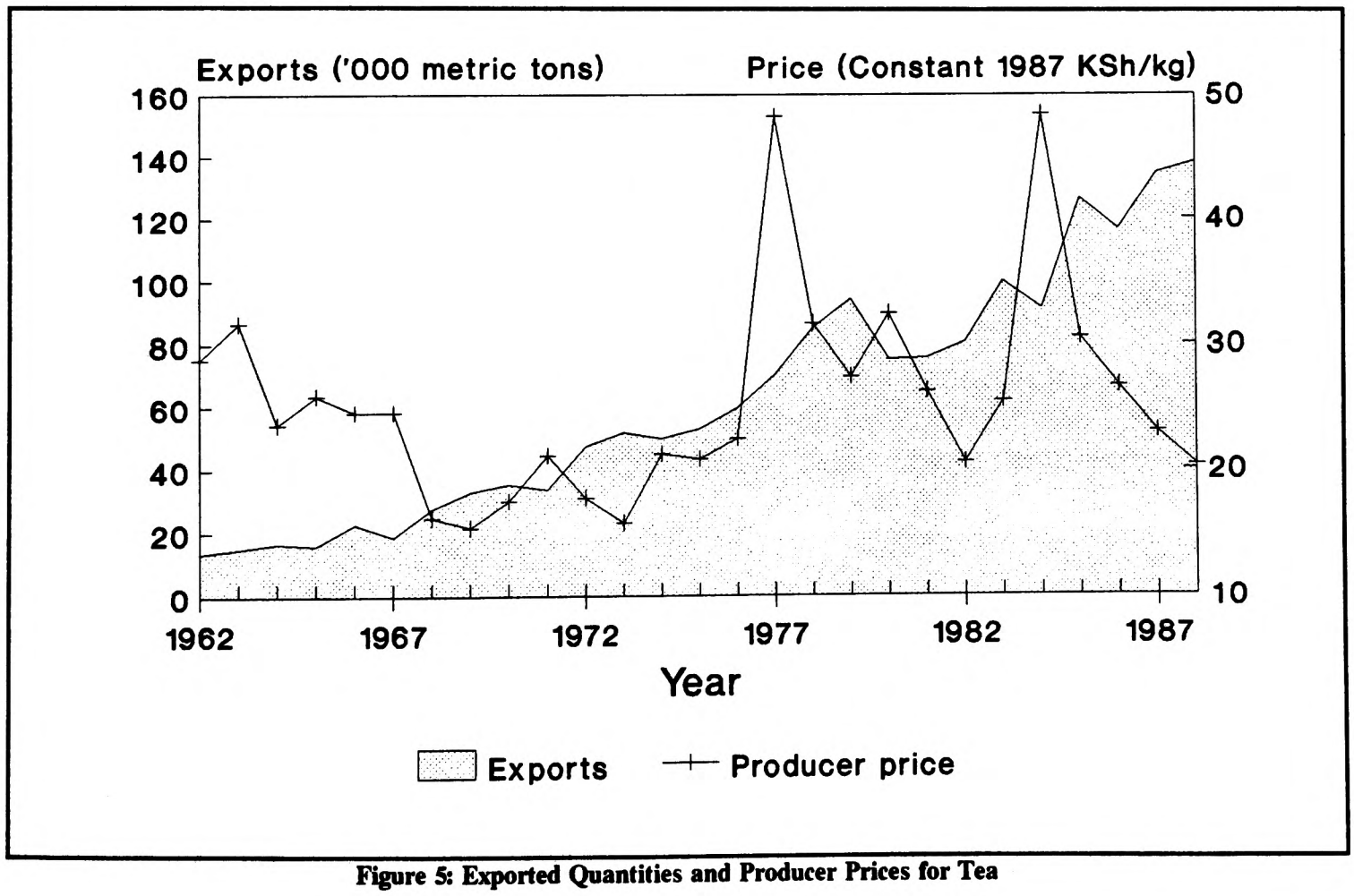


Figure 5: Exported Quantities and Producer Prices for Tea

response to increased producer prices.

Wattle bark exports, on the other hand, are significantly correlated with wattle bark producer prices (t=3.83, significant to 1 percent). This is partly a

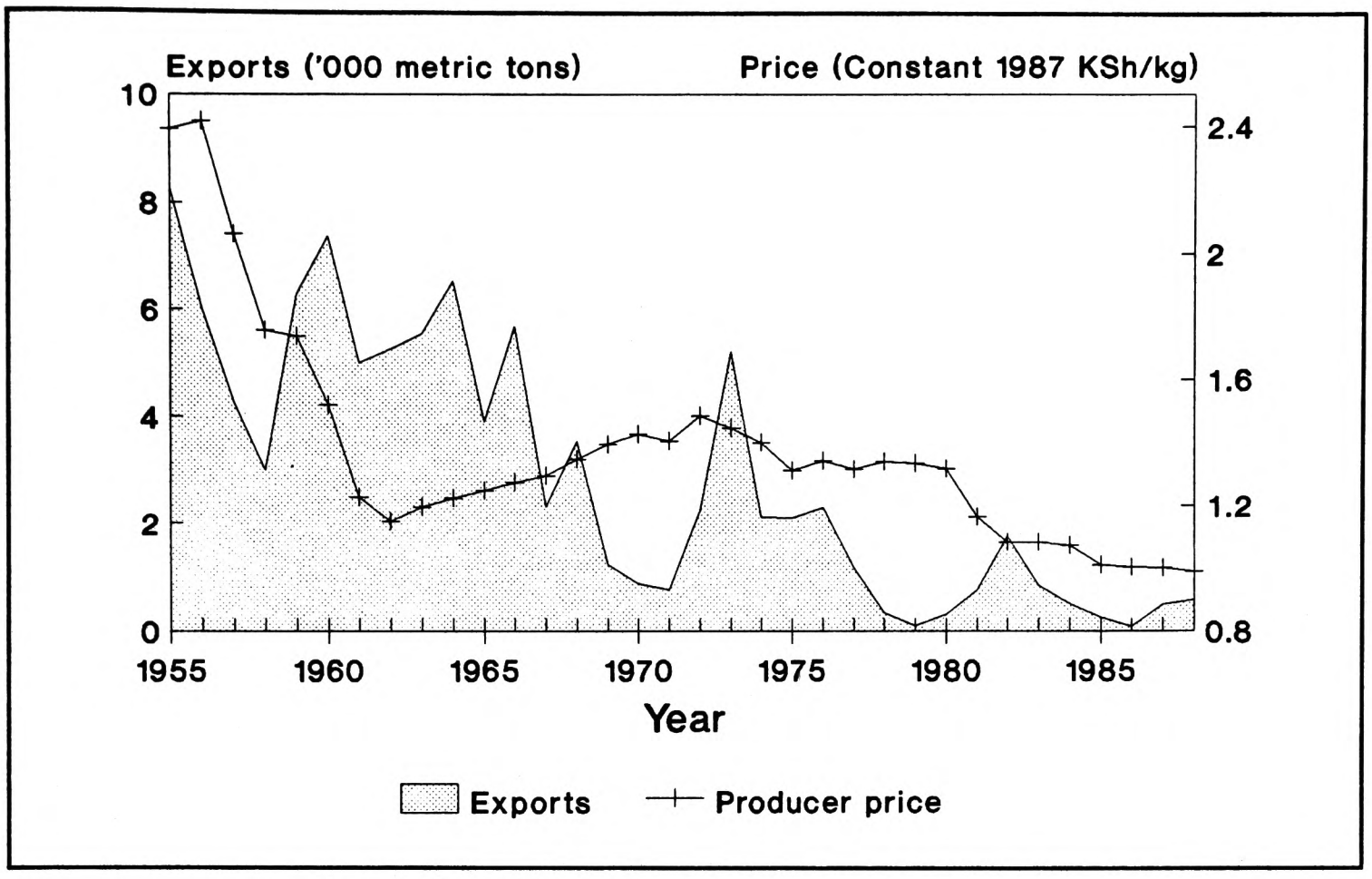


Figure 6: Exported Quantities and Producer Prices for Wattle Bark

reflection of long-term falling prices for bark, as well as long-term declining levels of exports. In the short-term, wattle bark producers are able to take advantage of short-term price increases, as their only harvesting constraints are that they have enough trees which are old enough (4 to 8 years old) and that they have sufficient labour for stripping the bark. Further, wattle bark from mature trees can be stripped and stored until the producer decides to sell. These options give producers much greater latitude than growers of coffee and tea in being able to take advantage of higher producer prices. Tanning extract export prices are compared with bark export and producer prices in Figure 7.

Contributions to Domestic Export Earnings

Export earnings from coffee, tea and wattle, as a percentage of all earnings from domestic exports, are shown in Figure 8. Proportional export earnings from wattle are shown in Figure 9. Earnings from wattle were considerable through the late 1950s, but now account for less than 2 percent of total domestic export

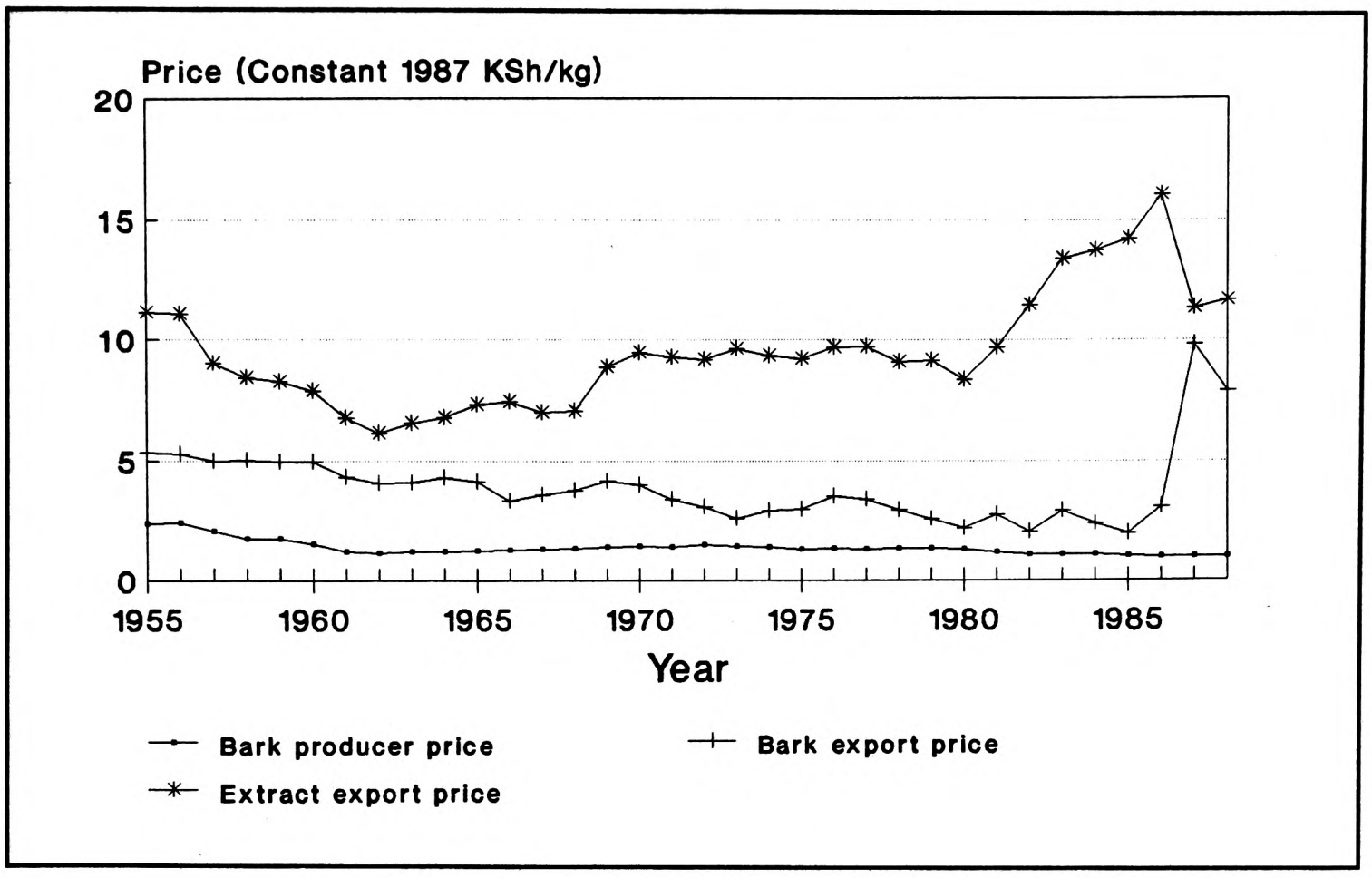


Figure 7: Producer and Export Prices for Wattle Bark and Export Prices for Tanning Extracts

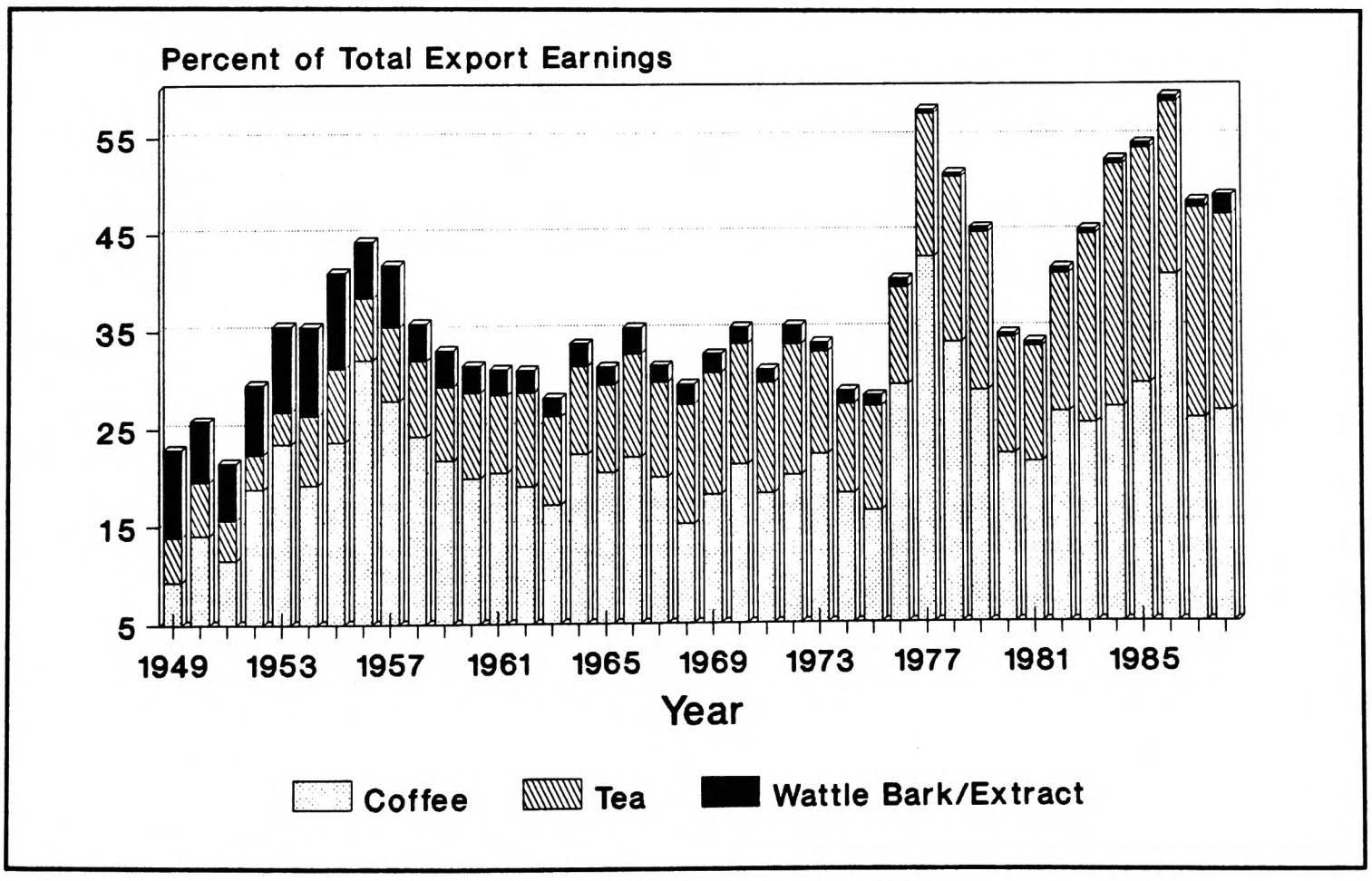


Figure 8: Domestic Export Earnings from Coffee, Tea, Wattle Bark, and Tanning Extracts

earnings. By comparison, tea and coffee have assumed a dominant position, in 1986 accounting for nearly 60 percent of domestic export earnings, over 4 times the 1949 proportion of around 15 percent.

