A study of some human impacts on indigenous woody vegetation in a part of the Luangwa district of Zambia.

by

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A dissertation submitted to the University of Zambia in partial fulfilment of the requirements of the degree of Master of Arts in Geography.

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SUMMARY

A study site in the Luangwa district, south-eastern part of Lusaka Province was used for an investigation of the impact of human activities on indigenous woody vegetation. Evidence obtained from the review of literature and initial field reconnaissance suggested that the observed changes and variations in woody plant communities was directly or indirectly related to human activities rather than natural changes or differences in topography.

Woody vegetation changes as a result of the varied human activities were identified from the review of relevant literature, aerial photographs, topographical maps and field reconnaissance undertaken in August 1981. During the period December 1981 and January 1982, the impact of the varied human activities on indigenous woody vegetation was investigated in the field. Since it was not possible to examine the indigenous woody vegetation in the entire study area due to time limitations five sample quadrats were examined for each identified major activity. The vegetation in each selected quadrat was examined in terms of species composition, structural damage as a result of the activity under consideration and the number of individuals in different size groups. This information was supplemented by that which was obtained from a selected number of households. Information from the 30 households was obtained through questioning and discussions and measurements were taken wherever possible.

The human activities which were considered included: cultivation, fuelwood,collection, bush burning, timber exploitation for

building purposes and grazing and browsing of domesticated animals. Measures were taken wherever possible to estimate quantitatively the total cleared area or corresponding clear-felled area as a result of the varied human activities. The result obtained showed that the varied human activities have led to a gradual transformation of the indigenous woody vegetation. Some of the above listed activities especially charcoal burning and arable agriculture have altered the woody vegetation of the affected areas through continuous clear-cutting.

The study also revealed that the study area is experiencing a steadily increasing rural population. This increase in human population is placing more pressure on the woodland due to increased demand for arableland and woodland resources. Thus vegetation degradation has started in most parts of the study area where people have gathered in large groups to form villages. It must however be noted that, the little evidence gathered from the study suggest that vegetation destruction appears to have originated from a recent history of regressive changes which have continued to the present day. Most of the changes in indigenous woody vegetation can be considered to be related to population increases since areas where population is high the demand for woody resources such as fuelwood and polewood is high and generally appears to exceed local supplies. Generally, it can be postulated that the study area as a whole is still underpopulated in the sense of having a small population in relation to the present utilization of woody resources. It must also be noted that in areas where human activities have stopped vegetation regrowth is taking place. However such areas are few because immediately one activity stops another follows.

ACKNOWLEDGEMENTS

In memory of my parents, the ones who sacrificed so much in order to pave my way into this modern world. And for my brothers and sisters for being co-operative and understanding during my period of study.

I also received valuable assistance from my supervisor Mrs M.E. Cheatle and also Mr J.D. Huckabay. I would like to express my gratitude for their courtesy and kindness shown in their guidance and continued review of my work at various stages along the way.

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WEIGHTS AND MEASURES : ABBREVIATIONS

WEIGHTS AND MEASURES

Km	-	Kilometre
m	-	Metre
Cm	-	Centimetre
mm	-	Millimetre
Km^2	-	Square Kilometre
Kg	-	Kilogram
^oC	-	Degree Centigrade
K	-	Kwacha

ABBREVIATIONS

A.S.L.	-	Above Sea Level
F.A.O	-	Food and Agriculture Organization of the United Nations
F.R.I.	-	Forest Research Institute
H.E.P.	-	Hydro-electric Power
I.T.C.Z.	-	Intertropical Convergence Zone
N.A.M.B.	-	National Agricultural Marketing Board
No.	-	Number