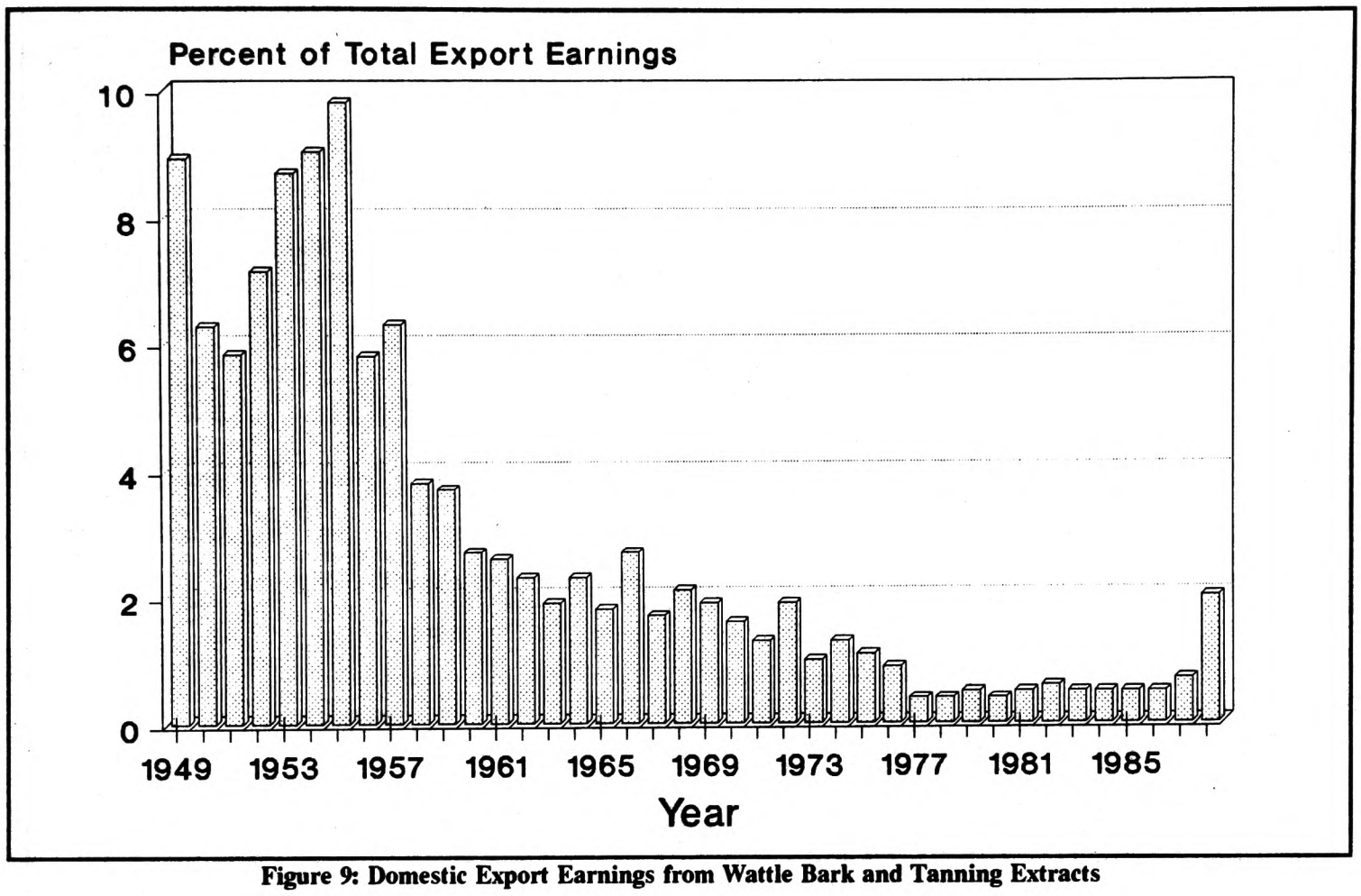


Figure 9: Domestic Export Earnings from Wattle Bark and Tanning Extracts

Table 1: Production, Producer and Export Prices of Coffee, Tea, Wattle Bark, and Tanning Extracts

	COFFEE			TEA			WATTLE BARK EXTRACT			WATTLE BARK			MIDDLE INCOME PRICE INDEX	CONSTANT VALUE OF FOB EXPORT PRICES (1987 KSh/kg)			
	Exports	Current Value		Exports	Current Value		Exports	Current Value		Exports	Current Value						
Year	metric tons	Total K£ '000	KSh per kg	metric tons	Total K£ '000	KSh per kg	metric tons	Total K£ '000	KSh per kg	metric tons	Total K£ '000	KSh per kg	(1987 =1.00)	Coffee	Tea	Wattle Extracts	Wattle Bark
1949	7,925	1,510	3.81	2,692	717	5.33	22,352	889	0.80				0.08	46.5	65.1	9.7	
1950	10,414	3,549	6.82	4,216	1,334	6.33	24,536	979	0.80				0.09	76.7	71.2	9.0	
1951	10,109	4,096	8.10	4,166	1,397	6.71	22,555	1,264	1.12				0.10	82.3	68.1	11.4	
1952	17,170	7,123	8.30	4,369	1,316	6.02	24,384	1,686	1.38				0.11	79.0	57.3	13.2	
1953	15,037	6,713	8.93	3,048	928	6.09	22,444	1,545	1.38				0.11	82.2	56.1	12.7	
1954	10,922	5,711	10.46	4,928	2,063	8.37	24,637	1,668	1.35				0.11	92.2	73.8	11.9	
1955	19,710	8,904	9.04	5,893	2,761	9.37	33,754	2,261	1.34	8,266	265	0.64	0.12	75.0	77.8	11.1	5.3
1956	27,101	13,653	10.08	7,067	2,616	7.40	22,166	1,501	1.35	6,006	193	0.64	0.12	82.5	60.6	11.1	5.3
1957	22,610	10,793	9.55	7,309	2,861	7.83	26,736	1,522	1.14	4,267	134	0.63	0.13	75.7	62.1	9.0	5.0
1958	25,398	10,405	8.19	8,266	3,217	7.78	19,286	1,024	1.06	2,998	95	0.63	0.13	65.0	61.7	8.4	5.0
1959	26,259	10,577	8.06	9,574	3,602	7.52	19,569	1,026	1.05	6,291	198	0.63	0.13	63.5	59.3	8.3	5.0
1960	28,235	10,261	7.27	10,881	4,411	8.11	14,481	730	1.01	7,378	233	0.63	0.13	56.9	63.4	7.9	4.9
1961	32,666	10,609	6.50	9,930	4,004	8.06	17,266	765	0.89	4,995	141	0.56	0.13	49.6	61.6	6.8	4.3
1962	29,785	10,593	7.11	13,452	5,189	7.71	16,712	705	0.84	5,252	147	0.56	0.14	51.6	55.9	6.1	4.1
1963	37,352	11,015	5.90	14,945	5,665	7.58	14,035	638	0.91	5,535	157	0.57	0.14	42.5	54.6	6.6	4.1
1964	42,304	15,396	7.28	16,567	6,056	7.31	18,444	883	0.96	6,533	198	0.61	0.14	51.3	51.5	6.8	4.3
1965	38,399	14,096	7.34	15,917	6,085	7.65	13,349	711	1.07	3,913	118	0.60	0.15	50.4	52.5	7.3	4.1
1966	54,461	18,780	6.90	22,608	8,714	7.71	26,199	1,454	1.11	5,675	142	0.50	0.15	46.1	51.6	7.4	3.3
1967	50,748	15,676	6.18	18,480	7,396	8.00	16,048	861	1.07	2,317	64	0.55	0.15	40.2	52.1	7.0	3.6
1968	37,594	12,808	6.81	27,499	10,041	7.30	20,840	1,134	1.09	3,547	104	0.59	0.15	44.0	47.2	7.0	3.8
1969	50,969	16,837	6.61	32,835	11,271	6.87	16,530	1,144	1.38	1,233	40	0.65	0.16	42.2	43.9	8.9	4.1
1970	53,725	22,259	8.29	35,063	12,704	7.25	15,056	1,141	1.52	874	28	0.64	0.16	51.8	45.3	9.5	4.0
1971	56,426	19,530	6.92	33,508	12,174	7.27	15,287	1,207	1.58	762	22	0.58	0.17	40.7	42.7	9.3	3.4
1972	63,142	24,769	7.85	47,126	16,485	7.00	20,807	1,690	1.62	2,245	61	0.54	0.18	44.2	39.5	9.2	3.1
1973	75,317	35,777	9.50	51,472	16,970	6.59	12,666	1,217	1.92	5,213	135	0.52	0.20	47.5	33.0	9.6	2.6
1974	71,681	38,387	10.71	49,594	19,391	7.82	13,503	1,434	2.12	2,117	70	0.66	0.23	47.1	34.4	9.3	2.9
1975	67,615	35,204	10.41	52,547	22,932	8.73	14,013	1,722	2.46	2,105	84	0.80	0.27	39.0	32.7	9.2	3.0
1976	77,546	93,303	24.06	59,267	31,763	10.72	19,327	2,686	2.78	2,301	116	1.01	0.29	83.8	37.3	9.7	3.5
1977	94,314	204,336	43.33	70,220	71,779	20.44	11,714	1,833	3.13	1,172	64	1.09	0.32	134.7	63.6	9.7	3.4
1978	85,392	124,679	29.20	84,968	63,187	14.87	9,412	1,487	3.16	330	17	1.03	0.35	84.1	42.8	9.1	3.0
1979	77,241	110,573	28.63	94,023	62,843	13.37	11,222	1,966	3.50				0.38	74.6	34.8	9.1	
1980	80,066	108,129	27.01	74,799	58,003	15.51	11,820	2,106	3.56	301	14	0.93	0.43	63.2	36.3	8.3	2.2
1981	86,108	109,370	25.40	75,350	61,104	16.22	10,620	2,743	5.17	764	56	1.47	0.53	47.6	30.4	9.7	2.7
1982	100,968	144,564	28.64	80,413	77,593	19.30	9,725	3,519	7.24	1,769	114	1.29	0.63	45.4	30.6	11.5	2.0
1983	90,444	160,087	35.40	99,938	123,421	24.70	6,038	2,808	9.30	848	86	2.03	0.69	51.0	35.6	13.4	2.9
1984	96,902	203,623	42.03	91,198	189,478	41.55	6,460	3,423	10.60	500	46	1.84	0.77	54.6	53.9	13.8	2.4
1985	104,668	230,623	44.07	126,303	191,657	30.35	6,257	3,821	12.21	250	21	1.68	0.86	51.3	35.4	14.2	2.0
1986	126,486	388,486	61.43	116,456	172,789	29.67	6,247	4,548	14.56	86	12	2.79	0.91	67.6	32.7	16.0	3.1
1987	99,967	194,569	38.93	134,627	163,366	24.27	9,268	5,247	11.32	486	238	9.79	1.00	38.9	24.3	11.3	9.8
1988	90,762	244,547	53.89	138,201	185,263	26.81	7,199	4,672	12.98	571	251	8.79	1.12	48.3	24.0	11.6	7.9

Source: Statistical Abstract series (trade statistics). Nairobi, Government Printer.

Table 1 (continued)

Year	MIDDLE INCOME PRICE INDEX (1987 =1.00)	MURANG'A DISTRICT ANNUAL REPORTS, COFFEE PRICES			KTDA REPORTED MURANG'A TOTAL TEA PAYMENTS (KSh per kg)			WATTLE BARK PRODUCER PRICING (KSh per kg)		PERCENT OF TOTAL DOMESTIC EXPORT VALUE			
		Current Price (KSh/ton)	Current Price (KSh per kg)	Constant Price	Current Green Leaf	Constant Green Leaf	Constant Made Tea	Current Pricing	Constant Pricing	Coffee	Tea	Wattle Bark	Wattle Bark and Extract
1949	0.08							0.20	0.00	9.4	4.6	8.1	8.9
1950	0.09							0.21	0.00	14.1	5.5	5.7	6.3
1951	0.10							0.27	0.00	11.6	4.1	5.3	5.8
1952	0.11							0.30	0.00	18.8	3.6	6.5	7.2
1953	0.11							0.30	0.00	23.4	3.4	7.9	8.7
1954	0.11							0.29	0.00	19.2	7.2	8.2	9.0
1955	0.12							0.29	0.00	23.6	7.5	8.8	9.8
1956	0.12							0.30	0.00	32.0	6.3	5.2	5.8
1957	0.13							0.26	0.00	27.8	7.6	5.8	6.3
1958	0.13							0.22	0.00	24.1	7.7	3.5	3.8
1959	0.13							0.22	0.00	21.6	7.6	3.1	3.7
1960	0.13							0.19	0.00	19.9	8.8	2.1	2.7
1961	0.13							0.16	0.00	20.4	8.0		2.6
1962	0.14	318	3.18	23.03	0.84	6.40	28.80	0.16	0.03	19.0	9.6		2.3
1963	0.14		2.62	18.87 *	0.97	7.03	31.65	0.17 *	0.03	17.1	9.1		1.9
1964	0.14	321	3.21	22.65	0.73	5.24	23.59	0.17 *	0.02	22.2	9.1		2.3
1965	0.15	302	3.02	20.71	0.82	5.75	25.88	0.18 *	0.03	20.3	9.1		1.8
1966	0.15	314	3.14	21.01	0.79	5.45	24.53	0.19 *	0.02	22.0	10.6		2.7
1967	0.15	288	2.88	18.74	0.82	5.46	24.56	0.20 *	0.02	19.9	9.7		1.7
1968	0.15	207	2.07	13.38	0.55	3.59	16.14	0.21 *	0.02	15.1	12.3		2.1
1969	0.16	290	2.90	18.53	0.53	3.42	15.39	0.22 *	0.02	18.1	12.5		1.9
1970	0.16	387	3.87	24.18	0.61	3.88	17.47	0.23 *	0.02	21.2	12.5		1.6
1971	0.17	276	2.76	16.24	0.75	4.68	21.08	0.24	0.02	18.2	11.4		1.3
1972	0.18	297	2.97	16.78	0.67	3.94	17.71	0.26	0.02	20.1	13.4		1.9
1973	0.20	458	4.58	22.91	0.62	3.50	15.73	0.29	0.02	22.2	10.5		1.0
1974	0.23	566	5.66	24.90	0.94	4.70	21.16	0.32	0.02	18.2	9.2		1.3
1975	0.27	543	5.43	20.33	1.05	4.62	20.77	0.35	0.02	16.4	10.7		1.1
1976	0.29	1,020	10.20	35.50	1.33	4.98	22.39	0.39	0.02	29.3	10.0		0.9
1977	0.32	1,842	18.42	57.26	3.08	10.72	48.24	0.42	0.05	42.5	14.9		0.4
1978	0.35	1,088	10.88	31.31	2.26	7.03	31.62	0.47	0.03	33.7	17.1		0.4
1979	0.38		11.42	29.75 *	2.11	6.07	27.33	0.51	0.03	28.7	16.3		0.5
1980	0.43		12.37	28.97 *	2.76	7.19	32.37	0.56	0.03	22.2	11.9		0.4
1981	0.53	1,217	12.17	22.83	2.49	5.83	26.23	0.62	0.03	21.3	11.9		0.5
1982	0.63	1,252	12.52	19.85	2.43	4.56	20.51	0.68	0.02	26.5	14.2		0.6
1983	0.69	1,557	15.57	22.43	3.56	5.64	25.40	0.75	0.03	25.3	19.5		0.5
1984	0.77	1,686	16.86	21.89	7.47	10.76	48.44	0.83	0.05	27.0	25.1		0.5
1985	0.86	1,887	18.87	21.98	5.22	6.78	30.50	0.87	0.03	29.4	24.4		0.5
1986	0.91		21.66	23.84 *	5.08	5.92	26.63	0.91	0.03	40.6	18.0		0.5
1987	1.00	1,144	11.44	11.44	4.64	5.11	22.99	1.00	0.02	25.8	21.7		0.7
1988	1.12	1,547	15.47	13.87	4.50	4.50	20.25	1.10	0.02	26.6	20.2		2.0

Sources: Statistical Abstract series (trade statistics); elsewhere, as indicated; * estimates.

APPENDIX 6:
Traditional Tree Cultivation and Management Practices

Land tenure processes have long been closely associated with traditional (as well as contemporary) tree cultivation and management practices. Some of these practices were undertaken with clear production objectives. Others were more closely related to traditional land tenure practices (particularly, boundary demarcation). Forest cover was also manipulated for the protection and fortification of villages. At the household-level, trees and woody biomass served similar purposes of protection and boundary demarcation, while being a key feature in livestock management. Finally, trees played a vital role in religious practices and were an abundant source of medicines and foods.[1] This Appendix was written to make the case that tree cultivation and management has a long history in Kikuyu areas of Kenya, and that contemporary tree planting practices cannot be viewed in isolation from earlier traditional practices.

Tree Tenure

As with other features of the *gĩthaka* system, rights of use to naturally-growing trees on a right holder's plot belonged to him and to his household, while rights of use to trees on unallocated portions of the *gĩthaka* belonged to the *mbari*. Permission to fell these trees had to be obtained from the *mũramati*, but as long as unallocated bushland remained, there were few supply problems.

In Murang'a and Nyeri Districts, a *mũguri* who obtained land through redeemable sale had no right to cut down the trees on the plot. Trees were

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1. See particularly, F.N.Gachathi (1990). *Kikuyu Botanical Dictionary of Plant Names and Uses*. Nairobi, Kenya Forest Research Institute. Gachathi documents the extensive use of trees for medicinal purposes in Kikuyu areas.

actually inventoried at the time of the sale, and if the *mũguri* wished to cut any of them, they had to be purchased from the original owner. Sometimes if he simply asked permission, he was allowed to cut them, as gifts. The cutting of trees without payment or permission, however, was an offense for which fines were assessed and compensation paid. New trees which grew up after the time of the sale belonged to the *mũguri*, and he could do with them as he wished. The same conditions applied to *ahoi* and *athami* in that they were not able to cut down existing trees. Unlike the *aguri* however, they were prohibited from cutting down new trees which might have grown up on the plot unless they had asked the permission of the right holder. In Kiambu, when land was sold outright, the trees growing on the plot were always included in the sale.[1]

Planted trees belonged to whomever planted them, as long as they held some sort of cultivation right. When *mũthami* or *mũhoi* agreements were cancelled, or when land was redeemed, rights to these trees were relinquished (although the trees could be disposed of until the time the lineage right holder regained possession).[2] Even by the late 1920s, the ownership of wattle woodlots or other permanent crops was posing problems for the tenure system because the owners of the crops were not necessarily the owners of the land.[3]

Similarly, coppiced production belonged to whomever held cultivation rights. A number of trees were particularly appreciated for their coppicing qualities, and were planted as timber species. These included *mũũũ* (Markhamia hildebrandtii) and *mũkuhakuha* (Macaranga kilimandscharica) which were both profusely coppicing timber species. Coppiced trees would be allowed to grow on cultivated

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1. Colony and Protectorate of Kenya (1929b), pp.28-29.

2. J.Ainsworth, KLC(I):501. Ainsworth had carried out a survey of traditional land and tree tenure practices in 1920, relying on a group of elders from Kiambu.

3. S.H.Fazan, RH.Mss.Afr.s.1153.

land, as well as in hedges and windrows. The Routledges, amongst the earliest of the social scientists to carry out ethnographic studies of the Kikuyu in Nyeri, reported that they commonly observed coppiced stems up to 20 feet in height on farmland.[1]

Trees as Boundary Markers

Demarcation of the *gĩthaka* boundary

Trees were commonly used to demarcate the boundaries of *mbari* lands. They were actually a departure from the norm (described below), but later came to be preferred because they provided greater visibility. Certainly as population pressures increased in Murang'a and other parts of Kikuyu country, tree planting around boundaries became the accepted practice.

The customary method of marking out *gĩthaka* boundaries involved the planting of the *gĩtoka* (pl.*ĩtoka*) -- the Pajama Lily (Crinum kirkii) -- by the hereditary *gĩthaka* right holder or by representatives of the *mbari* who held lineage rights to it. The 1929 Committee on Native Land Tenure in Kikuyu Province noted that boundaries in Murang'a and Nyeri were not fully marked in the days when the *gĩthaka* was a hunting area, but that they were sufficiently well enough established to allow for proper marking out when the occasion arose.[2] Natural features such as streams, prominent trees, game pits, and so on served as boundary markers in the meantime.

The marking out of *gĩthaka* boundaries was usually carried out as cultivation became widespread. Marking was often brought about as an outcome of land disputes, but was also undertaken simply as a means of preventing disputes in the future. It was to be done in the presence of witnesses and of representatives of the

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1. W.S.Routledge and K.Routledge (1910). *With a Prehistoric People: the Akikuyu of British East Africa*. London, Edward Arnold. p.39.

2. Colony and Protectorate of Kenya (1929b), p.19.



Figure 1: *Itoka* (Crinum kirkii) as a boundary marker (Kiambu District, late 1950s)

mbari which owned the land adjacent to the plot in question. Witnesses would be asked to bring large numbers of *ĩtoka*, which could only be removed from already well-established boundaries by senior elders. *Gĩtoka kĩirũ* was the variety of the species which was darkly coloured and was preferred for boundary marking.

The ceremony of marking out involved the ritual slaughter of a ram at the *gĩthaka* boundary. The whole of the stomach contents (*taatha*) would be removed and wrapped in a bundle of leaves of the *mũthakwa* bush (Vernonia auriculifera). *Taatha* was used in rituals where misunderstandings were to be avoided. The reason was probably related to the observation that sheep and goats ate grass and other plants which were considered peaceful and valuable for keeping harmful influences at bay, and so *taatha* had a peaceful character to it.[1] The procession of witnesses, elders, and senior clan members would walk along the boundaries, digging holes, and putting *taatha* in them or sprinkling it in streams and on trees and boulders. Lily bulbs would then be planted in the holes.

In some areas, large stones would be buried in the holes as well. In the event that *ĩtoka* died out over time, boundary disputes could be resolved upon the

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1. Leakey (1977), p.1368.

production of these more permanent boundary markers.[1] There was little fear that a person would willfully destroy boundary plants, as the Kikuyu believed that such a person would die almost immediately.[2]

Ĩtoka plantings along *gĩthaka* boundaries were seldom in continuous strips. Rather, lilies would be planted at irregular intervals, and it would not always be immediately clear that they were contiguous with boundaries.[3] Before death the lineage right holder or the *mũramati* would show the boundaries to his heirs and in the presence of elders and other witnesses, and in this way, lineage rights were passed from generation to generation.[4] Under cultivation, *ĩtoka* could grow to more than 7 feet in height; they more commonly only grew a couple of feet tall.[5]

While *ĩtoka* was the accepted boundary marker, a number of trees and bushes were accepted as substitutes. The planting of trees became considerably more common as the need for clearer boundaries to *mbari* land became evident. Trees were planted at irregular intervals, as well as in what would now be called windrows and hedges. This process was apparently well underway by the time of European settlement. The Routledges wrote about *gĩthaka* land in 1910:

> "The boundary of the estate .... was indicated by the planting of trees in line, by regular hedges, and by boundary stones sunk deep out of site.... The countryside presents the appearance of large allotments or of small fields divided by hedges."[6]

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1. S.H.Fazan, RH.Mss.Afr.s.1153.
2. Leakey (1977), p.108.
3. J.Kenyatta, KLC(I):433.
4. S.H.Fazan, RH.Mss.Afr.s.1153
5. H.Leakey, KLC(I):857.
6. Routledge and Routledge (1910), p.6 and p.39.

Trees which were used as *gīthaka* boundaries included *mūgumo* (Ficus natalensis),[1] *mwatha* (Synadenium compactum),[2] *mūiri* (Prunus africanum), *mūkawa* (Carissa edulis),[3] and *mūringa* (Cordia africana). With the exception of *mūiri* and *mūkawa*, these trees all have the characteristic that they can be propogated from cuttings, which would make boundary demarcation with them fairly easy. They were also easy to identify. *Mūgumo*, for instance, is even today a widely recognized fast-growing tree. It was often the site of important ceremonies. If it could be prevented, a *mūgumo* was never allowed to naturally regenerate. If a tree of this species was found growing somewhere, one inevitably had to assume that it had been planted for some reason or another.

Other boundary trees were also easy to spot. *Mwatha* is distinctive for its red leaves and latex. *Mūiri* is a tall tree with numerous medicinal properties and has extremely hard timber which was used for mortars, pestles and farm implements. *Mūkawa* is a thorny species which can form a dense hedge.[4] *Mūringa*, a tall timber tree, has profuse white flowers, and is valued for shade, for timber, and for its medicinal properties.

S.H.Fazan, the District Commissioner for Kiambu in the early 1930s, noted that in some instances, the boundary of the *gīthaka* would be marked by coppiced and pollarded tree stumps rather than by planted trees,

"... that is to say they cut off the tree itself and leave the bushy growth to spring

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1. J.Kenyatta, KLC(I):433.

2. Luka Wangana, KLC(1):185.

3. S.H.Fazan, RH.Mss.Afr.s.1153.

4. It seems likely that S.H.Fazan, who mentioned *mūkawa* and *mūiri* as boundary trees did not distinguish in his account between trees used for marking the boundaries of *mbari* lands and trees used for marking off household plots or for making livestock enclosures. *Mūkawa*, particularly, has more of the characteristics one would expect to find in the latter than in the former which generally are easy to propagate and which have some particularly dramatic feature relating to size or appearance. For instance, one could never mistake a *mūgumo* tree for something else, while *mūkawa* is just one of many thorny shrubs found in the bush.

from the root. I saw several of these, and in one place they have the general appearance of having been planted in a row."[1]

The Forest Department, wittingly or not, adopted the practice of boundary demarcation with trees. In 1933, it was reported that the boundaries to the Forest Reserves were being demarcated "by cut or ploughed lines, marked by posts, or exotic trees planted at intervals."[2] The planting of Reserve boundaries with exotic trees by the Colonial government must certainly held some significance to the Kikuyu who had always used their own trees for marking out their own boundaries.

The customary demarcation of *gĩthaka* lands with *ĩtoka* and with trees was first widely discussed during the hearings before the Kenya Land Commission in 1933. The Commission frequently asked European witnesses whether or not they had ever noticed boundaries planted with the lily. The reply was invariably that the lilies were reasonably common, but that they were seldom found planted in straight lines as if they were marking out boundaries.[3] Because of this, the Commission basically refused to settle the many pending land cases which involved alienated European farms on the basis of *ĩtoka* boundary markers, even though the Administration had earlier explicitly recognized this feature of traditional land tenure.[4] The irregular planting of *ĩtoka* along boundaries was perhaps its biggest drawback in establishing land claims in the face of colonial settlement.

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1. S.H.Fazan, KLC(I):960.

2. FD 1933, p.6.

3. Canon Harry Leakey noted in his evidence that he was aware that the lilies were used for boundary demarcation, although the boundary was not always evident to the European observer. "I have seen *ĩtoka* lilies all over the place, but I confess that in the early days they did not strike me at all." [KLC(I):857]. Others, like John Ainsworth rejected outright any notion that the Kikuyu had any specific practice for demarcating *mbari* lands. [KLC(I):497, 508].

4. Colony and Protectorate of Kenya (1929b), Chapter 2.

Boundary demarcation with *exotic* trees slowly became the norm. Kikuyu witnesses to the Land Commission gave evidence that even in the early 1930s, trees such as Eucalyptus and Black Wattle were sometimes planted in rows by themselves or in conjunction with indigenous trees over the spots where *ĩtoka* had originally been planted.[1]

A number of proposals were also made by the Chief Native Commissioner, G.V.Maxwell, that the practice of *ĩtoka* planting or boundary tree planting should be included as rules for Kikuyu areas under the Native Lands Trust Ordinance though they were never implemented.[2]

Trees on other boundaries

Tree planting practices for demarcating *gĩthaka* boundaries were different from the practices which were adopted for marking other boundaries. It is important to distinguish as well between boundary demarcation practices and functional or protective hedge establishment practices.[3]

Sub-divisions within the *gĩthaka* were often marked out. The species which predominated in these boundaries were usually utilitarian in nature. *Mũũũ* (Markhamia hildebrandtii), for instance, was commonly planted along the boundaries of *gĩthaka* subdivisions. It is an obvious tree with bright yellow flowers, but is especially useful in that it coppices easily and can be cropped many times for pole wood. It easily regenerates from cuttings. *Mũkũngũgũ* (Commiphora zimmermannii) shares these characteristics. Young trees of this species are still frequently found in many shambas where they are used to support climbing plants.

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1. Luka Wangana, KLC(I):185; Philip Karanja, KLC(I):145.

2. See for instance, Colony and Protectorate of Kenya (1929b), p.47ff.; and the evidence of Nyeri District Commissioner J.W.Pease before the Kenya Land Commission, KLC(I):1066. The cyclostyled records of meetings convened to discuss the draft rules proposed by the Committee on Native Land Tenure in Kikuyu Province are revealing. See, S.H.Fazan, RH.Mss.Afr.s.1153.

3. Unless otherwise noted, this discussion is largely extracted from Leakey's fascinating botanical appendix. Leakey (1977), pp.1286-1354.

Old *gĩthaka* subdivisions can still be identified where these trees, which grow as high as 20 metres, are found.

Around fortified villages (*kĩhingo*) near the border of Kikuyu country, it was common practice to fell trees and bushes into a barrier, and then to encourage thorny plants to grow around it or noxious creepers to climb over it to make the barrier impenetrable. Plants such as *mũtanda mbogo* (Pterolobium stellatum), *mũyuyu* (Chaetacme aristata), *muutĩ* (Aspilia spp.), and *mũkawa* (Carissa edulis) fall into this category.

Hedges would usually be planted around homesteads. Inevitably, there was some specific utility to the planted hedge -- for medicinal uses, as a famine food, for fodder, or for food. *Mũthakwa wa aathi* (Crassocephalum mannii) falls into this category and is still one of the most frequently found indigenous hedge species in Kikuyu country, particularly in Kiambu District. Its leaves have medicinal value. Other hedge species include *mũigoya* (Plectranthus barbatus), the leaves of which, when packed together with bananas helped to ripen them. *Mũbage* (Caesalpinia decapetala) was a native of Mauritius, but had been in Kenya for a long time, and is still widely planted as a hedge.

Within the homestead, boundaries would often be established between individual huts. *Mũhĩndahĩnda* (Trimeria tropica) and *mũkandu* (Lantana or Lippia sp.) were commonly planted as boundaries between huts. The former was primarily used for making household implements, and the berries of the latter were used as a famine food.

A frequent assumption on the part of the Colonial Administration was that enclosures of these types were an outcome of Kikuyu contact with European farming. The East Africa Royal Commission of 1953-55, for instance, said that enclosure was brought about by the introduction of cash crops and contributed to

the decline in tribal control.[1] In fact, others who noted the presence of these enclosures during the earliest stages of European settlement, particularly Leakey and the Routledges, confirm that these practices were in place long before Africans were exposed to Europeans.



Figure 2: Entrance to a Fortified Kikuyu Village (Murang'a District, around 1907)

Protected Forests and Woodlands

Timber reserves

Timber and fuelwood requirements, then, were met from a combination of sources: from planted trees or trees which were naturally growing on plots and from trees on unallocated *gĩthaka* land. Leakey noted that the *mbari* would sometimes explicitly protect good forest stands for the long-term and sustainable production of timber.[2] The Routledges similarly confirmed the presence of small copses which had been preserved for timber production and which could not be used without permission and until payment had been made variously to a chief, or to the *mbari* elders.[3]

The Karura Forest Reserve, as well as City Park in Nairobi were originally traditional forest reserve areas. As late as 1904, the Karura forest was recognized as one of the few remaining stands which acted as a buffer between the Maasai

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1. Government of the United Kingdom (1955), p.24.

2. Leakey (1977), p.123.

3. Routledge and Routledge (1910), p.39.

and the Kikuyu.[1] It was gazetted as a Reserve in 1912.[2] There are several traditional (and now gazetted) reserve forests remaining in Murang'a District, such as the Marimira Forest, as well as numerous small forested parcels of obscure origins and with unclear tenure and use rights.

The Murang'a Local Native Council took the concept of the traditional forest reserve one step further and claimed in testimony before the Land Commission in 1933 that "the whole of the forest reserve was reserved by Kikuyu for the purpose of obtaining trees for building, for herding, and for firewood for the present and future generations."[3]

Without any doubt, the reservation by the Government of large areas of forests conflicted with the *mbari's* traditional rights of control of these areas. The process of creating Forest Reserves, in itself, destroyed any traditional control the *mbari* may have had over the largest chunks of forests. As soon as it became clear that forests were being placed under the control of the Forest Department, the tendency would have been to overexploit the remaining pockets of woodlands.

The Colonial Administration recognized two types of forests. Forest Reserves, under the control of the Forest Department, were distinct from Native Reserve Forests, which were technically under the control of Local Native Councils, but which in practice were often managed by the Forest Department. Under the Native Lands Trust Ordinance, any lands in Native Reserves could be gazetted as Native Reserve Forests on the recommendation of the Native Lands Trust Board, even in the face of local opposition. By the time of the Kenya Land Commission, many of the remaining pockets of woodlands had disappeared and "in many

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1. E.Battiscombe, KLC(I):411. Battiscombe was an early Conservator of Forests in Kenya.

2. Proclamation, 6.9.1912. East African Protectorate, *Ordinances and Regulations*, Volume 13, p.126.

3. Fort Hall Local Native Council, KLC(I):119.



Figure 3: Road Cleared for Passage through the Nyandarua Forests, 1913

reserves...there (was) little left to preserve."[1] In Machakos District, for instance, it was noted that by 1935, any forests there had long ago been destroyed.[2]

The reservation of forests within the Native Reserves was problematic because it changed the controlling authority from the *mbari* to the Local Native Council, which had little authority in the traditional sense. The Forest Department claimed that such opposition would generally disappear

> "... when local people are reassured that the forests are still to belong to them, and that their old privileges of honey collection, gathering dead and fallen fuel and forests fruits, etc., will not be interfered with so long as they do no harm to the forests, and that finally they will receive any profits that accrue."[3]

It was an obvious contradiction for the Forest Department to claim that traditional rights of access would be recognized in the absence of a traditional authority with rights of control.

Groups of trees were commonly used as points of reference, and many towns and communities in Murang'a and in other parts of Kikuyu country are named after trees (cf.*Mũringaini*, *Mbũyũini*). The old Kikuyu name for Nairobi,

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1. FD 1933, p.21.

2. FD 1935, p.35.

3. FD 1934, p.21.

Kĩĩnūinĩ, referred to a grove of Cassia didymobotrya which grew there.[1]

Sacred groves

The other category of woodland which was preserved by the *mbari* were sacred groves. These were quite small clusters of trees, usually dominated by a *mūgumo* or a *mūkūyū* (Ficus sycomorus) tree, which were the sites of rituals and ceremonies. The extent of these sites is uncertain, but they were believed to be fairly widespread. They had very strong religious and cultural connotations.

Trees had their own spirits. Leakey maintained that when an area of forest had been cleared for cultivation, a number of big trees would be left standing at intervals. Such trees were called *mūrema kĩrĩti* (the trees which resisted the cutting of the forest) and these trees became the dwelling place of the spirits of all the trees which had been felled. The *mūrema kĩrĩti* were not normally felled, but in the event that they became old and were in danger of falling or needed to be felled for timber, a ceremony would be carried out in order to ask the resident spirits to move their abode. In the event an old tree was felled, a young tree would be planted to replace it.[2]

As a result of the Kenya Land Commission, there had been an offer to relocate some of the Kiambu Kikuyu on to land belonging to the Nyeri Kikuyu. Senior Chief Koinange wa Mbiyu objected to the Governor General, H.M.Brooke-Popham:

> "We can never agree to the Kiambu people to take land of Nyeri people. Further more, a large bulk of African people still retain their ancient religious rites and belief that to be removed from their trees, ceremonies and graves of their ancestors is to be suddenly torn in their spiritual body."[3]

A sacred tree, standing alone or in a grove, was chosen as the site for clan

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1. Leakey (1977), p.1308.

2. *Ibid.*, p.1117-1118.