CHAPTER ONE

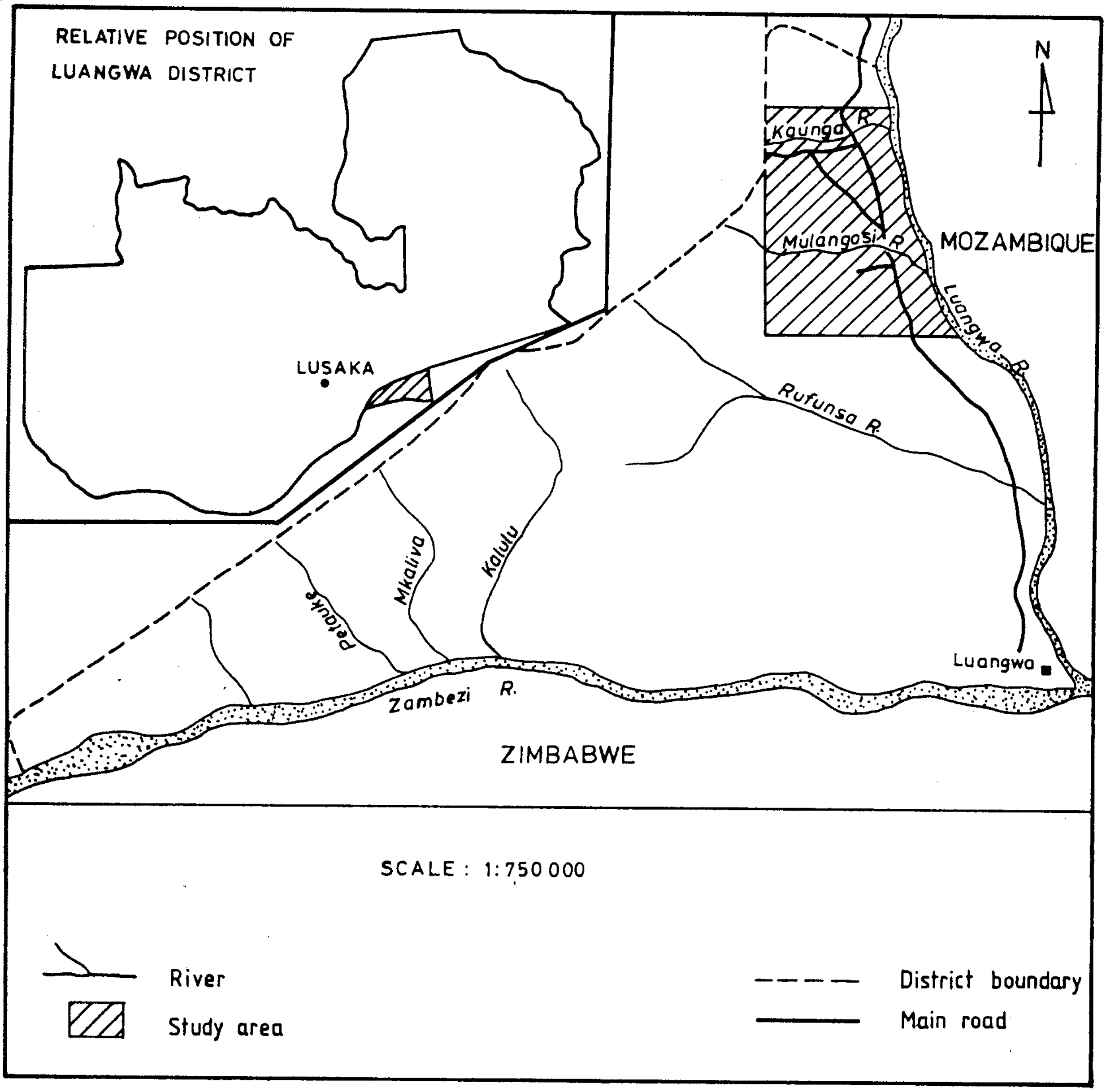
GENERAL INTRODUCTION

BACKGROUND TO THE STUDY AREA

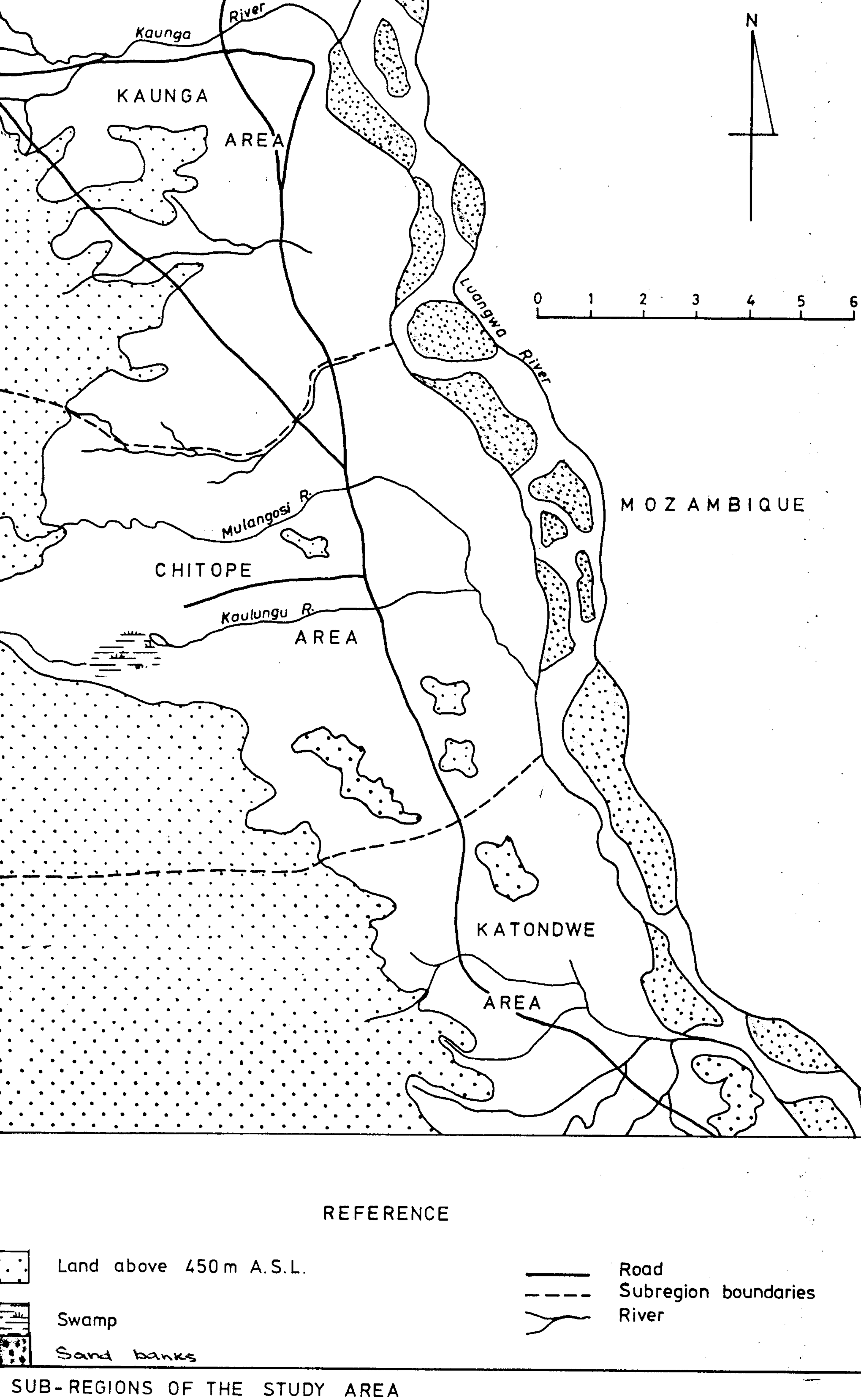
Position and size

The study area lies within Luangwa district which is situated in the south-eastern corner of Lusaka Province (Map 1) at the confluence of the Zambezi and Luangwa rivers. It occupies the northern portion of the district. It lies between Latitudes $15^{\circ}04'$ and $15^{\circ}17'$ South and Longitudes $30^{\circ}08'$ and $30^{\circ}17'$ East. The Luangwa river forms the eastern boundary for a distance of about 36 km. separating the study area from Mozambique. The Rufunsa range in the west forms the western boundary separating the study area from Rufunsa, a part of Lusaka rural district. The study area covers about 560 km^2 and is part of Chief Mburuma's area which extends from the Great East Road in the north to the Rufunsa river in the south.

The study area can conveniently be divided into three main sub-regions (Map 2). These are: Firstly, Kaunga which occupies the northern part. It is a densely populated area and has some fairly fertile soils. Secondly, Chitope which occupies the central position of the study area. It is an area of high population and the soils have reasonable potential for development. Thirdly, Katondwe which occupies the southern portion. It is a hilly area with poorer soils than the other two areas. The terrain is rocky in many parts with only a few pockets of fertile soils. This is an area of very low population.



MAP 1 LUANGWA DISTRICT



SUB-REGIONS OF THE STUDY AREA

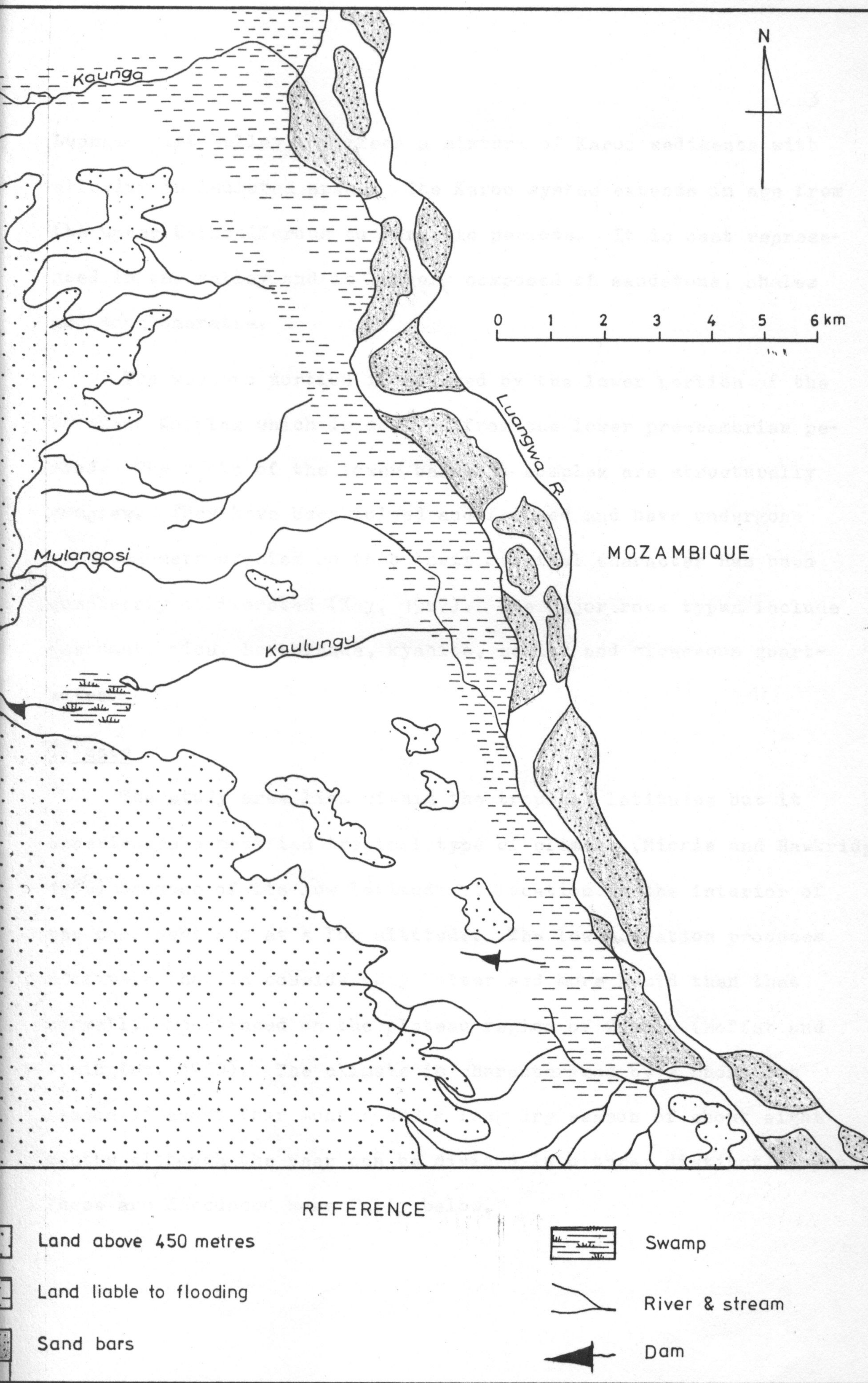
Relief and Drainage

The study area lies below 900 metres A.S.L. It is virtually within the valley of the Luangwa river with an average altitude between 300 and 900 metres A.S.L. (Lilje, 1972). The Luangwa valley is part of the Great African Rift Valley which crosses East Africa and extends into Zambia across the eastern portion of the country from the North-East to the South-West. This area was subject to trough faulting which resulted in the formation of a number of Rift Valleys which can be identified even today (Archer, 1971 a). The area is generally low except on the Western side where it is bordered by the Rufunsa Range. Here it rises rapidly to 900 metres A.S.L. The countryside between the Luangwa river and the Rufunsa range is broken by a number of outliers and winding tributary valleys (Map 3).

The study area is drained by the Luangwa river system. Small rivers such as the Kaunga, Mulangosi and Kaulungu together with smaller streams rise from the highland area in the west and drain their water into the Luangwa river. (Probably due to considerable slopes and low permeability, these streams carry alot of water to the Luangwa but by July/August, most are dried up already). The Luangwa river finally drains into the Zambezi.

Geologic Foundation

The study area consists of a complex of ancient sediments into which rocks of Volcanic origin have widely intruded (Kay, 1967). There are two major groups of rocks in the study area. Archer (1971 b) observed that the eastern portion which is the


N
Kaunga
Mulangosi
Kaulungu
Luangwa R.
MOZAMBIQUE
0 1 2 3 4 5 6 km
REFERENCE
Land above 450 metres
Land liable to flooding
Sand bars
Swamp
River & stream
Dam

Luangwa Rift Valley comprises a mixture of Karoo sediments with alluvium in isolated areas. The Karoo system extends in age from the upper Carboniferous to Jurassic periods. It is best represented in the valley and is largely composed of sandstone, shales and conglomerates.

The western portion is covered by the lower portion of the Basement Complex which is derived from the lower pre-cambrian period. The rocks of the lower basement complex are structurally complex. They have been folded and faulted and have undergone repeated metamorphism so that their original character has been completely obliterated (Kay, 1967). The major rock types include gneisses, mica, hornblande, kyanite, schist and micaceous quartzites.

Climate

The study area lies within the tropical latitudes but it experiences a modified tropical type of climate (Michie and Hawkridg 1965) because of its low latitudinal location in the interior of the continent and at a low altitude. The low elevation produces a climate that is considerably hotter and more humid than that normally experienced on the plateau region of Zambia (Moffat and Symington, 1950). The climate is characterized by a short wet season of about four months and a long dry season of about eight months although the year can be divided into three distinct seasons. These are discussed more fully below.

<u>The cool dry season (April - August)</u>

At the beginning of this season, the air may still be moist and rain may be experienced. Mist occurs on most mornings. As the season progresses, the temperatures begin to decrease because the sun will be overhead in the Northern Hemisphere making the area experience the lowest temperatures of the year. The weather is generally very pleasant with the average daily temperatures ranging between 15° and 21°C. June and July are the coldest months with mean monthly temperatures of about 19.6° and 19.4°C respectively. Temperatures of about 19°C are common but frost has never been recorded. The mean maximum temperature of 27°C in July demonstrates the effect of altitude. The winds during this season are light. They are predominatly from the east and south-east. (Archer, 1971 c). Towards the beginning of August, the temperatures begin to increase rapidly and give way to the hot season.

<u>The hot dry season (September - mid November)</u>

During this season, temperatures increase rapidly and reach a peak in October before they are modified by rain. September is the driest month and October is the hottest month. In some years when the rains are delayed, November turns out to be the hottest month. The temperatures during this season are generally high. The average monthly temperature for the season ranges between 26° and 30°C. (The highest temperatures are recorded during the middle of October. The mean daily maximum temperature in October can be as high as 36°C.). Towards the beginning of November humidity begins to rise and by mid-November the rains generally begin

The warm rainy season (Mid-November-March)

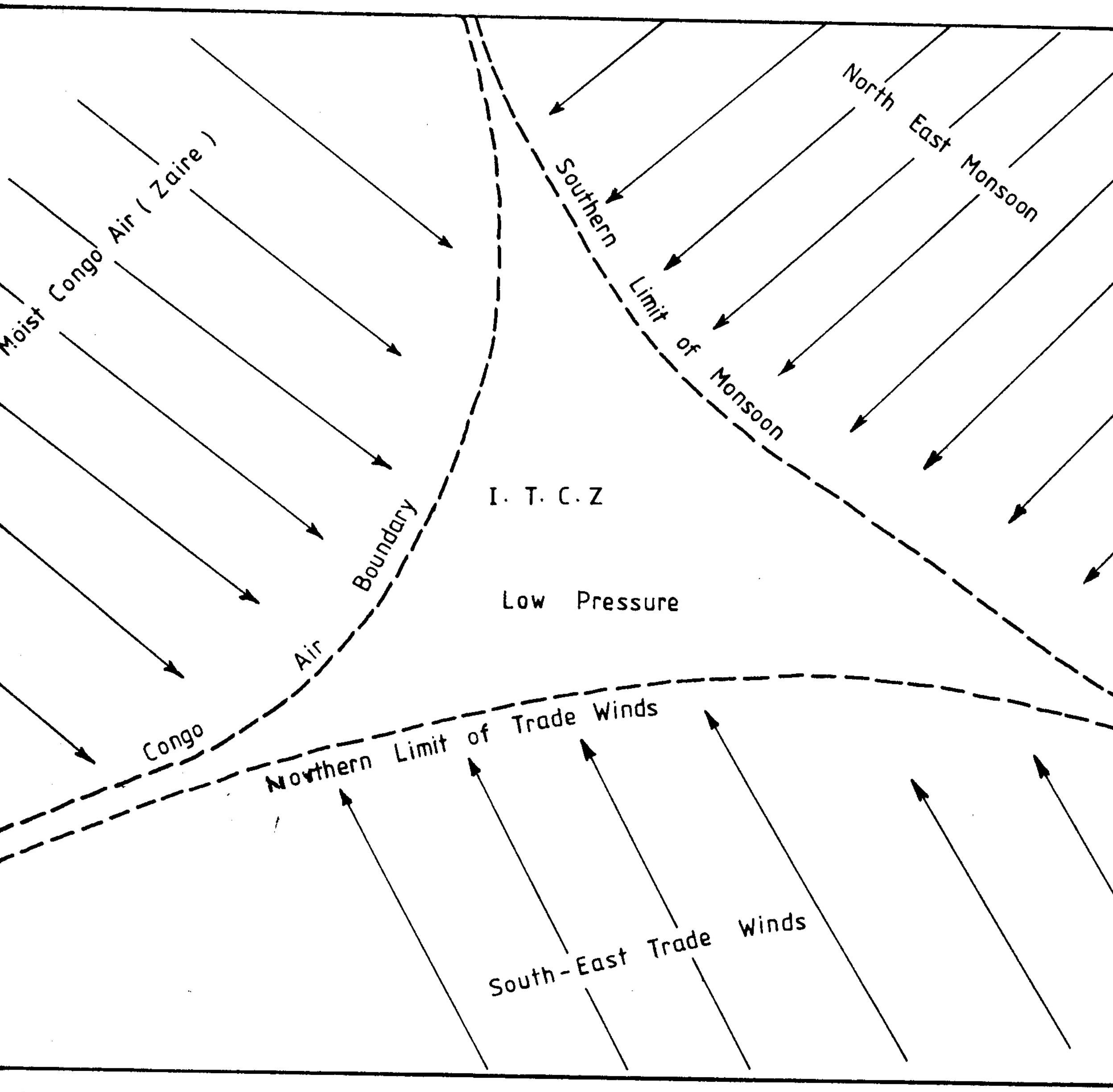
During this season temperatures decrease a little with the beginning of the rains. Humidity is high, as a result the weather becomes very uncomfortable (Naidoo and Mumbwe, 1981). Rainfall is not of everyday occurrence but comes in the form of showers or thunderstorms. The total annual rainfall is generally below 900mm. Rainfall variability from year to year is above 25 percent and is one of the greatest in Zambia (Archer, 1971d).