3. Senior Chief Koinange wa Mbiyu to Governor General H.M.Brooke-Popham, dated 5.7.39. RH.Mss.Brit.Emp.s.332.

and sub-clan ceremonies and sacrifices. They were not permanent fixtures, but were only associated with the ruling generation of the clan or sub-clan. A sacred *mũgumo* or *mũkũyũ* tree only had this status for the duration that a particular age grade was in control. It would be uprooted upon the appointment of a new ruling age grade, and a new tree would be chosen in its place. It was essential that the new *mũgumo* had been planted at some time or another, but not necessarily by someone in the new ruling age grade nor at the time of the appointment of the new ruling age grade. Generally, preference was given to a *mũgumo* which had become parasitic on another tree.[1]

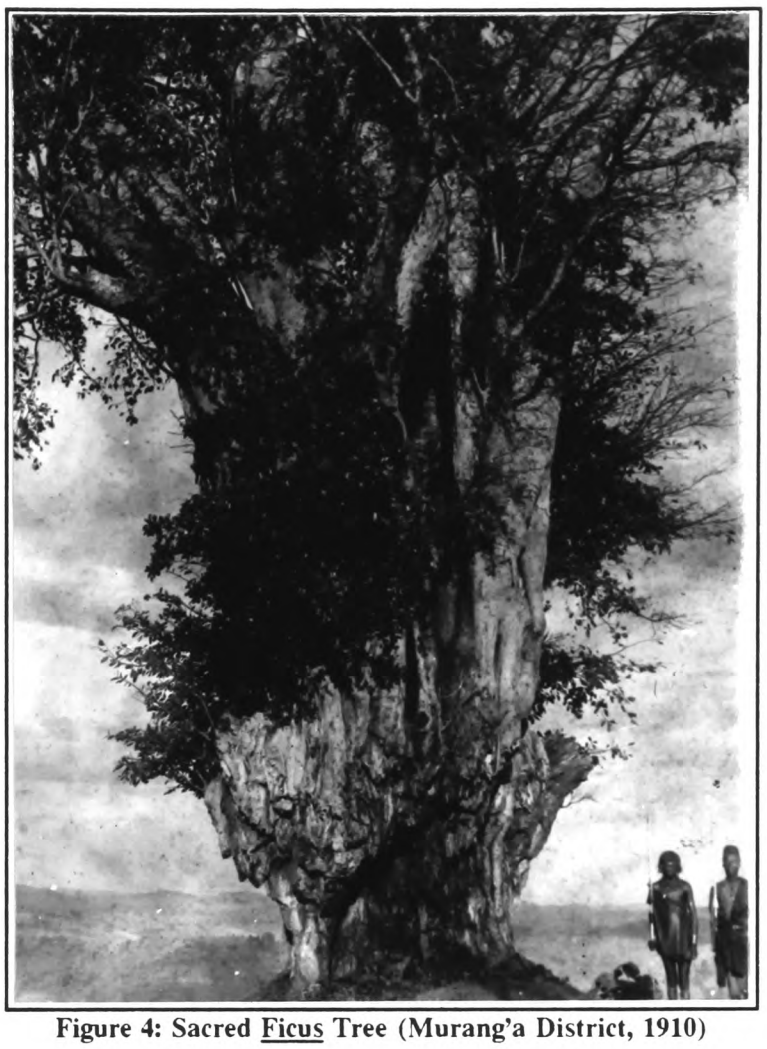


Figure 4: Sacred Ficus Tree (Murang'a District, 1910)

Other Tree Management Practices

Trees and livestock management

The owning of livestock, the fundamental medium of exchange amongst the Kikuyu, generally involved some form of tree cultivation and management. Cattle enclosures (*kĩugu*) were a basic feature of the homestead. Enclosures were generally reinforced with cuttings from fast growing species such as *mũgumo*, *mũrigono* (Clerodendrum johnstonii), and *mũhũtĩ* (Erythrina abyssinica) which eventually formed living fences. In the 1940s, an Assistant Agricultural Officer, L.A.Elmer noted the predominance of *mũtũra* (Solanum aculeastrum or

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1. Leakey (1977), pp.1078-1089.

S.marginatum) which was used in living fences for Kikuyu cattle enclosures. He recommended that European farmers should adopt these species as alternatives to expensive wire fencing and described in great detail how to propagate and plant them out.[1] The wood of *mũbirũ mũirũ* (Vangueria linearisepala) was also used in cattle enclosures, but it was seldom planted as a living hedge.

There were fairly sophisticated strategies of stall-feeding which increased productivity and limited disease. *Mũkũngũgũ*, sometimes planted to demarcate the boundaries of the homestead, was also planted in the main courtyard and was used to suspend fodder for goats and sheep, keeping it free from contamination. Stall fed animals rarely, if ever, suffered from intestinal worms. Usually, small huts would be used for keeping stall fed animals, and they would rarely leave them until they were ready for slaughter. They were prized for their fat content, which would be used for cooking and for preparing skins.[2]

The most common sources of livestock fodder were sweet potato vines. During times of famine, a number of species were used as alternatives. These were generally climbing bindweeds and creepers, called rather generically *ihũrũra* (Ipomea sp. and Glycine sp.). There were just a few tree species which were used for fodder. These included *mũheregendi* (Grewia similis) which made very good goat food, and *mũhethu* (Trema orientalis).

Tree replacement

A final tree planting practice which bears mention was tree replacement. Trees often had negative and positive features to them which might have been associated with an event which took place in the vicinity or which might have been

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1. L.A.Elmer (1944). "Two useful hedge plants for high country", *East African Agricultural Journal* (January). pp.162-165.

2. W.Lyne Watt (1942). "Stall-feeding of goats and sheep by the Kikuyu tribe, Kenya", *East African Agricultural Journal* (October). pp.109-111.

a function of the species and its relationship to spirits and to magic. The ficus *mũgumo* was a tree with particularly strong associations, both positive and negative. They were generally chosen by diviners as sacred trees for the sub-clan, though only specific trees served this function. *Mbari* ceremonies and sacrifices were held by these trees, and persons accused of crimes could seek sanctuary at the foot of a sacred tree. *Mũgumo* trees only had positive associations if they were planted. Naturally-sprouted seedlings were uprooted and a tree with a positive association would be planted in its place.

These trees and woody shrubs were generally *mũthakwa* (Vernonia auriculifera), *mũkenia* (Lantana trifolia) or *mũkeu* (Dombeya sp.). They were commonly used as sacred trees for household ceremonies and sacrifices. *Mũthakwa* was the most common of these. It was widely used in all manner of ceremonies and was associated with "good" magic. It was specifically planted as a replacement tree under three circumstances: to replace uprooted *mũgumo* trees; to replace a tree which had been cut down to make a cattle trough; and to replace a tree which had been used by someone for hanging themselves. *Mũkenia* was planted for the same reasons as *mũthakwa*, but in addition it would be planted in place of a sugar-cane plant which had flowered and been uprooted, or in place of a banana tree which had been slashed in anger with a knife. *Mũkeu* was less frequently planted than these other species, but was still recognized as a "good" tree.[1]

The effect of these practices on total woody cover is unclear. The three species are very frequently found in Murang'a and in other parts of Kikuyu country. *Mũthakwa* is particularly common, easily recognizable because of its deep purple flowers.

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1. Leakey (1977), pp.1313-1314, pp.1343-1344, and p.1347.

Trees as part of Traditional Land-use Practices

Clearly then, there are strong traditions of tree cultivation and management in Kikuyu areas of Kenya. Boundary demarcation with trees was a particularly common practice, both for marking off boundaries of the *gĩthaka* as well as for marking off divisions of the *gĩthaka* and divisions within the household. Trees were planted as living hedges around livestock enclosures, and were incorporated into village fortifications. Trees had both positive and negative magical and spiritual associations, and several species were widely planted because of their "good" characteristics. Timber production largely came from trees which were protected in *mbari* controlled forest reserves, from farm trees, or from trees which had been left standing on farmlands after the forest had been cleared.

Changing patterns of land tenure and the wholesale reservation of large stands of forests by the Colonial Administration probably strengthened the tendency to use trees for boundary demarcation, but jeopardized traditional forest management and reservation practices. Contemporary patterns of tree management share many characteristics with these traditional practices.

APPENDIX 7:
Glossary of Kikuyu Words

This glossary contains the most frequently used Kikuyu and Swahili words used in this report. Definitions are from a number of sources, primarily Benson's *Kikuyu-English Dictionary*, but also from Leakey's *The Southern Kikuyu before 1903*. Botanical descriptions are from Leakey's botanical appendix to *The Southern Kikuyu...* and from Norman Gachathi's excellent *Kikuyu Botanical Dictionary of Plant Names and Uses* as well as from information collected from key informants. Words in this Glossary are in Kikuyu, unless otherwise noted.

aguri — Plural of *mūguri*.

ahoi — Plural of *mūhoi*.

athami — Plural of *mūthami*.

fito — Swahili plural of *ufito*. Small finger-thick branches which are used for the construction of mud and wattle buildings, livestock enclosures, and fences.

Gĩkūyū — Name of the mythical male forbearer of the Kikuyu, to whom God gave all the land south and east of the Nyandarua mountains. Married to *Mumbi*, who bore nine daughters who were the mothers of the nine Kikuyu clans. Also sometimes used in place of Kikuyu which is the orthographically incorrect, but commonly used, form of *Gĩkūyū*.

gĩthaka — sub-clan (*mbari*) land holding. Originally meaning uncultivated bush, the holding was based on rights of first-use, and were derived from hunting, rather than from agricultural traditions.

gĩthūmbi — Term used to describe an impoversihed and often landless person, who, rather than seeking land as a *mūhoi*, chose instead to work on other people's farms in exchange for food. This was more a form of charity than it was wage labour per se.

gĩtoka — The Pajama Lily (Crinum kirkii) which was used to demarcate the boundaries of the *gĩthaka*. The dark flowering variety which was preferred for demarcation was called *gĩtoka kĩirū*.

ihūrūra — A general term for various plant species which vine and twine. Often these were vines of the genus Ipomea and were used as goat and sheep fodder.

irio cia ĩmera — Term used to describe seasonal crops such as maize, beans, millet and sorghum. Literally, it means "foods which sprout." Usually, these were subsistence crops which women were expected to cultivate.

irio cia menja — Term used to describe perennial crops such as taro, yams, cassava and bananas. Literally, it means "food of digging," reflecting the labour task required for their cultivation. Traditional these were famine foods, and were cultivated by men.

ĩthūmbi — Plural of *gĩthūmbi*.

ĩtoka — Plural of *gĩtoka*.

itūūra — Village or collection of homesteads, usually of people connected by kinship.

kaiaba — Dovyalis caffra. Also called kei apple and often used for hedging. Usually impenetrable because it is very thorny.

kariaria Euphorbia tirucalli. Also called Finger Euphorbia, which is often used for hedging in arid and semi-arid lands. Easily propogated from cuttings. Has a thick latex which is highly toxic, and particularly noxious to livestock.

kĩhingo Short tunnel of strong tree-branches at the entrance to a village, which is barricaded at night for protection.

Kikuyu Orthographically incorrect name for *Gĩkũyũ*, refering variously to the language or people or to the mythical tribal forbearer.

Kĩĩnũinĩ Early Kikuyu name for Nairobi, referring to "the place where there are many *mĩĩnũ* (Cassia didymobotrya) trees.

kĩugu cattle enclosure.

mbari Sub-clan of one of the nine Kikuyu clans.

Mbũyũini Swahili place name for the town where the baobab (Adansonia digitata) was growing.

mũbage Caesalpinia decapetala. Also called Mauritius Thorn. A native of Asia, but naturalized in East Africa. Used for hedging around homesteads.

mũbariiti Grevillea robusta. Also called Silky Oak and in Kikuyu, *mũkima*. Native of Australia, but widely planted in fields. Prolific producer of mulch. Is often sidepruned to limit light competition and for fuelwood or small construction timber.

mũbirũ mũirũ Vangueria linearisepala. A small tree, the wood of which was often used for constructing cattle enclosures. The berries are edible.

mũgumo Ficus thonningii. Sacred tree, widely distributed. Easily regenerated from cuttings but seldom found naturally growing. Naturally regenerating trees were often uprooted and replanted with other trees or bushes. Trees would be planted to mark sacred groves.

mũguri Purchaser of land in a redeemable land sale. Usually, land would be sold for livestock for bridewealth or to pay off debts. The land could be redeemed by returning the original number of livestock to the *mũguri*.

mũheregendi Grewia similis. Tree used for constructing granaries. Also produced very good fodder.

mũhethu Trema orientalis. Saplings of this tree were used for building rafters. Leaves were used as fodder.

mũhĩndahĩnda Trimeria tropica. Often planted between huts of a homestead as a living fence.

mũhoi Tenant with cultivation rights on *mbari* holdings. Not allowed to construct a homestead and had to live elsewhere. Land was temporarily lent to a *mũhoi*. The arrangement could be inherited and could be cancelled by the original rightholder. *Ahoi* arrangements were most common when land was abundant and labour to cultivate it, and so to establish permanent tenure, was scarce.

mũhũtĩ Erythrina abyssinica. Cuttings of this tree were commonly planted to reinforce the cattle enclosures and to make living fences.

mũigoya Plectranthus barbatus. Often grown as a hedge, the leaves were used for ripening bananas.

mũiri Prunus africanum. Tall timber tree.

mūkandu Lantana or Lippia sp. Grown as hedges. Lantana was introduced with colonization, while Lippia is indigenous. Branches of both were commonly used for the construction of small buildings and for fencing.

mūkawa Carissa edulis. Bush used for fencing around fortified villages. Is very thorny but with edible berries.

mūkenia Lantana sp. See *mūkandu*. A "good" tree planted in the place of naturally generating *mūgumo* trees.

mūkeu Dombeya sp. Saplings of this tree were favored for timber cross beams. Good timber for beehives. A "good" tree, planted in place of naturally generating *mūgumo* trees.

mūkindūri Croton megalocarpus. Very common tree planted on field boundaries. Produces good fuelwood and has a high canopy that allows light to pass through, limiting crop competition. Often managed as a tightly pruned hedge.

mūkuhakuha Macaranga kilimandscharica. Timber tree used for building poles.

mūkūngūgū Commiphora zimmermannii. Cuttings of this tree were used to mark boundaries within a *gĩthaka*. Also commonly planted in the centre of a courtyard to support fodder for goats and sheep.

Mūkurwe wa Gathanga "The sandy place where the Albizia grows" also variously translated as "the building place." Traditionally held to be the place in Murang'a District where God gave *Gĩkūyū* all the land south and East of the Nyandarua mountains.

mūkūyū Ficus sycomorus. Sacred tree from which the name *Gikūyū* is derived.

Mumbi Name of the mythical female forbearer of the Kikuyu. Married to *Gĩkūyū* and mother of nine daughters who were the mothers of the nine Kikuyu clans.

mūnyago Digging sticks.

mūnyua maai Kikuyu name for Eucalyptus. Literally translated, in means "the drinker of water."

mūramati Lineage authority with rights of control over sub-clan lands. The eldest son of the eldest son...

mūrema kĩrĩti Trees which were left after an area had been cleared for cultivation to become the dwelling place of the spirits of the trees which had been felled. Literally, "the trees which resisted" the felling of the forests.

mūrigono Clerodendrum johnstonii. Branches of this shrub were used for constructing cattle enclosures. Also used as stakes for training yam vines.

mūringa Cordia africana. Large timber tree covered with white flowers. Cuttings of this tree were used for marking *gĩthaka* boundaries.

Mūringaini Place name of the village where the *mūringa* grows.

mūtanda mbogo Pterolobium stellatum. Bush used for living fences around fortified villages.

mūtego Snare or trap for catching small game.

mūthakwa Vernonia auriculifera. Bush with many ritual uses. A "good" tree used for replacing naturally generating *mūgumo* trees.

mūthakwa wa athi Crassocephalum mannii. Shrub commonly planted around homesteads and field boundaries. Propogated by cuttings, the leaves are used for treating gall sickness in cattle.

mūthami Tenant with cultivation rights on *mbari* land. Similar to a *mūhoi* except that a *mūthami* was allowed to construct a homestead. A *mūhoi* had to live elsewhere. Tenancy rights could be inherited, but could also be cancelled by the original rightholder.

mūtūndū Croton macrostachyus. Common boundary tree and sometimes managed as a hedge. Naturally regeneration was reportedly prolific on burnt-over sites.

mūtūra Solanum aculeastrum. Bush planted as a living fence.

muutĩ Aspilia spp. Noxious shrub planted around fortified villages.

mūūū Markhamia hildebrandtii. Freely coppicing timber tree used to mark subdivisions of the *gĩthaka*.

mūyuyu Chaetacme aristata. Shrub planted around fortified villages.

mwatha Synadenium compactum. Tree used for boundary demarcation. Has bright red leaves and white latex.

ngundu Name for a sub-clans holdings, similar to *gĩthaka* but in less common usage.

ngwatio Form of labour organization involving reciprocal labour use during times of peak labour demand.

Nyandarua Proper name for the Aberdare Mountains, which form the western boundaries of what were traditionally Kikuyu lands.

riika an age group.

rūgongo A ridge lying between two rivers in Kikuyu country. Ridges were often formally recognized territorial units sharing similar social obligations.

shamba Swahili for a smallholding.

taatha The undigested contents of a goat's stomach, used for ceremonial purposes such as the marking out of *gĩthaka* boundaries.

wĩra Used to describe large work parties which would be convened on particular holdings to complete big tasks such as digging. The person whose land was being attended to would be required to provide beer, at least, and sometimes food as well.

PRONUNCIATION OF THE KIKUYU ALPHABET

Letter	Description	Example
	CONSONANTS	
b	voiced weak bilabial fricative	bĩbĩbĩbĩ
c	voiceless prepalatal affricate (the sound varies with the individual, resembling *ch* in *chop* or *sh* in *shop*)	cũcũ
g	voiced weak velar fricative	igego
h	glottal fricative, often voiced	haha
k	voiceless velar plosive	aka
m	voiced bilabial nasal	muuma
mb	prenazalized voiceless bilabial plosive (a single sound-unit with nasal kick-off)	mbeme
n	voiced alveolar nasal	nene
nd	prenasalized voiced alveolar plosive	ndundu
ng	prenazalized voiced velar plosive	nganga
ng'	prenasalized voiced velar nasal (as in *singing*)	ng'ang'a
nj	prenasalized voiced prepalatal affricate	njanja
ny	voiced palatal nasal	inyanya
r	voiced alveolar flap (a single tap of the tongue, not a roll)	raara
t	voiceless dental plosive (in some areas, alveolar plosive)	tũtĩ
th	voiced weak dental fricative (as in *that*)	thutha
w	voiced labiovelar semi-vowel	wĩra
y	voiced palatal semi-vowel	aya
	VOWELS	
a	central open	tama
e	front half-open	heha
i	front close	thithi
ĩ	front half-close	gĩko
o	back half-open	hota
u	back close	tura
ũ	back half-close	tũra

From: T.G.Benson. *Kikuyu-English Dictionary*. Oxford, Clarendon, 1964.