Table 1: Average Climatic Conditions for Luangwa December 1950 - July 1957

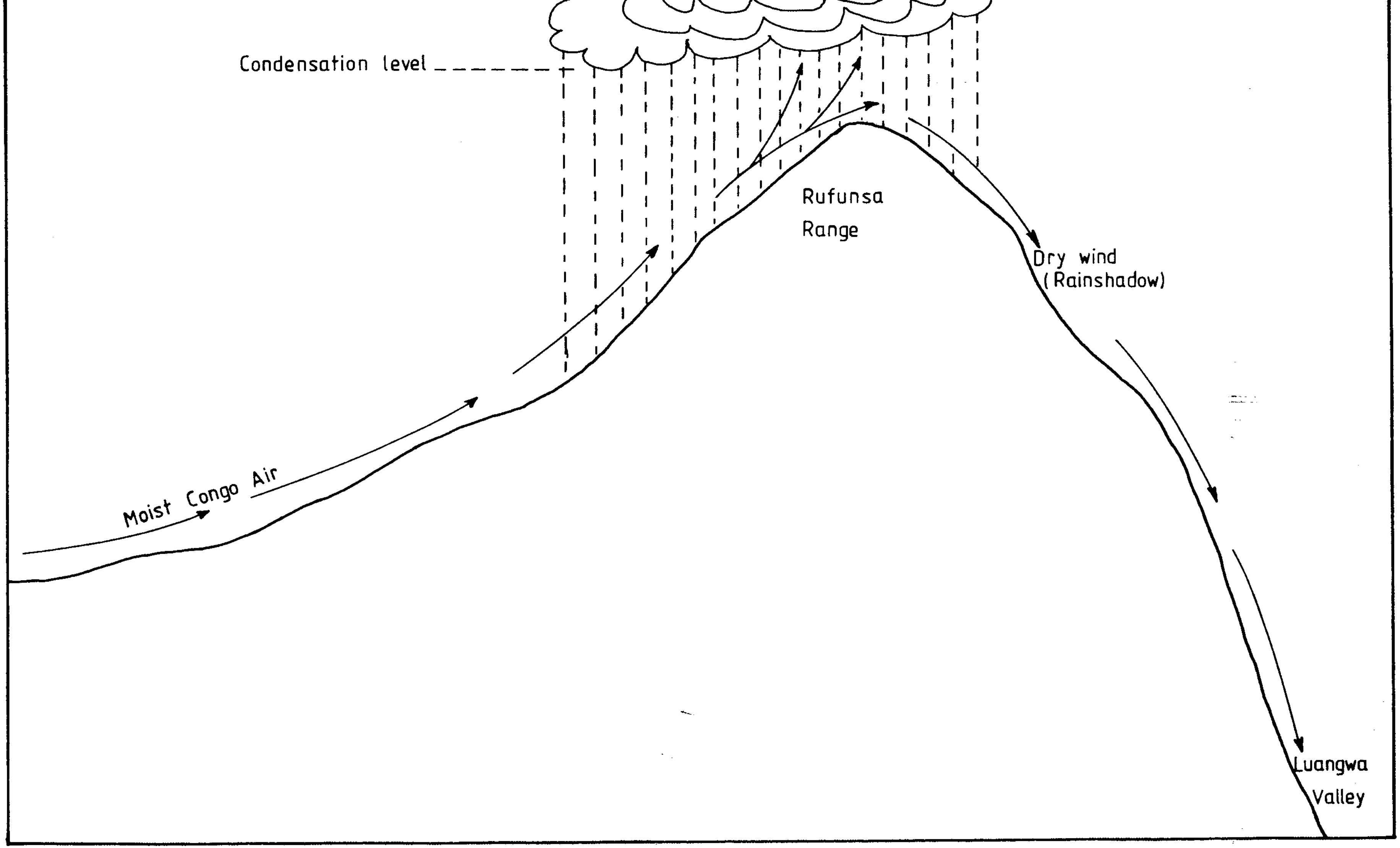
MONTH	EXTREME TEMPERATURES		MONTH Mean of Max & Min temp.	RAINFALL	
	MEAN MAX.	MEAN MIN.		AMOUNT	RAIN DAYS
JULY	26.7	12.2	19.4	-	-
AUGUST	29.6	14.8	22.2	4	-
SEPTEMBER	32.4	19.2	25.9	1	-
OCTOBER	35.9	23.5	29.7	9	1
NOVEMBER	34.4	23.7	29.2	103	7
DECEMBER	31.4	22.4	27.0	167	12
JANUARY	30.9	22.3	26.7	200	13
FEBRUARY	31.0	22.6	26.8	205	11
MARCH	31.3	22.0	26.6	52	4
APRIL	31.5	20.6	26.0	17	1
MAY	28.9	16.7	22.9	3	1
JUNE	26.7	12.8	19.6	-	-
YEAR	30.9	19.4	25.2	761	50

Source: Lilje, B.G. (1972, p.2).

Rainfall is of several origins. The most important is related to the southward movement of the equatorial low Pressure Belt in summer months in association with the apparent movement



AGRAM I: INTERTROPICAL CONVERGENCE ZONE



DIGRAM II: RELEIF RAINFALL AND RAINSHADOW EFFECT of the overhead sun. Air streams converge on this belt from the semi-permanent subtropical anticyclonic cells either in a distinct line or in a broad zone with an intervening area with light wind. The meeting place of these air streams is referred to as I.T.C.Z. (Diagram 1). The three principal air masses affecting the area are Congo (Zaire) air, South-east trades and North-east trades (Archer, 1971d).