APPENDIX 8:
Charcoal Production, Marketing, and Pricing

Background

The main fuel used for cooking amongst urban households in Kenya is charcoal. Although fuelwood may be cheaper in terms of the amount of energy delivered to the pot,[1] charcoal retains clear advantages over fuelwood as a household fuel: its energy content per weight is around twice that of fuelwood; it can be burnt more efficiently; it is relatively easy to cook with, and it is smokeless. For a number of reasons, it is more easily supplied and marketed in urban areas.

Remarkably little has been written about the charcoal economy in Kenya, though it has long operated to provide urban domestic energy supplies. For many years as well, external markets for charcoal, particularly in the Middle East, generated significant sources of capital for African entrepreneurs. As recently as 1975, these exports were reportedly valued at around £90 million a year.[2]

Even in parts of rural Kenya, especially in areas with a predominance of cash crops, charcoal is becoming an increasingly important household fuel, and markets for it are becoming fairly widespread. The largest urban centres of demand -- in Nairobi, Mombasa, Nakuru, and Kisumu -- will likely continue to have a dominant influence on the overall supply/demand balance.

Charcoal is widely used in a number of other African countries (such as in Tanzania and Sudan) but is less commonly used in others (such as in Zimbabwe and Botswana). Its use seems to be more common along old Arabic inland trading

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1. M.Jones (1985). "Pricing," *Kenya Peri-Urban Charcoal/Fuelwood Study* Working Paper III. Washington, D.C., Joint UNDP/World Bank Energy Sector Assessment Programme. p.11.

2. J.Barry (1975). "Elephants, Charcoal and the Rape of a Nation," *Sunday Times*, 24 August 1975.

routes.

By the early 1920s, markets for charcoal were reportedly well developed in Nairobi. Karen Blixen -- that romantic chronicler of early settlement and farming in the highlands -- recorded her failed attempt, probably around 1920, to produce charcoal from the forests in the vicinity of her coffee plantations. Her idea was

> "... to burn charcoal and sell it to the Indians of Nairobi, at a time when we were, on the farm, more than usually hard up. There were thousands of rupees in it...(but) our charcoal burning, in the end, was no financial success. From time to time it would happen that one of our kilns caught fire, and there was our profit gone up in smoke."[1]

Amongst the Kikuyu, knowledge of charcoal burning probably predates the slave trade, as it was an important input used by metalsmiths. Leakey describes the smithing process in some detail, and notes that smelting was usually carried out using charcoal which was made from *mūthati*, *mūthĩga*, *mwathathia*, or *mūhūtĩ* wood (Ocotea usambarensis, Warburgia ugandensis, Erythrina abyssinica, and Olinia usambarensis respectively).[2]

Sources of Charcoal

Land clearance and woodland harvesting

Currently, the largest sources of charcoal supplies for urban areas come from the non-sustainable 'mining' of closed-forests, bush, and savannah rangelands. In both cases, charcoal production is largely the result of land improvement practices which are carried out in preparation for agricultural development: the clearing of closed high forests generally precedes land development for crop production; the clearing of savannah rangelands makes the land much more suitable for raising livestock. Charcoal production, then, has largely been carried out as a salvage operation, making use of woody biomass which would otherwise have been destroyed on-site. The wood used for producing charcoal has no

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1. K.Blixen (1937). *Out of Africa*. London, Putnam and Co., p.147-148.

2. L.S.B.Leakey (1977). *The Southern Kikuyu before 1903*. London, Academic Press. p.306.

intrinsic stumpage value: indeed, there is a cost to the farmer to leaving trees standing in terms of crop production foregone. Supplies of charcoal produced as a result of land clearance operations are of course limited and this type of production is not sustainable in the long term.

In some areas, particularly in arid and semi-arid lands, charcoal burning is being undertaken only to supplement household incomes and is not associated with any particular land clearance exercises. Charcoal burning becomes a dominant form of income generation and increases in intensity when other types of activities fail to produce sufficient household income, for instance, during the dry season or during extended periods of drought. This type of practice may be sustainable, depending on the productivity of the local bush and on how intensive the practice has become. Savannah woodlands can regenerate over time, provided root stock is left undisturbed or if there are enough remaining seed trees. Land clearance which precedes agricultural expansion, on the other hand, virtually destroys any possibility of natural regeneration.

Sustainable production from wattle woodlots

Charcoal production is a key feature of wattle woodlot management. Although it was not always the case, charcoal which is produced from the wood of black wattle trees is worth far more on the market today than is its bark. A hectare of wattle, after 7 or 8 years, can produce around 9 tons of bark (worth around KSh 3,900 farmgate) and around 10 to 15 tons of charcoal (worth around KSh 29,000 farmgate). Particularly around Nairobi where producers are likeliest to obtain the highest prices for charcoal, wattle woodlots can be especially lucrative if they are intensively managed. When woodlots are managed over successive rotations, charcoal production is clearly sustainable.

Markets for charcoal made from wattle trees are nothing new. Wattle woodlots around Nairobi began providing significant supplies of woodfuel from the early 1930s in response to increased urban domestic and industrial demands.

> "... The demand for fuel for domestic and industrial purposes around Nairobi is increasing rapidly and is becoming increasingly difficult to satisfy owning to the limited area of forest within an economic distance of Nairobi... It is likely that the price of fuel will drop when wattle plantations around Nairobi mature."[1]

In 1945, between 700 and 1,000 sacks of wattle charcoal *a day* were being transported the short distance from Kiambu District to Nairobi to meet urban fuel demands.[2]

Export markets were also quite good. Cowen noted that particularly after World War II, exports of charcoal to Zanzibar and the Middle East were substantial. For instance, over a three month period in 1947, a merchant exporter made deals worth over KSh 100,000 on the black market through sales of charcoal to Zanzibar.[3] As with much of the subsequent export trade in charcoal, it passed through informal and unrecorded channels.

Murang'a District also provided significant supplies of charcoal to meet domestic and export market demands. Charcoal which was transported out of Murang'a District to Nairobi was checked by Produce Inspectors at an inspection point in Thika where cesses were collected by the County Council. Records about shipments were kept for many years. Wattle bark was also inspected and graded at this point before shipment to the tanning factory. Figure 1 shows trends in the charcoal and wattle bark trade which originated in Murang'a District from 1949 through 1974.

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1. FD 1929, p.11.

2. KNA AGR/4/220, 21 August 1945. *Wattle Rules and Marketing.* Letter from the Assistant Agricultural Officer, Kiambu to the Senior Agricultural Officer for Central Province.

3. M.P.Cowen (1978). *Capital and Household Production: The Case of Wattle in Kenya's Central Province, 1903-1964* (unpublished PhD dissertation). University of Cambridge, Cambridge. p.200.

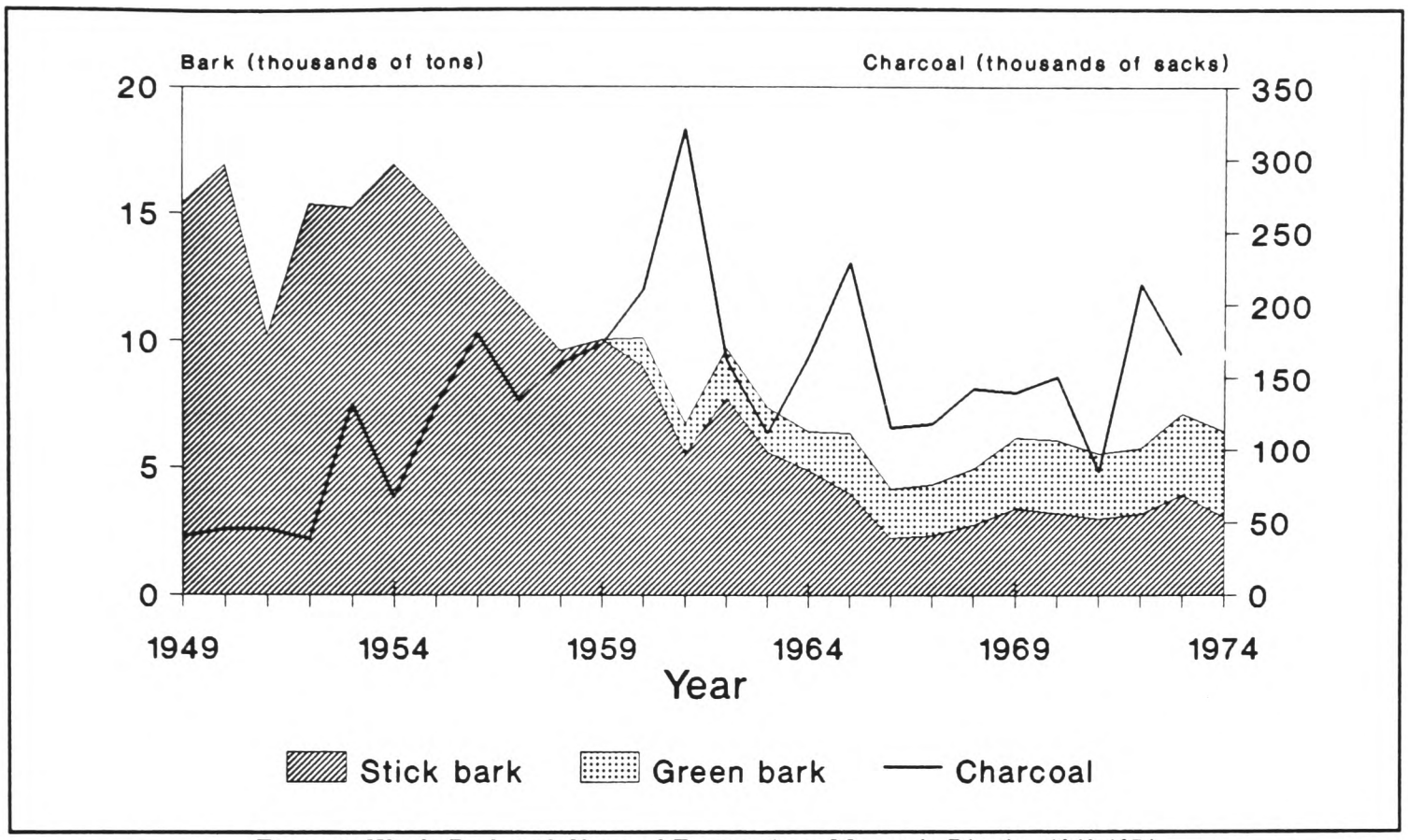


Figure 1: Wattle Bark and Charcoal Exports from Murang'a District, 1949-1974

Figure 1 shows as well how the two production processes complemented each other. Wattle bark production from Murang'a District peaked around 1950, and production declined for nearly every year from 1954. It was the repeated complaint of the tannin factory in Thika that wattle was being harvested before it was mature. The tannin content of wattle bark increases substantially after trees are around 5 years old, and the best tannins are processed from trees which are at least 7 years old. Charcoal, by comparison, could be produced from relatively small trees. Elmer reports that a single charcoal stack, constructed from wattle wood, would require around 300 trees with butt diameters of 10 to 12 cm.[1] These would be trees no older than 4 years or so. While the production of high quality wattle bark depends on there being a relatively low density of trees in a woodlot, returns to charcoal production can be maximized by the management of very dense stands of trees on short rotations. Indeed, as prices for tannins fell and as prices for charcoal increased, farmers tended to shorten the rotation of their woodlots in

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1. L.A.Elmer (1943). "The Kikuyu method of burning charcoal," *East African Agricultural Journal* (July). p.16.

order to produce charcoal. Because these trees were too young to produce high quality bark, bark production fell.

Although some charcoal burning was carried out in conjunction with bark production, particularly of older trees, this was probably the exception.

> "... the main reason, in the past, for bad bark in this district has been the activities of the charcoal burners, who have bought trees standing, mostly immature, and stripped them in and out of season and stored the bark hoping to sell it later. Their main source of living is from the sale of charcoal and they have never paid much attention to the quality of bark."[1]

The other driving forces behind charcoal production were the significant land reforms and changes in agricultural production which followed the Emergency. Land reform, particularly consolidation, eliminated the need for farmers to keep remote parcels cultivated (usually with wattle) in order to maintain use rights. The introduction of tea and coffee in the early 1960s meant land could be used for cultivating higher-valued crops. As the pace of land reform increased, large areas of wattle were cleared and planted with other crops. Charcoal was produced from the cleared woodlots, accounting for the six-fold increases in production between 1952 and 1961.

Export Markets for Charcoal

The export market for charcoal flourished for many years, though it went largely unreported in official records. The Forest Department noted that small quantities of charcoal were exported to Britain through the 1950s and into the 1960s, but these exports never totalled more than 1,000 tons per year.[2] The bulk of the exports were to the Middle East. In the 1960s and 1970s, much of it was exported through a company called the United African Corporation which in fact held a monopoly on exports and on much of the domestic market as well. The

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1. KNA AGR/4/220, 21 August 1945. *Wattle Rules and Marketing*. Letter from the Assistant Agricultural Officer, Kiambu to the Senior Agricultural Officer for Central Province.

2. Forest Department Annual Reports, 1958 through 1963.

chairman of the company, Margaret Kenyatta, was also the mayor of Nairobi -- and the daughter of President Kenyatta.[1] Exports peaked around 1975, and totalled around 100,000 tons that year -- around twice Nairobi's annual consumption of charcoal.

A *Sunday Times* series of articles in 1975, chronicling the abuses of the Kenyatta family, suggested that most charcoal exports were being produced through the wholesale destruction of the Mau Narok forest -- at the time the largest surviving tropical moist forest in East Africa.[2] This is only partly correct. As with most charcoal production, the destruction of the Mau Narok forests was precipitated by the need for land for agricultural settlement. Charcoal was produced as a salvage operation as a result of land clearance. While its export clearly enriched many of Kenya's elite, agricultural expansion -- and not the export market for charcoal -- drove the destruction of these vast forests. Long after the export trade ceased, the Mau Narok forests continued to provide a large proportion of Nairobi's charcoal supplies.[3]

Other significant sources of supply for the export market came from coastal forests. These forests were harvested *specifically* for charcoal production, and not as an outcome of land clearance/agricultural expansion operations. Reports from

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1. The United African Corporation was not the first or the last venture of the Kenyatta family into the energy business. James Muigai, President Kenyatta's brother, was a director of the Kenya Fuel and Bark Supply Company, established in 1943, which sought to become the sole agent for African producers of bark and charcoal. The company also owned Kiburi House in Nairobi, which housed the offices of the Kenya Africa Union before the State of Emergency. More recently, Uhuru Kenyatta (Jomo Kenyatta's son) became a major shareholder in Alpa Nguvu, a company specializing in the sale of solar panels and solar water heating units. Kenyatta's brother-in-law, George Muhoho (also former chairman of the National Environmental Secretariat), sought to develop tree plantations on some of the family's vast estates close to Mombasa for the production of charcoal.

2. J.Barry (1975). "Elephants, Charcoal and the Rape of a Nation", *Sunday Times*, 24 August 1975.

3. P.A.Dewees (1985). "Commercial fuelwood and charcoal production, marketing and pricing," *Kenya Peri-Urban Charcoal/Fuelwood Study* Working Paper III. Washington, D.C., Joint UNDP/World Bank Energy Sector Assessment Programme.

the mid-1970s noted that "the area between Mtito Andei and Kibwezi had been ravaged by the charcoal industry."[1] Unlike land clearance processes which precede agricultural expansion, charcoal production along the coast did not irreversibly damage the vegetation, and much of it has recovered over the last 15 years.

Coastal forests had much earlier been used to provide large quantities of fuel for the railway in the early part of the century and were badly cut over by 1910. They were found to have largely recovered by the mid-1920s, and there were proposals to bring them under sustained yield management.

> "Areas which had been cut over for the supply of fuel (for the railway) 20 years ago had been cut over again within recent years. The information is valuable as showing the re-growth made by the scrub forest in spite of adverse conditions.... Large areas of 'bush' which are traversed by the railway for nearly 200 miles are not the subject of any forest management... but there is no doubt that if they were systematically protected and worked... they could be made to produce a very much larger and at the same time sustained yield than at present."[2]

Despite their potential for regeneration, the devastation of the coastal forests in the early-1970s, to fuel the energy requirements of the petroleum-rich Middle East (which had just vastly increased its prices for crude oil), was hardly palatable either to conservationists or to politicians. Outrage over the destruction of forests resulted in the imposition of several bans on the production and export of charcoal. The earliest bans were imposed in 1971, though they were of limited effectiveness. Complete bans on the export of charcoal were finally officially gazetted in August, 1975. They were widely circumvented through the intervention of State House.[3]

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1. "Charcoal trade: lucrative to a few," *Weekly Review*, 13 October 1975.

2. FD 1924, p.7.

3. In order to strengthen Margaret Kenyatta's close working relationship with her charcoal business contacts in the Middle East, she was slated to be appointed Kenya's ambassador to Saudi Arabia. The Kenyan-assisted Israeli raid to free PLO-held hostages from Uganda's Entebbe airport, and the collapse of the export trade, effectively shelved her appointment. Late in 1976, forgoing another term as Nairobi's mayor, she was (perhaps ironically) appointed by President Kenyatta to be Kenya's Permanent Representative to the United Nations Environment Programme. See: J.Karimi and P.Ochieng (1980). *The Kenyatta Succession*. Nairobi, Transafrica Books. pp.70-71.