The study area receives little rain on the average because it lies in the rainshadow of the Rufunsa range (Naidoo and Mumbwe, 1981). As a result of the Rufunsa range, the moist Congo (Zaire) air drops most of its moisture on the escarpment as relief rainfall (Diagram 2). By the time these winds descend into the Luangwa valley they contain very little moisture. The low rainfall conditions are not ideal or favourable for arable agriculture thus the inhabitants practice a great deal of rituals and magic to counter the short comings of natural conditions (Kay, 1967).

Soils

The soils of the study area and those of Luangwa district as a whole have not yet been surveyed in detail. The soils map of Zambia compiled by Trapnell and Clothier (1937) and that compiled from information supplied by the soils section of the Department of Agriculture in 1965 (Brammer, 1974) both show this aspect. An examination of the above named maps and also using information obtained during field reconnaissance, the soils of the study area can broadly be put into three classes. These are discussed in detail below.

Soils of the Luangwa Valley

These are derived from Karoo Sediments largely by colluvial and alluvial processes. These are clayey soils which include solonetzic pale sands, dark grey clay, deep sands and grey brown alluvial soils. This soil class covers a large part of the valley above the flood plain and is entirely undifferentiated. Moffat and Symington (1950) observed and noted that these soils are perhaps capable of cultivation with improved methods of agriculture.

Soils of the escarpment and hills

These are mainly lithosols which occupy the broken hilly country. The soils are skeletal on hill sides and are characterized by much surface rock or laterite crust in flat areas. The soils are basically shallow, stony and show severe signs of erosion due to the broken nature of the region. Lithosols are incapable of supporting any form of cultivation due to rockiness, stoniness or poverty of the soil. Lithosols cover a large area of the escarpment country in the western side of the study area.

Soils of the flood plain

Alluvial soils are found on the high flood plain along the Luangwa river and its tributaries. These soils are normally flooded during the rainy season. The actual deposition of alluvium varies greatly in distance from the river. The variation is a result of the direction of the current of the river at a particular point. Thus deposition may change from year to year. These soils are exceedingly fertile and wherever water is available, cultivation can be done in both the wet and dry seasons. These are the only soils capable of supporting agriculture under the present traditional methods.

Indigenous Woody Vegetation

Trapnell and Clothier (1937). Fanshawe (1968 and 1971) and Mackel and Pullan (1972) in their attempts to classify and describe the vegetation of Luangwa district placed the study area and the district as a whole under Mopane woodland. Mopane woodland varies from fair quality woodland to very poor open scrub. It can be classified into three distinct quality classes(Fanshawe, 1968). These are discussed in detail below:-

Mopane Woodland

This is the best quality of the three quality classes of Mopane. The woodland is composed of pure or almost pure stands with an almost closed canopy up to about 18 metres high, considerable undergrowth and an open grass floor. Mopane is typical on heavy, transported, alkaline soils which characterize the alluvial flats with seasonal flooding. The tree canopy is dominated by Colophospermum Mopane. The common understorey species and shrubs include:- Acacia nilotica, Albizia anthelmintica, Boscia matabelensis, Combretum elaeagnoides, Cronton gratissimus, Dalbergia melanoxylum, Diospyros quiloensis, Zambesiacum erythroxylum, Ximenia caffra, Grewia kirkii, Disperma crenatum and Vellozia equisetroides are normally frequent on the ground floor but occasionally the ground is bare. The only climber of any importance is Fockea Multiflora.

Mopane/Munga Woodland

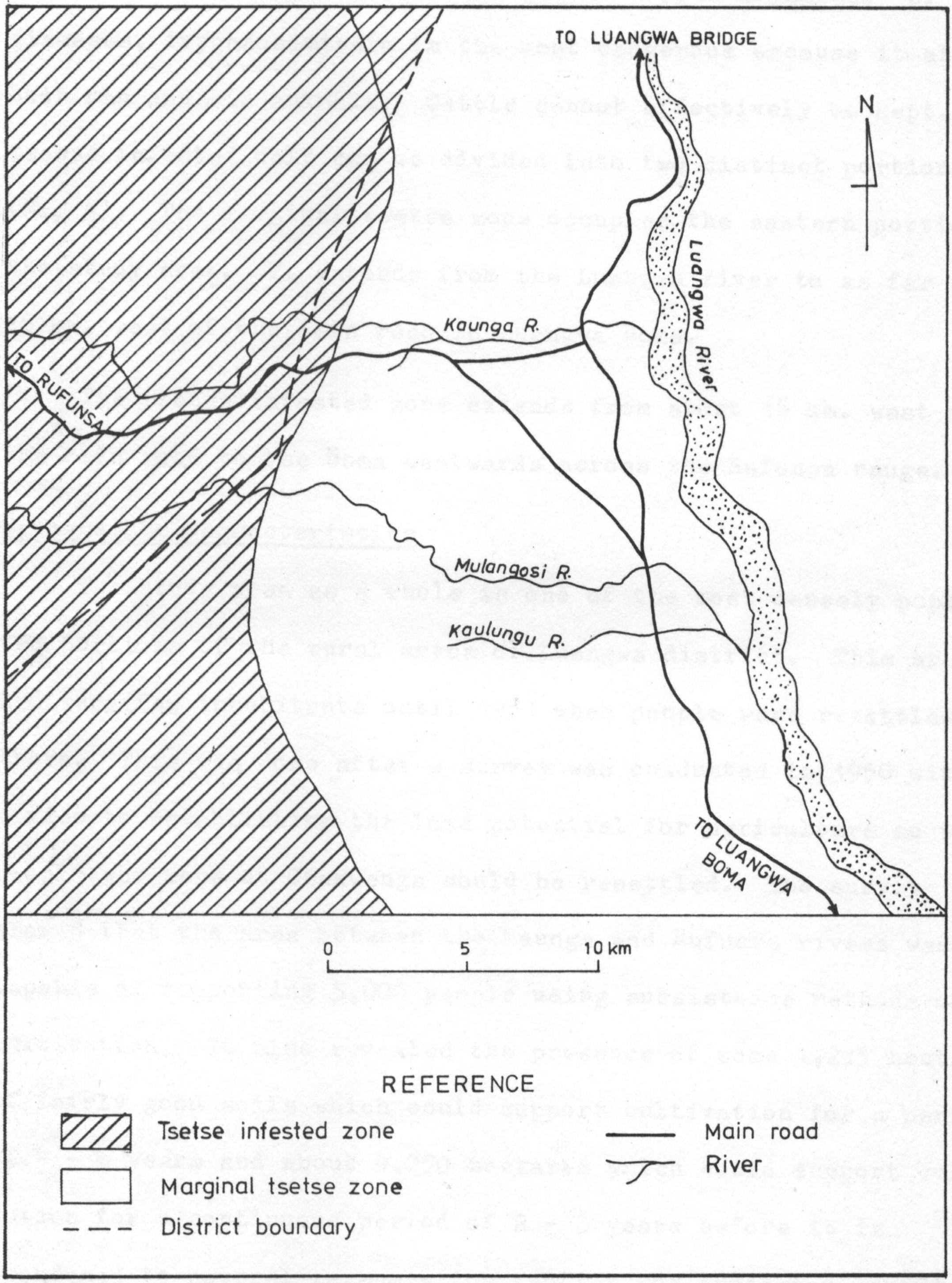
This woodland is between 9 and 12 metres high. It is found on gravelly, rocky soils which are formed at the foot of the escarpment. Here Mopane may be pure or mixed with up to 50 percent of Munga species. A thicket undergrowth may or may not be present. When present, it is similar but not as well grown as that described under Mopane woodland. Most Munga canopy species occur as mixed stands of Acacia nigrescens and Combretum apiculatum. Other common species include Albizia harveyi, Commiphora karibensis, Hyphaene ventricosa, Kirkia acuminata, Lannea stuhlmannii, Lonchocarpus capassa and Pterocarpus antunessi.