Structure and Organization of Domestic Markets

Production

Charcoal production and marketing arrangements have been variously described by Elmer,[1] Dewees,[2] Kinyanjui,[3] and Bess.[4] Kinyanjui categorized producers into three groups: small-scale (producing fewer than 10 sacks per burning cycle), medium-scale (10 to 100 sacks per cycle), or large-scale producers (producing more than 100 sacks per cycle).[5] Of Kinyanjui's surveyed producers, 26 percent were small-scale, 64 percent were medium-scale, and 10 percent were large-scale.

Traditional producers of charcoal from wattle woodlots fall into all three categories. What is characteristic of production from wattle is that conversion efficiencies are quite high. Roundwood is relatively uniform in size, and can be closely stacked before the carbonization process is started. The flow of air to the stack can be carefully controlled. The charcoal which is produced by these kilns is of high quality partly because wattle wood is of relatively high density (around 900 kg per cubic metre) but also because the burning process can be carefully controlled.

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1. L.A.Elmer (1943). "The Kikuyu method of burning charcoal," *East African Agricultural Journal* (July). pp.14-16.

2. P.A.Dewees (1985). "Commercial fuelwood and charcoal production, marketing and pricing."

3. M.Kinyanjui (1987). "Fueling Nairobi: the importance of small-scale charcoal enterprise," *Unasylva* 39(157/158), pp.17-28.

4. M.Bess (1989). *Kenya Charcoal Survey Final Report and Annexes* (draft consultant's report). Nairobi, Long Range Planning Unit (Ministry of Planning and National Development).

5. Large-scale production of charcoal using wattle timber and Missouri brick kilns by the East African Tanning Extracts Company in Eldoret has largely ceased, for reasons having to do with price controls. Until 1987, EATEC produced around 8,000 tons of charcoal annually, principally for markets in Western Kenya.

Elmer described medium-scale wattle charcoal production using traditional earth kilns in the early 1940s.[1] He could have been describing contemporary production practices in Murang'a District. Kilns are built up in stacks using wattle timber (stripped of its bark) which is cut into 2 metre lengths, laid end to end, and loosely packed with dry twigs and sticks. When the stack is close to a metre high, it is entirely covered with a layer of sod, sealing the stack so it is nearly airtight. Four or five evenly spaced vents are left in one end of the stack, which, when completed, is usually around 3 metres wide and 8 metres long. An opening is made at the other end of the stack (which should be facing into the wind) and fire is introduced.

Once lit, the stack must be closely watched and airflows carefully regulated to prevent overcombustion. A stack takes 3 to 6 days to burn. It is allowed to cool for another 2 to 4 days before charcoal is removed, further cooled, and packed into maize sacks (*gunia* in swahili). The top of each *gunia* is packed with wattle branches, bracken, or grass which is then sown down to hold charcoal in the sack. A single *gunia* holds 30 to 35 kg of charcoal. *Gunias* are generally provided by the transporter, who makes arrangements to sell the load of charcoal to a dealer in Nairobi or elsewhere. A team of four or five experienced burners can construct and burn up to a dozen stacks over a month.

Arrangements for the payment of burners vary. Amongst burners interviewed in Murang'a, the most common arrangement seemed to be that the owner of the woodlot would evenly split earnings from the sale of the bark and the charcoal with the burners. Kinyanjui[2] estimated that tree-owners earn around 60 percent of the gross revenues produced by wattle. In any event, considering the

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1. L.A.Elmer, *op.cit.*

2. M.Kinyanjui (1987). "Fueling Nairobi...". p.23.

fact that the owner's costs of production are nil, this generates very high returns for a very small investment, which consists largely of allowing trees to freely regenerate on underutilized fallow land.

Wattle is an exception in the sense that charcoal producers have implicitly paid something for the roundwood. This is usually not the case, as most producers pay virtually nothing for their wood. In land clearance operations, charcoal production is carried out as a salvage operation, and the cost of charcoal at the roadside reflects only the cost of labour for production. The result is that the roadside cost of charcoal produced by salvage operations comes nowhere near to reflecting either its economic or replacement value.

Wattle charcoal, on the other hand, is made from roundwood which has an implicit value. Recalling that wattle tree owners recover 60 percent of the gross revenues from charcoal production, it could be argued that this represents the real stumpage value of wattle timber, the balance being accounted for by conversion and production costs to the roadside.

Transportation to urban centres

A comprehensive study of urban charcoal transportation and marketing arrangements was carried out in 1985 as a pre-investment activity for a World Bank project.[1] Some of this data was updated in recent work. The 1985 study was based primarily on around 150 interviews with charcoal dealers and on interviews with around 300 lorry drivers who were transporting charcoal to Nairobi. While the market situation since then has changed considerably, a few points are worth considering. The 1985 study confirmed, for instance, that agricultural land clearance was providing the largest sources of supplies of charcoal for urban markets. Sources of supplies for primary markets are summarized in Table 1.

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1. P.A.Dewees (1985). "Commercial fuelwood and charcoal...".

Table 1: PRIMARY SOURCES OF SUPPLIES FOR URBAN CHARCOAL MARKETS, 1985

URBAN MARKET	SOURCE OF SUPPLY	TYPE OF RESOURCE	DISTANCE FROM MARKETS (KM)	% OF MARKET SHARE
Nairobi	Kiambu District	smallholder wattle	20 to 100	5%
	Machakos/Kitui Districts	bush clearance for agriculture	80	15%
	Mau Narok forests	forest clearance for agriculture	150	20%
	Mtito Andei	rangeland improvement/bush clearance	200	10%
	Laikipia	bush/forest clearance for agriculture	220	25%
	Baringo	bush harvesting/clearance	240	15%
	Others	..	..	10%
Mombasa	Kwale District	bush/forest clearance for agriculture	50	40%
	Kilifi	rangeland improvement/bush clearance	70	30%
	Malindi	bush harvesting/clearance	100	15%
	Taita-taveta	rangeland improvement/bush clearance	140	10%
	Others	..	..	5%
Nakuru	Eldama Ravine	forest clearance for agriculture	65	25%
	Uasin Gishu District	smallholder wattle	70	15%
	Londiani	forest clearance for agriculture	70	10%
	Baringo	bush harvesting/clearance	80	40%
	Others	..	..	10%
Kisumu	Eldoret	plantation grown wattle	120	40%
	Uasin Gishu	smallholder wattle	130	20%
	Kisumu/S.Nyanza Districts	bush clearance for agriculture	50	30%
	Others	..	..	10%

Source: Dewees, 1985.

Transportation is the most crucial link between rural producers and urban wholesalers and retailers. The efficiency of this part of the supply/demand network is perhaps the most critical determinant of how, and at what price, charcoal will be delivered to urban markets. In rural areas, transport is often required to deliver charcoal from remote areas of production to centralized collection points at the roadside. In urban areas, it is often required to take charcoal from central distribution points to institutional consumers and to other retailers. Clearly, however, the most important transportation link is between rural roadside locations and urban distribution links.[1]

This type of transport contributes most significantly to the cost of delivered charcoal. In Nairobi, for instance, primary transport costs (including overheads

1. This type of transport is referred to as "primary" transport. Transport in rural areas to central collection points and transport in urban areas from distribution points to other wholesalers or retailers is referred to as "secondary" transport.

and profit margins) accounted for fully 45 percent of the retail price of a sack of charcoal. The structure of the retail price of charcoal, for 4 primary markets in Kenya in 1985, is indicated in Table 2 and in Figure 2. Although primary transport costs figure less importantly in the cost structure of charcoal which is sold in other urban areas, differences in the delivered price of charcoal are accounted for mostly by differences in transportation costs -- and in the proximity of supplies to urban markets.

Long-haul primary charcoal transporters operate wherever charcoal demands and prices are sufficiently high enough to guarantee a market for a lorry-load of charcoal. Primary transporters operate in a way to most effectively maximize their profit margins, primarily by reducing their operating costs. The result is that charcoal transporters are either dedicated solely to picking up and delivering charcoal (usually to and from single locations), or instead carry full loads of other commodities up-country and return with a load of charcoal. In this discussion, "return transport" refers to dedicated charcoal transporters who travel up-country empty and return with full loads of charcoal. "Backhaul transport" refers to transporters which travel up-country with a load of goods for local delivery, then return to urban areas carrying a load of charcoal. Of the transporters supplying the Nairobi charcoal market in 1985, only around 10 percent of those surveyed were backhaul transporters.

The degree to which return transporters are involved in the wholesaling and retailing of charcoal is variable. Some transporters are hired specifically to arrange a pickup and delivery for one or more wholesalers or retailers. These transporters are seldom exclusively in the charcoal business, and operate on a for-hire basis. This type of transport is generally the most expensive, in part because of the inexperience of drivers in locating and purchasing charcoal in rural areas, and in

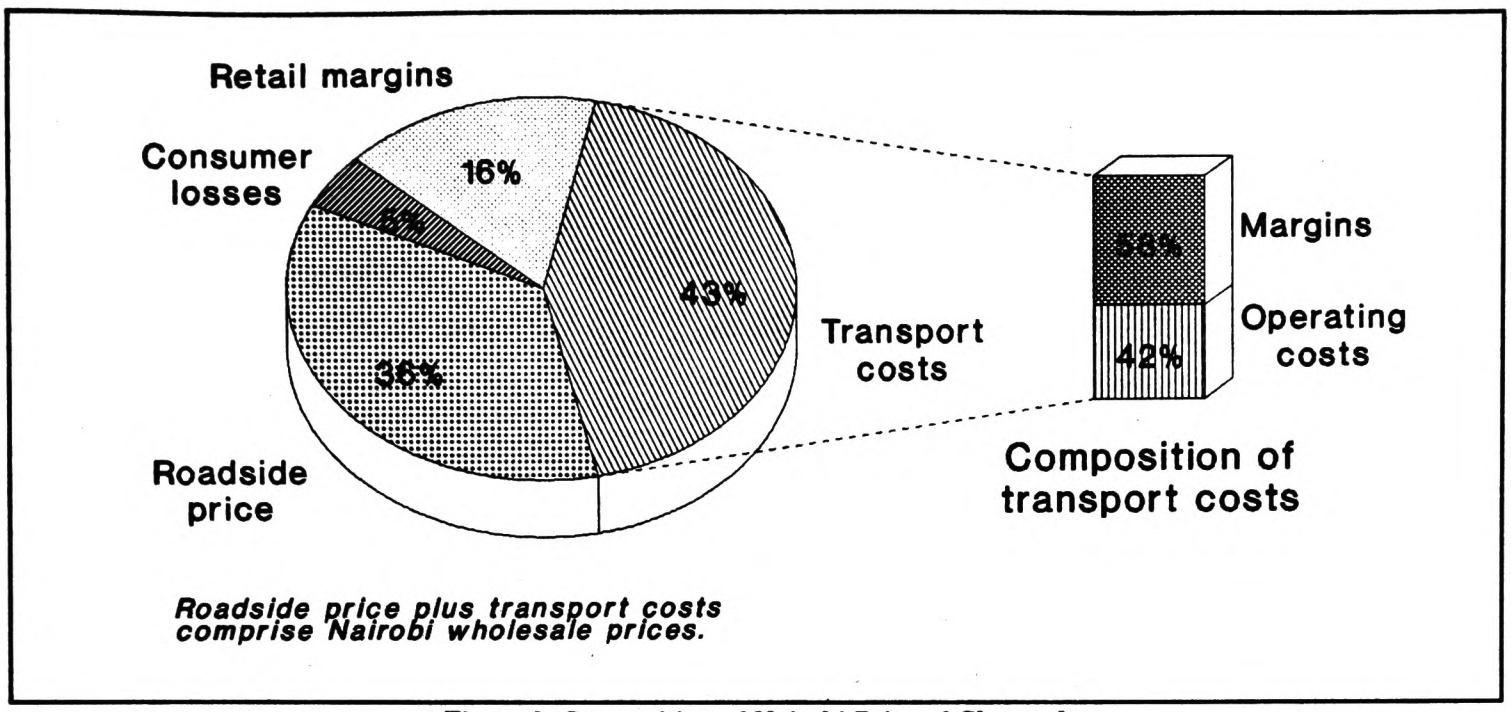


Figure 2: Composition of Nairobi Price of Charcoal, sold by the sack

part because hired transport involves generally higher overheads and operating margins than other types of dedicated transport.

More common are transporters that are exclusively in the charcoal delivery business. Drivers of these lorries are very familiar with areas where supplies can be obtained. They will buy only in relatively large quantities -- 40 to 250 sacks from any single supplier. Suppliers may produce everything themselves, or instead will act as local marketing agents, collecting the production from numerous producers to sell to one transporter. Transporters will usually deliver to a number of urban dealers, or will sell a few sacks to small-scale dealers off the back of the truck.

While return transporters, for the most part, operate independently of urban wholesalers and retailers, an increasingly common trend is the emergence of the retailer-transporter who either owns or has a direct interest in a lorry. For high-volume retailers who have access to capital, the acquisition of a lorry gives them much better control over their supplies and costs and enables them to widen their margins. These margins can be quite large. In 1985, it was estimated that in order to deliver charcoal to most urban markets, transporters incurred costs of around

Table 2: COMPOSITION OF URBAN CHARCOAL PRICES, 1985

Cost item	Urban market centre: Nairobi	Mombasa	Nakuru	Kisumu
Cost of supply:				
Roadside price per ton	557 KSh	499 KSh	540 KSh	790 KSh
Controlled roadside price	600 KSh	600 KSh	600 KSh	600 KSh
Transport distance	196 km	80 km	100 km	122 km
Transport costs per ton				
Operating costs	282 KSh	115 KSh	144 KSh	176 KSh
Transporter's margins	393 KSh	325 KSh	309 KSh	297 KSh
Total transport	675 KSh	440 KSh	453 KSh	473 KSh
Wholesale price per ton				
Off-the-truck	1232 KSh	939 KSh	993 KSh	1263 KSh
Controlled wholesale price	990 KSh	933 KSh	867 KSh	933 KSh
Retailer's losses (KSh/ton)				
when sold by the sack	nil	nil	nil	nil
when sold in small quantities	185 (15%)	94 (10%)	149 (15%)	189 (15%)
Retail margins, per ton				
when sold by the sack	255 KSh	145 KSh	128 KSh	199 KSh
when sold in small quantities	511 KSh	117 KSh	72 KSh	98 KSh
Retail prices, per ton				
when sold by the sack	1487 KSh	1084 KSh	1121 KSh	1462 KSh
when sold in small quantities	1928 KSh	1150 KSh	1214 KSh	1550 KSh
Controlled retail price				
when sold by the sack	1500 KSh	1200 KSh	1133 KSh	1200 KSh
when sold in small quantities	..	..	..	..
Consumer's losses (KSh/ton)				
when sold by the sack	74 (5%)	54 (5%)	56 (5%)	73 (5%)
when sold in small quantities	nil	nil	nil	nil
Consumer's costs, per ton				
when sold by the sack	1561 KSh	1138 KSh	1177 KSh	1535 KSh
when sold in small quantities	1928 KSh	1150 KSh	1214 KSh	1550 KSh

September 1985 prices. Retailer's losses result when charcoal is sold in small quantities because the dealer is generally unable to sell small pieces and dust in the sack. Consumer's losses result because of wastes in the sack which can't be burnt.
Source: Dewees, 1985.

KSh 0.72 per ton-kilometre, while they could actually recover nearly two and a half times this amount -- around KSh 1.72 per ton-kilometer.

In 1985, the return transporters surveyed who were supplying charcoal to Nairobi travelled on average around 200 km (one-way) to collect charcoal. Backhaul transporters generally travelled a lesser distance, but amongst a larger number of suppliers.

A number of studies have indicated that there are seasonal fluctuations in supplies and demands for charcoal, and that there are corresponding price

fluctuations. Nyoike, for instance, noted that retail charcoal prices in Thika increased by 10 percent during the rainy season.[1] Retailers surveyed in Nairobi in 1985 said that rainy season prices were 10 to 40 percent higher than dry season prices.[2] Price fluctuations were reportedly linked to problems that transporters had in travelling during the rainy season, with many rural access roads being virtually impassable. However, charcoal prices collected twice-monthly in 1989 and 1990 showed no seasonal variation to this extent.

Marketing arrangements

Transporters ultimately deliver their loads of charcoal to distribution points in the city, seldom delivering more than 100 sacks to a single dealer, and often selling single sacks off-the-truck. Dealers sell by the sack or by small quantities -- usually in amounts of 1 or 2 kg (but by volume). Household users generally buy charcoal in small quantities, rather than by the sack (except around the end of the month when salaries have been received).

In areas where there are high demands for charcoal, secondary retailers buy single sacks off-the-truck, and divide them, usually by volume, for sale to urban household consumers. The markup for small quantities of charcoal can be as high as 25 percent above the price of charcoal sold by the sack. According to Elmer, secondary sales of charcoal in the early 1940s were unheard of and all sales were by whole sacks.[3] Few dealers now sell exclusively by the sack. Kinyanjui estimated that most retailers in Nairobi sell around 6.6 sacks a day.[4]

Sales by the sack and in small quantities are almost always by volume.

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1. P.Nyoike. (undated). *Report on a Reconnaissance Marketing Survey on Woodfuel Products Including their Dynamics within Murang'a District* (consultant's report). Kenya Woodfuel Development Programme, Nairobi. p.9.

2. P.A.Dewees (1985). "Commercial fuelwood and charcoal...", p.22.

3. L.A.Elmer (1943). "The Kikuyu method of...", p.16.

4. M.Kinyanjui (1987). "Fueling Nairobi...", p.22.

Mombasa markets are an exception, however, where charcoal is almost always sold by weight. This poses something of a problem for consumers, because charcoal is often adulterated by soaking it with water to make it heavier.