Scrub Mopane

Scrub Mopane ranges from four to nine metres in height. It is found on skeletal mudstone and basalt soils. Trees are Terminalia stuhlmannii. Some associated species of some frequency include Commiphora mossambicensis, Cronton gratissimus, Dalbergia melanoxylon, Diospyros kirkii, Erythroxylum zambesiacum, Kirkia acuminata and Terminalia stenostachya. There is virtually no understorey apart from Diricletia Pubescens as almost all plants are at the same level with a very sparse ground cover of Aloe Zebrina and Vallozia equisetoides.

Disease and Tsetsefly infestation

The study area is infested with numerous diseases. These include both human and bovine diseases. The common ones are



MAP 4 TSETSE INFESTATION

endemic malaria, Bilharzia, Filaria and Trypanosomiasis. Of these diseases, trypanosomiasis is the most dangerous because it affects both man and his animals. Cattle cannot effectively be kept. The tsetse infested belt can be divided into two distinct portions (Map 4). The marginal tsetse zone occupies the eastern portion of the study area. It extends from the Luangwa river to as far as 16 km. west of the main road to Luangwa Boma.

The tsetse infested zone extends from about 16 km. west of the main road to the Boma westwards across the Rufunsa range.

Demographic Characteristics

The study area as a whole is one of the most densely populated portions of the rural areas of Luangwa district. This area had very few inhabitants until 1951 when people were resettled there. This was done after a survey was conducted in 1950 with a view to establishing the land potential for agriculture so that people who were at Chakwenga could be resettled. The survey showed that the area between the Kaunga and Rufunsa rivers was capable of supporting 5,000 people using subsistence methods of cultivation. It also revealed the presence of some 1,215 hectares of fairly good soils which could support cultivation for a period of 4 - 6 years and about 4,050 hectares which could support cultivation for a continuous period of 2 - 3 years before it is abandoned to natural regeneration (Moffat and Symington, 1950). It was visualized then, that this area could provide, under subsistence methods of cultivation, for a population of up to 6,000.

It was then that the inhabitants of Chakwenga, a tsetse infested area were resettled between the Great East Road and the Rufunsa river. These new settlers joined the people who were already settled there.

The total population of the study area as reflected in the 1963, and 1969 censuses of village population and the 1980 population from the Chief's and headmen's records is shown in the table below:-

Table 2: Population data for the study area

YEAR	TOTAL POPULATION	POPULATION DENSITY/km^2
1963	5 020	8.6
1969	4 108	7.1
1980	6 639	11.5

Source: Compilation, M.C. Mulenga

The 1963/69 intercensal period

The population of the study area decreased by 18 percent during the 1963/69 intercensal period. The decrease can partly be attributed to "Urban drift" (Jackman, 1971). The majority of the middle aged males migrated from the rural to urban areas in search of paid employment and better prospects after independence in 1964. The absence of industries, low agricultural potential, lack of medical and other social facilities and tsetse infestation and other diseases exerted a negative influence on the young people. As a result of rapid migration of ablebodied males from the area to towns, agricultural output suffered due to a shortage of labourers (Jackman, 1971). This is so because only older men and women were left to work on the land in villages.

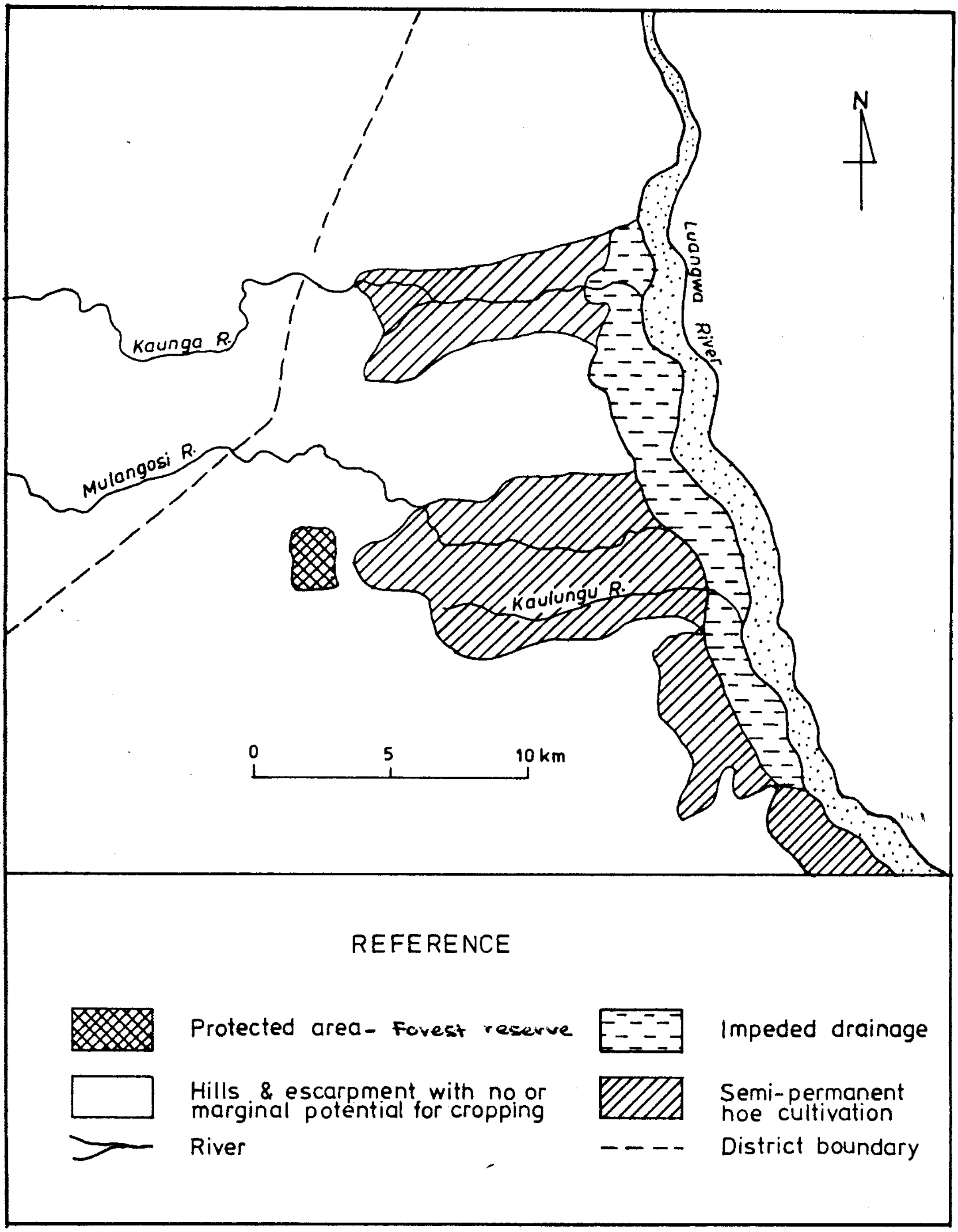
The 1969/80 Intercensal Period

The population of the study area increased by 37 per cent between 1969 and 1980. This increase can partly be attributed to natural increase. The provision of hospital facilities, has improved the health of the people and thus they now live longer and infant mortality has been reduced. In 1964 there was only one small hospital at Katondwe and a small dispensary at Kaunga. By 1980, three rural health centres had been constructed in the study area and the hospital at Katondwe had been extended and has more qualified personnel than in 1969.

The increase in population can also partly be attributed to the Government's "Back to the Land Policy". Since jobs have become scarce in urban areas the rural areas have been improved. The provision of market and medical facilities have helped attract some young people back to the rural area (Central Statistical Office, 1980).

Attempts by the Government to introduce cash crop growing in the area such as cotton, sunflower and beans have also contributed in attracting people back to the study area. In this respect seasonal loans are given to farmers who express the wish to take up cash crop growing.

The major activities of the households



MAP 5 LAND USE

An examination of the land use map of the study area (Map 5) showed that a large proportion of the area is composed of land with no or marginal potential for cropping. This area occupies larger parts of the central and western portions of the study area. This area cannot effectively be used for arable agriculture with the present levels of technology. The majority of the people are living on the narrow stretch along the Luangwa river.

The study area has a subsistence agricultural economic base. This is reflected by the absence of industries of any kind and a poorly developed agriculture base. Very few inhabitants are recorded in wage employment. The bulk of the population remain at subsistence level, each household meeting its basic needs from the land by cultivation using the axe and hoe as their main tools.

Fishing

Fishing, an activity which is currently flourishing in the area, is basically a part-time activity. This is a result of great fluctuations in the water level in the Luangwa river during the course of the year (table 3). In the dry season, there is very little water in the river which reduces the area for fishing. At some places the river is less than two metres wide especially during the months of September and October. The tributaries of the Luangwa such as the Kaunga and Mulangosi almost dry up by October. Thus fishing remains a seasonal activity which can only be conducted effectively when there is sufficient water in the river.

Table 3: Monthly water levels for the 1965/66 season in the Luangwa river as recorded at Luangwa bridge.

MONTH	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
WATER DEPTH (M)	1.95	1.77	1.63	1.95	1.92	2.52	3.66	5.01	5.23	3.03	2.46	2.16

Source: Lilje, B.G. (1972, p.4)

Moffat and Symington (1950) and Lilje (1972) have shown that fishing is still carried out for subsistence purposes. They noted that fish is only caught in small quantities, and that there were only a few full-time specialist fishermen who are entirely dependent upon their earnings from such work. Most inhabitants do not depend on fish for earnings or diet, some do however obtain some cash from the sale of fish.

Arable farming

Most of the inhabitants are subsistence producers. They farm land primarily to provide food for themselves and their families though a little produce is often sold to raise cash to pay school fees for their children, or buy essential commodities. The very nature of subsistence production means that the producers and the consumers are the same people. Money has only a limited importance. All efforts are aimed at meeting the immediate needs, usually the farmer has very little produce left for bartering and selling. The inputs involved are usually limited to work by the farmer and his family.

For these subsistence people, it is important that they grow sufficient food for themselves and their families for without it, there is no guarantee that they will not starve because even when relief food is provided many do not have the money to buy it. It is for this reason that subsistence farmers spread the risk of crop failure as widely as possible by cultivating a range of crops which tolerate different soils and weather conditions so that if some fail others may not be affected. This ensures that some harvest is always made should one or two crops fail.

There is no clear-cut division between commercial and subsistence farming in the study area since most commercial farmers have fields set aside for the growing of food crops. Generally, commercial agriculture is on a very small scale. For example during the 1974/75 season, the study area marketed only 32 bales of cotton and three bags of sunflower and during the 1976/77 season, 89 bags of maize, 30 bags of sunflower and 396 kg. of cotton were marketed. Some of the factors contributing to low production are discussed below:-

Lack of farm Implements

Tractors are generally too expensive and most of the inhabitants cannot afford to buy them. The mechanized unit services has introduced two tractors for hiring purposes at a rate of K16 per tractor hour. (1981/82 Season). This rate has already proved to be too high for the poor rural inhabitants.

Generally, for small scale farmers, it is ideal for them to use Ox-drawn ploughs but this has not been possible because of tsetsefly. It must be noted however that up to date there have been no attempts on the part of the Department of Agriculture to introduce cattle despite the many pleas from the inhabitants. Additionally, the tsetse control services have not done anything as regards the tsetse zone (Veterinary and Tsetse control services, 1971). It is for this reason that Agriculture mainly utilizes the axe and hoe as the major tools. Cattle are only used by a few farmers who have managed to take them there from neighbouring areas.

The Scarcity of Markets

Markets are very limited since they depend on the size of the population and the cash income of the inhabitants. Both of these are small and the produce has to be offered for sale to either NAMB in the study area or transported directly to Lusaka, a distance of more than 240 km by the producer.

Communications

The study area has access to the Great East Road in the north and the Boma in the south through an all weather first class gravel road. It starts at Luangwa bridge and runs parallel to the Luangwa river right across the eastern side of the study area to the Boma. The condition of the road is very poor during the rainy season. The other roads are few and are of poor quality. They all act as feeder roads to this major road.

The Village as an Economic Unit

The villages in the study area consist of settled, cultivated and uncultivated sections. The settled section is primarily occupied by human huts and animal pens. The settled area has been cleared by removing almost the entire vegetation cover with the exception of a few large trees which are valued for their shade during the hot season.

The uncultivated section is usually in woody fallow. Timber for building in the form of poles, grass for thatching huts and wood for cooking and heating are all obtained from this section. Some edible fruits, roots and leaves including those used as traditional medicines are also obtained from this section. Additionally, some domestic animals like goats and sheep are grazed in this section.

The cultivated section of the village is occupied by fields where arable crops such as maize, sorghum, millet and pumpkins are grown. This area is also cleared by removing most of the woody plants.

Some consequences of population increase

The study site, a finite area with a rapidly growing population was selected for the study. Almost 96 percent of the inhabitants are dependent on arable cultivation using mainly the traditional methods. These methods are predominantly shifting in nature with a gradual shift towards more sedentary types (Siddle, 1971). Since each agricultural system has a finite limit, under natural circumstances, the population should not exceed the carrying capacity. If it is exceeded there is need for more land or a change to more intensive land usage. Once this is not done, which is usually the case with most subsistence people who cannot afford fertilizing their fields artificially, the carrying capacity is exceeded. Thus the natural restorative fallow period cannot be continued due to population pressure on the land. In such circumstances the amount of land in fallow decreases and in more densely settled areas agriculture becomes entirely sendentary with little or no fallow. Closely associated with these changes, is a gradual transition to a market economy. This is achieved to a certain extent because the Government provides seasonal loans in the form of seed, fertilizers and tractor ploughing hours. The export of products is a drain upon the nutrient reserves of the soil. In the new sedentary systems, the farmers are unable to replace the out put of nutrients by biological cycling or other means thus introducing the application of fertilizers. These have already proved to be too expensive for the poor people and in the absence of government loans production suffers.

Soil erosion is encouraged by population increases because the area under woodland decreases in favour of cultivated land. Erosion under such circumstances may be expected to increase unless conservation measures are taken to protect the soil. It has been suggested that beyond a critical population density vegetation and most other aspects of the ecosystem will be degraded (Morgan, 1969). For example, Eastern Province, an area of relatively fertile soils, can carry no more than 9.6 persons per km^2. under comparatively intensive use of land. Similarly the Lamba system in Ndola rural can only support 6.9 persons per km^2 and the <u>Chitemene</u> system in the northern parts of the country can support only a maximum of 3.9 persons per km^2 (Morgan, 1969). Shifting cultivation is not an ecological evil in Africa at low population levels and most of the available evidence support this view (Bennett, 1975).