Charcoal Pricing

There is simply not enough information about the structure and dynamic of charcoal markets over time to easily conclude that the price of charcoal has been influenced to a greater or lesser extent by specific events both locally and geopolitically. Fluctuations in long term pricing trends, shown in Figure 3, are the result of a number of these events. Effects on the price of charcoal have been introduced by,

-- *Price controls* on charcoal and on paraffin and the extent to which they are enforced;

-- *Fluctuations in paraffin prices*, as paraffin is widely regarded as the closest substitute for charcoal as an urban domestic fuel;

-- *Paraffin subsidies*, which have reduced the price of paraffin considerably, making it a preferred domestic fuel, and have acted on the price of charcoal;

-- *Fluctuations in petroleum prices*, as a large proportion of the market price of charcoal is accounted for by transport costs, petrol and diesel price increases are reflected in the price of charcoal;

-- *Export markets*, substantial in the mid-1970s, acted to constrain supplies;

-- *Monopolies on production and sale,* for many years held by a few individuals and were a form of political patronage;

-- *Local political events*, such as the death of President Kenyatta, bans placed on the export of charcoal, and bans on the felling of trees;

-- *Periods of low rainfall*, during which charcoal was widely burnt to generate income, increasing supplies and lowering prices.

Price controls

As with many price controls in Kenya, controls on the price of charcoal are post-Colonial relics. Price controls on charcoal were first imposed quite early, in the 1940s, at the same time as more rigid controls on the production of wattle bark were being imposed. Close market controls during and after the State of Emergency were used to favour growers of wattle and others who remained loyal

Table 3: CONTROLLED CHARCOAL PRICES

Maximum price in KSh per 30 kg sack or in (KSh per ton)			
Burner's Price	Wholesale or Hauler's Price	Retail Price	Place of sale
18 (600)	33 (1,100)	45 (1,500)	Nairobi area.
18 (600)	28 (933)	36 (1,200)	Mombasa, Thika, Kakamega, Kiambu, Kitale, and Kisumu municipalities.
18 (600)	26 (897)	34 (1,133)	Embu, Meru, Machakos, Nyeri, Nakuru municipalities; Ngong township; Kiambu, Bungoma, Nyeri, Kakamega, Busia, Kisii, Murang'a, Siaya, S.Nyanza, Lamu and Kisumu Districts (excluding Kiambu, Thika, and Kisumu municipalities).
18 (600)	24 (800)	32 (1,067)	Eldoret municipality; Malindi township; Kitui, Machakos, Kilifi, Garissa, Nandi, Meru, and Nakuru Districts (excluding Machakos, Meru, Nakuru, and Nyeri municipalities).
18 (600)	22 (733)	30 (1,000)	Isiolo, Kajiado, Kericho, Mandera, Marsabit, Taita/Taveta, Tana River, Trans Nzoia, Uasin Gishu, Wajir, and W.Pokot Districts (excluding Kitale and Eldoret municipalities and Ngong township).
18 (600)	20 (667)	28 (933)	Laikipia, Elgeyo-Marakwet, Samburu, Narok, Turkana, Kirinyaga, Nyandarua, Kwale, and Baringo Districts.

Effective from 24 May 1983.
Sources: Price Control Act (Cap.504); Price Control (Charcoal) Order of 1982 as amended. Legal Notices 29/1982; 183/1982; and 82/1983.

to the Government. Loyalist transporters, for instance, were favored when transport permits were issued.[1]

Charcoal prices continue to be controlled. Current gazetted controlled charcoal prices are shown in Table 3. The last time prices were gazetted was in 1983.

The gazetted size of a sack of charcoal is 30 kg, but in practice, sack weights are highly variable. For instance, in 1985 market survey, sacks averaged 37.2 kg in weight. If anything, sacks have increased in weight over time. Elmer reported

1. KNA DC/MUR/3/2/20. 2 December 1952. *Agricultural Policy Fort Hall, 1939-57.* Letter from the DC Fort Hall District to the DC Thika District, "Marketing of Charcoal".

that sacks weighed around 31.8 kg in 1943.[1]

Although retail prices in Nairobi are not supposed to exceed KSh 45/- per sack (according to the schedule of controlled prices), current prices are around KSh 150/- per sack. In retail markets, price controls are, effectively, ignored. In 1985, they were still enforced, but only loosely. Nonetheless, it would be fair to say that they are politically expedient, even though they are not rigidly enforced, and that an attempt to remove them altogether would be widely resisted.

In the early 1980s, the largest single producer of charcoal in Kenya, East African Tanning Extracts, sought to sell charcoal produced in its highly-efficient brick kilns at fair market prices. The District administration intervened, and told the company they would be in violation of the Price Control Act if they did so. As a result, EATEC stopped producing charcoal altogether. They continue to sell their wattle timber as *fuelwood* to anyone who wants to buy it, and make their charcoal kilns available as a "public service."

The price of fuelwood *is* controlled (at around KSh 43 per ton, delivered), but these price controls were last revised in 1957.[2] As a result, price controls on woodfuel were long ago forgotten, and EATEC sells its fuelwood (in 1989) for around KSh 300/- per ton at the roadside.[3]

Long term pricing trends

Charcoal and paraffin prices on Nairobi markets have been collected as an input into the basket of goods used to calculate the Consumer Price Index since Independence. This price series (deflated by the low income price index) is shown graphically in Figure 3. It is often argued that paraffin is the main substitute for

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1. L.A.Elmer (1943). "The Kikuyu method...," p.16.

2. Price Control Act, Cap.504. *Price Control (Woodfuel) Order* (L.N.234 of 1957).

3. Interview with H.F.von Kaufmann, Managing Director, East African Tanning Extracts Company, 5 April 1989.

charcoal in urban areas. Because of this, it is useful to examine charcoal prices vis-a-vis paraffin prices. An understanding of the market also helps to explain price fluctuations over time. Three particular pricing periods are of special interest: from 1963 through 1972; from 1972 through 1985; and after 1985.

In the first period, charcoal prices remained relatively constant from 1963 to 1966, then showed a substantial increase through 1972. Over the same period, there were very small fluctuations in the price of paraffin, though in general, prices declined slightly. Price increases in the charcoal market may have reflected increasing competition between domestic markets and the export market. In 1967, Kenya exported 2,500 tons of charcoal. By 1972, this had increased to around 45,000 tons.

Domestic and export prices are instructive. While a sack of charcoal could be purchased on the Nairobi market for around KSh 1.50 (in constant 1985 prices), in the Middle East, it was worth around KSh 50. It is perhaps surprising then, that price increases on the Nairobi market between 1966 and 1972 were so modest. The price impacts of the export market were likely buffered by the substantial added transportation costs which had to be incurred by transporting charcoal from upland areas to the coast for shipping. Much of the export market was dependent on supplies from coastal areas, particularly along the road between Mombasa and Kibwezi.

It also must be kept in mind that charcoal exports were controlled by a monopoly, which functioned through the late 1970s. The monopoly, with strong local political ties, was easily able to fix prices and price controls on domestic production. In order that the monopoly retained its political advantage, it had to ensure that charcoal supplies on the domestic market were abundant, prices were low, and that the domestic market was not being constrained by export market

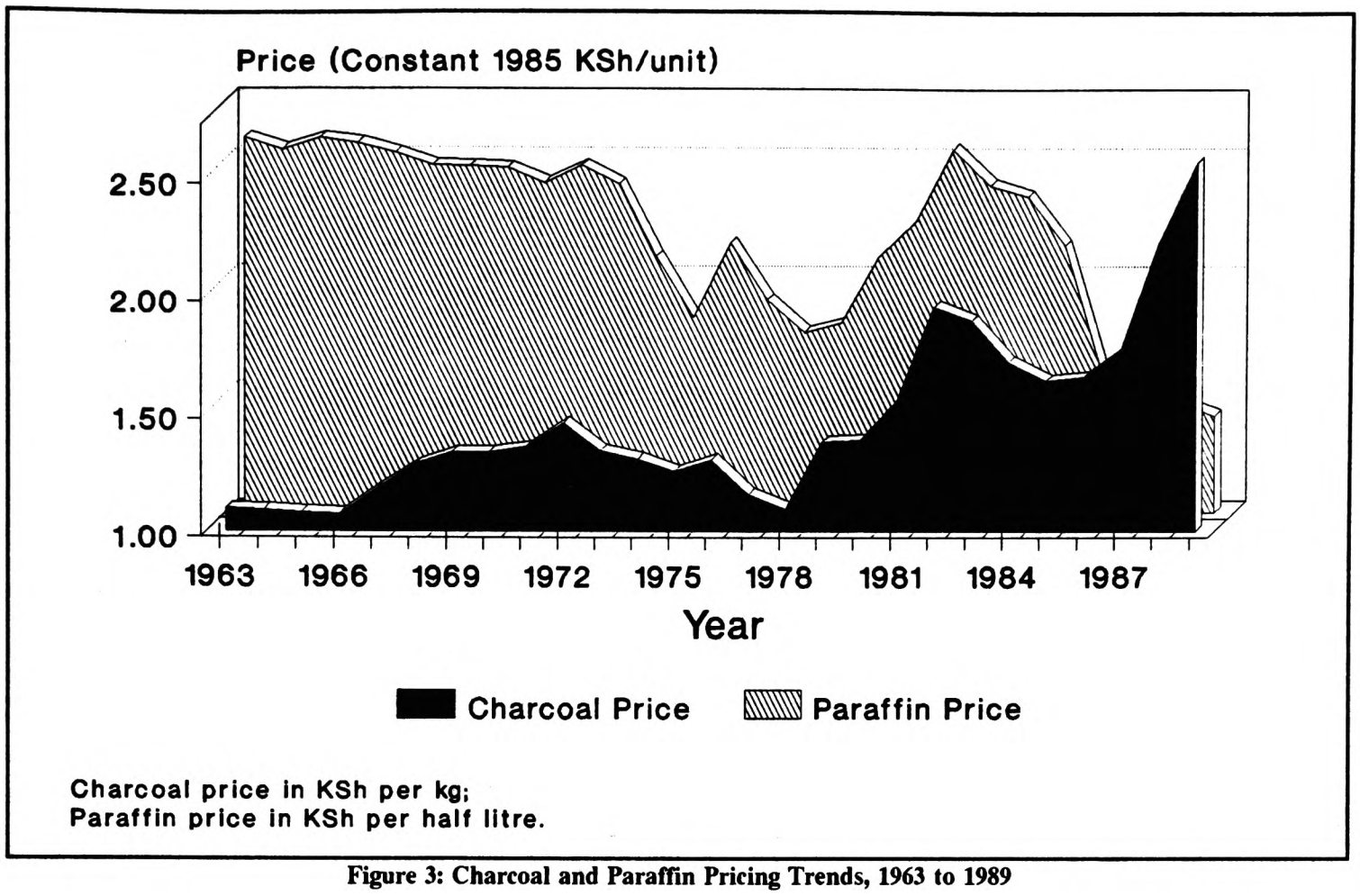


Figure 3: Charcoal and Paraffin Pricing Trends, 1963 to 1989

demands.

Relative paraffin price stability over the same period partly reflects stability in international petroleum markets. Kenya began refining its own products from crude imports in 1965, when a refinery was opened in Mombasa. The amount of paraffin produced depends on the fractional refinery output, which may be determined by priorities for other petroleum products such as for diesel fuel. If insufficient paraffin is produced to meet market demands, the balance is provided by imported refined product. Kenya also re-exports considerable quantities of refined product, and so it is problematic to conclude just how much domestic consumption is met by locally produced or imported paraffin. Sales of paraffin are compared with constant prices in Figure 4.

There is little evidence from the pricing information that, between 1963 and 1972, paraffin and charcoal were easily substituted as domestic fuels. If paraffin and charcoal were effective substitute cooking fuels, it could be expected that increased charcoal prices would be reflected in increased paraffin prices. This is

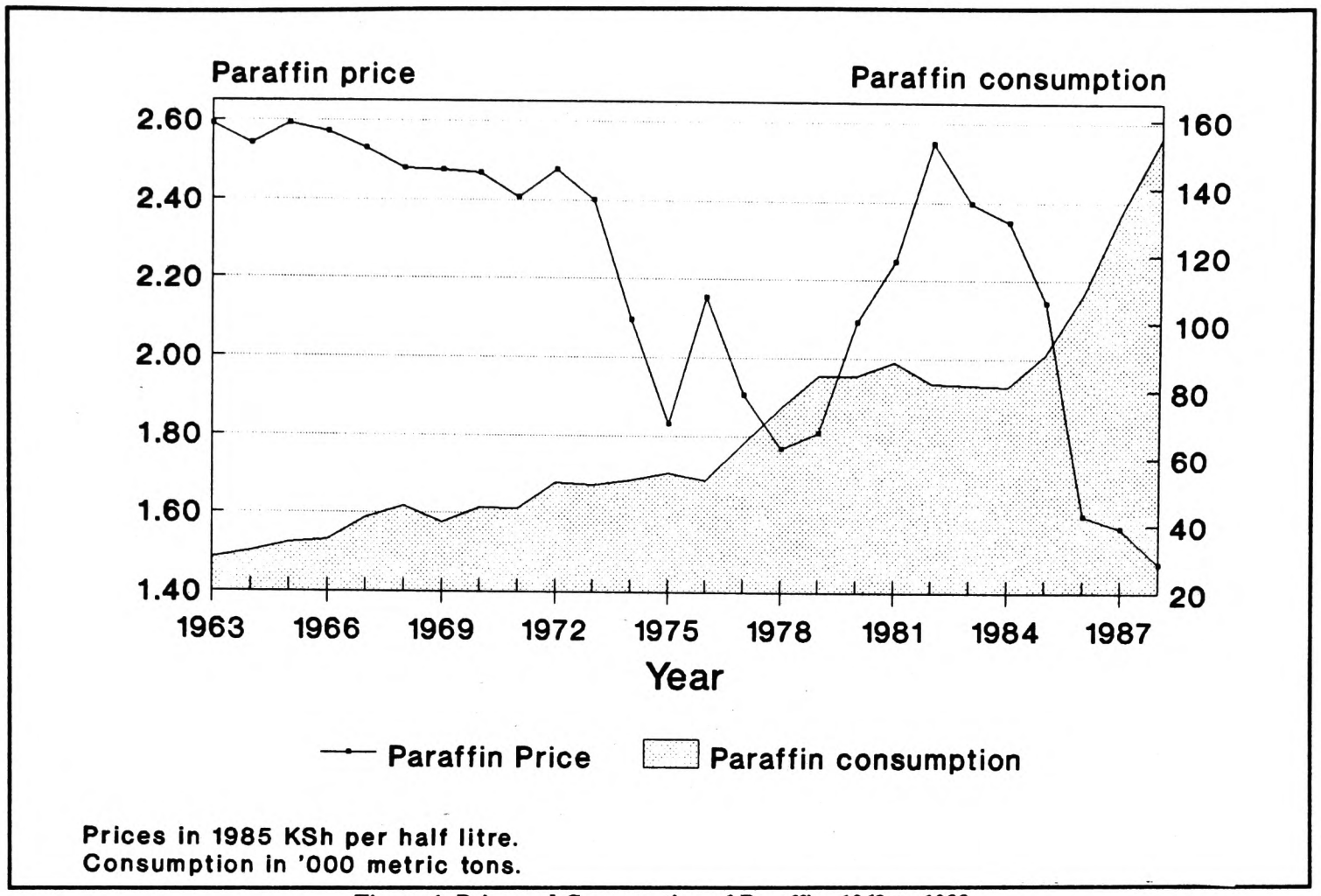


Figure 4: Price and Consumption of Paraffin, 1963 to 1988

not the case, as charcoal and paraffin prices were negatively correlated (r=-0.87, significant to 1 percent). During this period, it is likely that paraffin was mostly used for lighting, rather than for cooking, as, compared to charcoal, it was relatively expensive. Despite the nearly 50 percent increase in price over the period, charcoal maintained significant price advantages over paraffin as a domestic cooking fuel.

The situation appears to be quite different over the second period, from 1972 to 1985. Charcoal and paraffin prices both declined between 1972 and 1978, with small price rises in 1976. Declining paraffin prices following the 1973 oil crisis do not reflect changes in international prices for petroleum products. Prices for both commodities consistently rose between 1978 and 1982, and then fell again between 1982 and 1985. Charcoal and paraffin prices are positively correlated during the period (r=0.74, significant to 10 percent).

If trends in paraffin consumption are considered, paraffin price effects on demand are evident. Demand rose slowly between 1963 and 1976, at a rate of less

than one percent per year. Between 1976 and 1982, demand rose by around 3 percent per year perhaps as consumer preferences for cooking fuels slowly shifted from charcoal to paraffin. Between 1979 and 1982, there were substantial increases in the price of paraffin and demand fell until 1984.

Declining prices of charcoal between 1972 and 1978 may be partly related to the closure of export markets as well as to declining paraffin prices. The first export bans were imposed in 1971, but they had little effect. Other bans followed in 1973 and 1975. The bans themselves did not prohibit the burning of wood to make charcoal, but merely banned the export of charcoal from Coast Province. Despite a total ban on charcoal exports, imposed in April 1975 (and gazetted in August), they continued for some time.[1]

A concern over keeping control over the monopoly in the face of political pressures against exports may have helped to force prices down for a period. The maintenance of the monopoly became increasingly difficult in the face of political opposition to it, and with the appointment of Margaret Kenyatta as Kenya's Permanent Representative to the United Nations Environment Programme in 1976. It was hardly a position from which she could defend continued exports.
The monopoly held by the Kenyatta family was finally ended with the death of Jomo Kenyatta in 1978 which may well have been linked to a period of substantial price increases which began that year.

Charcoal prices also tend to fall during extended periods of low rainfall. Rainfall (measured at Kiambu) was below average from 1972 through 1976. During low rainfall periods, supplies of charcoal become more abundant because it is produced in dryland areas to generate income.

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1. "Charcoal trade: lucrative to a few," *Weekly Review*, 13 October 1975.

Unlike declining prices following the 1973 oil crisis, subsequent price increases in both the paraffin and charcoal markets mirrored the unstable situation in the Gulf, with the second oil shocks which came between 1979 and 1982. While charcoal price fluctuations partly reflect fluctuations in the price of paraffin as a substitute fuel, some variability is also due to fluctuations in production and delivery costs, which are also a function of the price of petroleum products. Transport costs, for instance, account for somewhere around 45 percent of the market price of charcoal sold in sacks. It could be expected that fluctuations in the price of diesel fuel would also account for fluctuations in the market price of charcoal. This does not explain, however, why the price of charcoal fell following the 1973 increases in most petroleum product prices.

Indeed, the first oil shocks in 1973 appeared to have no impact whatsoever on the price of paraffin. Steep falls in the price of paraffin took place between 1972 and 1976. This was likely because government was able to buffer fluctuations in the price of paraffin, and indeed, took conscious and clear steps to subsidize the consumption of paraffin while it sold other petroleum products at a proportionately higher price. This was, and continues to be, a key feature of Kenya's domestic energy policy.

Another extended period of low rainfall was encountered between 1983 and 1986, when rainfall was below average. This period also coincided with a period of declining charcoal prices, and may be related to increased production of charcoal to generate income in dryland areas.

This is what predominantly characterizes pricing trends in the paraffin market, in the third period, since 1985. Since 1985, the price of paraffin has fallen, in real terms, by a third while consumption has increased by over 70 percent. During the same period, however, charcoal ceased to show signs of being an

effective substitute for paraffin, as its price increased by over 65 percent despite the substantial fall in the price of paraffin.

Charcoal prices during this period reflect both lower demand for charcoal as well as supply constraints. With the shift in demand to paraffin, it could be argued that retailers are seeking to maintain their gross margins in the face of lower demands, and so have increased retail charcoal prices, while selling lower quantities. Producers similarly have cut back in production, knowing that charcoal will go unsold.

There may be real supply constraints as well. Around 1986, the President imposed a ban on the felling of indigenous trees. The utilization of timber from closed forests stopped around that time, and production shifted almost entirely to plantation-grown timber. The ban was, at the time, hardly credible, as large areas of land were still being cleared for agricultural development. Price increases however may reflect supply constraints which have resulted from the ban.

Paraffin subsidies

An assessment of the extent to which paraffin prices are cross subsidized by other products -- and the consequent impact on the price of charcoal -- is difficult to make because of a lack of time series data. In 1984, it was reported that around 10 percent of the price of paraffin was accounted for by subsidies, while petrol was being sold for around 12 percent more than its value.[1]

Paraffin and jet fuel are distilled from the same fractions of crude oil and are in all respects identical products. In order to assess the impact of subsidies on paraffin pricing trends, the c.i.f value of jet fuel was compared with the market price of paraffin, over time, in Figure 5. The price of jet fuel fluctuated widely, from 75 percent more than the mean price, to around 60 percent less than the

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1. M.Jones (1985). "Pricing," p.15.

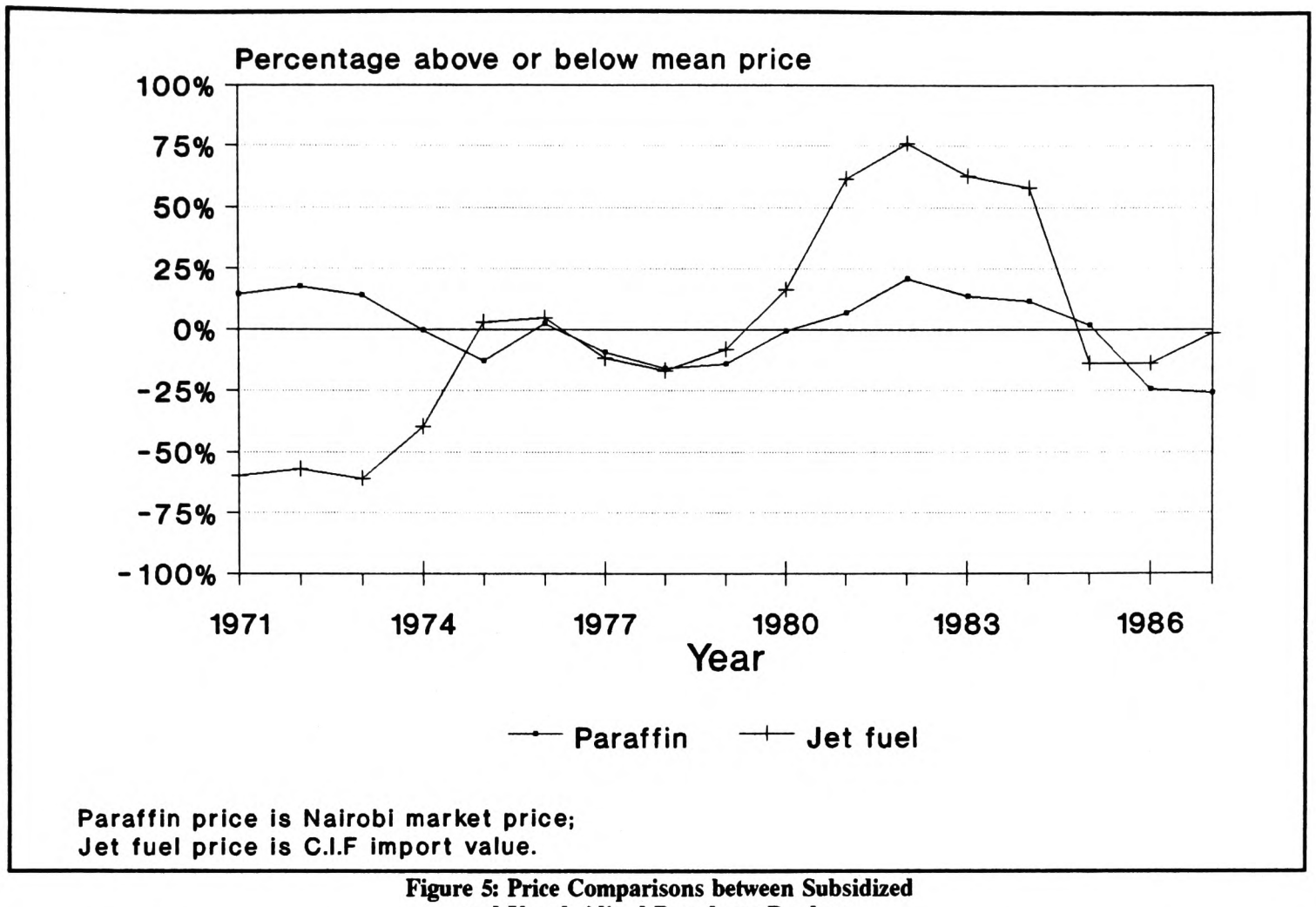


Figure 5: Price Comparisons between Subsidized and Unsubsidized Petroleum Products

mean price. The price of paraffin, however, fluctuated much less -- no more or less than 25 percent of the mean price over the period. The main impact of subsidies appears to have been to limit the consumer's exposure to large price fluctuations.

The Government's current policy towards paraffin subsidies is that they are necessary to reduce charcoal consumption.[1] Since 1985, there has been no clear relationship between the price of paraffin and the price of charcoal so it appears that this argument is not particularly tenable. From the data in Figure 5, there is a much stronger case to be made that paraffin subsidies have served primarily to buffer consumers from price fluctuations, rather than encouraging the use of paraffin as a domestic fuel instead of charcoal.

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1. Republic of Kenya (1989). *Development Plan, 1989-1993.* Nairobi, Government Printer. p.179.

Seasonal price changes

Between April 1989 and September 1990, charcoal and paraffin prices were monitored in 6 different market centres in Nairobi. The monitoring exercise involved purchasing small quantities of charcoal from dealers in each market, checking the price of charcoal sold in each market by the sack, and checking the price of paraffin sold by small quantities and sold at the pump. The markets were selected because they seemed to be representative of areas with different economic characteristics. Briefly, these markets could be classified in 3 groups:

-- Low income areas. Kibera, Eastleigh and Mathare Valley markets serve large low income populations, highly dependent on the use of charcoal as a domestic fuel.

-- Middle income/institutional markets. Kipande Street markets service the middle income areas of lower Parklands, with their large Asian populations, as well as institutional users such as food kiosks and hotels.

-- Upper middle income/institutional markets. Parklands markets service the upper middle income areas of Parklands and Westlands (again with large Asian populations). Ring Road markets service institutional users.

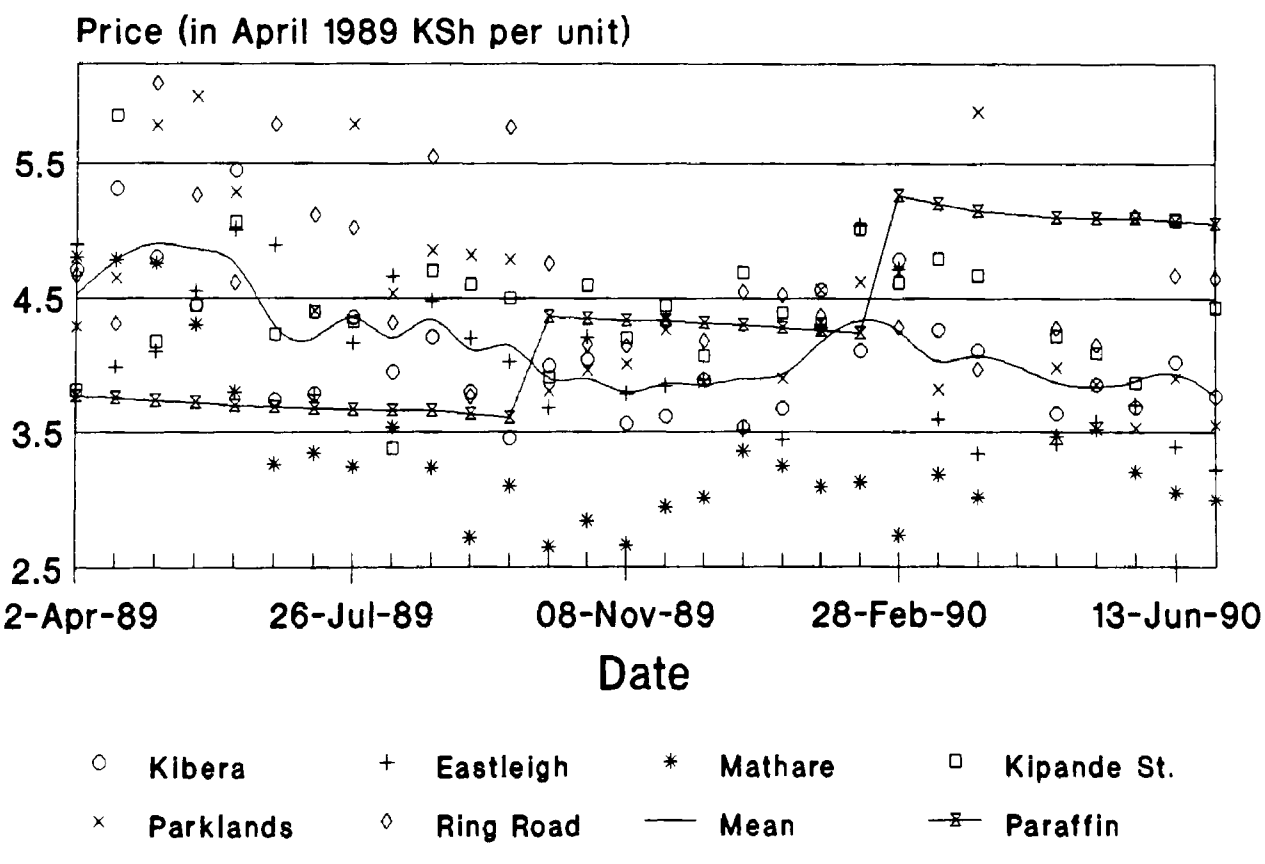


Figure 6: Seasonal Pricing Trends of Charcoal and Paraffin, in six Nairobi Markets

Figure 6 show pricing trends over the year for charcoal sold in small quantities and for paraffin sold at the pump. Paraffin is sold in intermediate markets in small quantities (usually in 300 ml Coca-cola bottles) for 30 to 50 percent above the pump price. These prices fluctuate with the pump price. The pump price of paraffin increased twice, totalling 30 percent, over the study period.

In four of these markets (Eastleigh, Ring Road, Mathare, Parklands), the price of charcoal was found to be significantly correlated (to 5 percent) to the pump price of paraffin (t=-3.66, -2.40, -2.24 and -2.23, respectively). Over the year, the real price of paraffin increased by around 30 percent, while the average price of charcoal dropped by around 20 percent.

Highest charcoal prices were found in the Ring Road (KSh 4.7 per kg, σ=0.64) and Parklands markets (KSh 4.6 per kg, σ=0.74). Ring Road markets deal more with institutional consumers, and sell relatively little charcoal in small quantities, which accounts for why these prices may be higher. Parklands markets sell to higher income households, which are more dependent on LPG gas and electricity for cooking. These markets also showed greater variability in price over time than did most other markets.

Charcoal prices were lowest in Mathare Valley (KSh 3.3 per kg, σ=0.66), Eastleigh (KSh 4.2 per kg, σ=0.51), and Kibera markets (KSh 4.2 per kg, σ=0.54). These are all areas of high population density and low income. Of these markets, price variability was least in Eastleigh.

Kipande Street markets sold at slightly higher prices than markets in low income areas (KSh 4.5 per kg, σ=0.48) but showed the least variability in price over time. In interviews with these dealers, they seemed much more regularly and better supplied than other markets.

Prices and changes in the market

Three particular pricing periods of interest have been identified here. Between 1973 and 1972, the price of charcoal rose, while the price of paraffin fell. Between 1972 and 1985, fluctuations in the price of paraffin are reflected in fluctuations in the price of charcoal: as the price of paraffin rose or fell, the price of charcoal also rose or fell. Since 1985, the price of paraffin has fallen dramatically, while the price of charcoal has increased dramatically. To what extent do charcoal price fluctuations reflect changes in supply or demand?

Improvements in the transportation infrastructure in Kenya have partly made it possible for market prices to be moderated over the long term. More supplies became more accessible as new forest or bush areas were cleared for cultivation, and as charcoal was produced as a byproduct of land clearance.

Land clearance has long provided the bulk of the charcoal used in urban areas of Kenya. The pace of adjudication and settlement in new areas was sufficient to produce enough charcoal to meet urban demands. When charcoal is produced as a byproduct of land clearance, labour costs of production are quite low. When land is cleared *specifically* to produce charcoal, labour costs of production increase considerably. Price increases since 1985 may reflect this change in the structure of supply, as charcoal supplies are increasingly being produced as the sole object of land clearance, rather than as a by product of land clearance.

The other interesting development in the structure of production is the relatively larger share of charcoal on the Nairobi market which is produced as a result of the burning of wattle. In 1985, it was estimated that around 5 percent of the market was being supplied by charcoal produced from wattle woodlots. By 1989, it was estimated that as much as a third of the charcoal which is sold on the

Nairobi market was being produced from black wattle woodlots.[1]

This transition in the structure of production makes sense. As the price of charcoal increases, the residual stumpage price of wood used to make it also increases. At higher prices, wattle charcoal can yield similar stumpage prices as could wattle building poles -- the main alternative use of wattle timber.

Most of this charcoal comes from the immediate vicinity of Nairobi, particularly from the Kiambu and Limuru areas. Although the real costs of production are higher (both in terms of labour and roundwood costs), charcoal produced close to Nairobi has a real competitive advantage over charcoal produced elsewhere because of savings in transportation cost. Consequently, it can be sold at prices which are competitive with prices for charcoal which is produced from bush timber (which has no stumpage cost) but which must be transported great distances to reach Nairobi markets.

Because of the ban on the felling of indigenous trees, it is conceivable that charcoal from land clearing operations has become less available since 1985, and that this has driven charcoal price increases. Even so, land clearance processes have been underway for many years. That they should rapidly decelerate over a few short years would be something of a surprise. Price increases of the magnitude observed since 1985 could be expected over the longer term, as the pace of land clearance slowed and as less land became available for cultivation.

There is some evidence which suggests that controls on charcoal movements and on charcoal production may have limited supplies for the market, and that price increases have reflected this. In Murang'a District, for instance, very little wattle charcoal is produced which ends up on the Nairobi market. This is despite the fact that Murang'a is within easy proximity of Nairobi and has historically

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1. M.Bess (1989). *Kenya Charcoal Survey...*

supplied large amounts of charcoal to meet urban demands.

Most charcoal production in Murang'a services rural demands in the lower zones of the district and does not pass beyond district boundaries. When interviewed, charcoal burners in Murang'a noted that transport out of the district is problematic because of movement and transport controls. In order to sell charcoal to Nairobi, they would have to first obtain a permit from the Forest Department indicating that charcoal supplies were not obtained from the high forests, then they would have to obtain a movement permit. Permits are difficult to obtain and bribes must be paid. The result is that wattle woodlots in Murang'a are underutilized for charcoal production and little ends up on Nairobi markets.

APPENDIX 9:
Notes on Sources

The only abbreviations used in the footnotes which may appear to be obscure are FD, KLC, and KNA. FD refers to the Annual Reports of the Forest Department, for the years noted. KLC refers to the report of the Kenya Land Commission and the volumes of evidence and memoranda which comprise one of the most valuable sources of oral history extant. KNA refers to the Kenya National Archives, where most unpublished district and provincial records are kept. Published material which was found in the Archives is referred to, as published, in the bibliography.

The following are private papers held in the Rhodes House Collection of the University of Oxford, and which are noted in the footnotes by their Rhodes House classification.

W.H.Thompson	(Mss.Afr.s.839)
S.H.Fazan	(Mss.Afr.s.1153)
A.W.Horner	(Mss.Afr.s.1685)
MacGregor Ross	(Mss.Afr.s.1178)
F.D.Homan	(Mss.Afr.s.1267)
J.A.Stuart Watt	(Mss.Afr.s.391)
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A.Creech Jones	(Mss.Brit.Emp.s.332)
T.G.Askwith	(Mss.Afr.s.1170)
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