When population increases under these traditional systems, vegetation begins to suffer from excessive clearing which is imposed by an increased demand for fuelwood, housing and fields. This would in turn be followed by vegetation degeneration.

Dansereau (1975) noted that the advent of man marked a new level in the exploitation of environmental resources with a capacity for upsetting the natural balances by the elaboration of completely new ecosystems.

Aims and Objectives of the study

The study has three main objectives which can readily be identified as follows:-

(1) To identify the present impacts on woody vegetation from the following human activities:- cultivation, fuelwood collection, timber exploitation for building purposes, grazing and browsing and bush burning. These activities were selected because field reconnaissance and literature review suggested that they were prominent in the study area.

(2) To compare the present impacts on woody vegetation resulting from each activity.

(3) To determine whether the area of woodland is changing as a result of man's activities.

The selected approach to the study

Literature review has shown that almost all research work that has been conducted as regards the impact of man on indigenous woody vegetation has tended to be more specialized than integrated in nature. Most of the studies have adopted a single factor method. This method involves the separation of activities in an area so that each study concentrates on only one activity without considering those activities which occur together with it. For example Trapnell (1959), Charter and Keay (1960) and Cnochie (1961) have all considered the effects of burning indigenous vegetation at different times of the year. Richards (1939) Peters (1950) and De Schlippe (1956) have all considered the effects of shifting cultivation on indigenous woody vegetation in various parts of Africa. All the above listed studies have focussed on only one aspect in the affected areas and have ignored the presence of other activities.

The current study has adopted what might be described as an integrated approach. In this method all the major activities taking place in the area under study are identified and considered as contributing to the overall impact. For example in carrying out the current study, all the major activities were identified. These were then examined separately and their contributions and extent noted. Then the overall impact was considered. This method was selected because it recognizes the interrelationships between the various activities. It also recognizes the fact that there are no clear-cut boundaries between areas in which the various activities occur, thus the results obtained using such an approach tend to reflect the overall impact in the area under consideration.

CHAPTER TWO

LITERATURE REVIEW

Human impacts on indigenous woody vegetation

The present state of the plant world as it emerges from its evolution over geologic times is controlled by three main groups of factors (Mangenot, 1963). These are human, climatic and soils. Of these three groups of factors, the powerful force and influence of man has for a long time changed indigenous vegetation everywhere. Climate and soils which alone determine the plant communities before the advent of man now mainly control and limit the nature and extent of human intervention and give landscapes thereby created varying physiognomics in different regions. Since the beginning of his existence, man has relied heavily on plants and has disturbed the flora and plant landscapes everywhere on the earth's surface. His history may be regarded partly as a struggle of the human species against its environment involving a progressive liberation from certain natural laws and a gradual enslavement of the world, its soils, plants and animals by his inventions and activities (Dorst, 1972). Thus his influence upon indigenous woody vegetation has been one of the most conspicuous modifications of his environment (Graham, 1956). For example land in cultivation, being maintained by constant care and attention is always different in aspect from its appearance before cultivation. Similarly, forests that are lightly cut and pastureland that is lightly grazed may show little change in appearance although there may be some differences in species composition. On the other hand, heavily used pastureland shows greater change and may finally support only a scattered stand of shrubs or annual plants largely non palatable to stock.

Tivy (1971) noted the destructive nature of the human species in any plant community because of its activities. This is reflected by the presence of only a few areas on the earth's surface where the plant cover is completely natural, in the sense of being the result solely of the interaction of the physical and non human biotic factors. It would be difficult to find any substantial area entirely unaffected by the activities of man (Pratt and Gwynne, 1977). It is possible only in the most remote and forbidding areas to find such original vegetation. And even here much has been modified by human activity.

Human activities, with the exception of fire clearing caused relatively little disturbance to indigenous woody vegetation in the early part of man's history on earth (Stewart, 1956). This was because populations were small and technical equipment modest (Dorst, 1972). This situation prevailed until "modern" times in certain parts of the world. This does not mean that ancient man did not exert a dominant influence on his environment. Unlike most animal species, man is capable of destroying his habitat long before feeling the effect of his wantonness (Dorst, 1972).

As man improved his technology, his impact on the natural environment increased, not only modifying it to meet his needs but degrading it through over use (Smith, 1972). Generally, man was exploiting rather than caring for his habitat. Many, if not most, non human animal species possess some form of homeostatic control (Smith 1972). This is evident when population levels in a particular locality increase and pressures on the environment increase, the population declines and with the decline in the population of the animal species, the environment recovers. For example, when a herbivore multiplies beyond the carrying capacity of its habitat and starts to destroy the latter, population decrease rapidly and pressure on the habitat immediately drops. Similarly when a predator multiplies to an extent that its prey is considerably reduced then, the predator population decreases (Dorst, 1972). But man possesses no homeostatic control. Thus when the human population increase, the pressure on the environment also increases (Bennett, 1975). One way to relieve this pressure was through emigration to new lands. Now there are restrictions in human movements and as such options for nations no longer exist. In order to meet material demands, man is forced to modify his environment too often to the detriment of both the environment and other animal species with whom he shares the earth (Dorst, 1970). By his activities man has consequently changed the balance of life on earth. Th natural biological balance between man and nature disappeared as soon as man the hunter became man the pastoralist and certainly by the time he began to cultivate land in order to produce arable crops (Flawn, 1972).

In more recent times, the awareness has grown that man's activities are leading to accelerated changes particularly in densely populated areas. Marsh (1864) emphasized the fact that nature could not always rehabilitate itself and noted that man's activities frequently started a chain of events which impoverished the environment. Sauer (1938) considered the way in which the activities of man altered the natural environment to produce a cultural landscape. Sears (1935) and Osborn (1948) have both discussed the phenomenon of ecological deterioration and have shown the extent of environmental destruction. They have both emphasized that environmental destruction has not been limited to one particular continent but is a world-wide phenomenon.

Growing concern about the deteriorating natural environment led to a symposium in New York in 1955 on the role of man in changing the face of the earth. The proceedings of this symposium were later published (Thomas et al. 1956).

Impacts resulting from human activities have also occurred on the Zambian environment. Storrs (1968) observed that a greater part of Zambia was covered with continuous woodlands except for the very marshy lands, flood plains and dambos. Most of the woodland area has been cleared as a result of man's continued dependence on it. Large areas of woodland have long since been cleared for pasture, arableland, and settlement or to obtain wood for fuel and timber for building. Some attempts have been made to examine them. For example, Richards (1939) considered the effects of the Chitemene system of agriculture among the Bemba in her attempt to analyse land, labour and diet in Northern Rhodesia. The Forest Department in 1933 established a series of experimental burning plots at Ndola in order to investigate the effects of burning indigenous vegetatio at different times of the year (Trapnell, 1959). In 1979 a seminar was held in Lusaka to discuss some of the human impacts on the natural environment (Johnson and Roder, 1979). Though the seminar did not specifically identify the major impacts affecting the Zambia environment, the following were emphasized as prominent factors throughout the proceedings: cultivation, bush burning, fuel wood collection and grazing. A detailed discussion of these factors is presented in appendix A1.

CHAPTER THREE

METHODOLOGY

Selection of the study area

The size of area required for the study was determined so that it could easily be traversed using a bicycle, since this was the most efficient and convenient mode of transport available to the researcher. Secondly, the area needed to have a sequence of aerial photographic cover. The aerial photographs were to be used in preliminary laboratory work and in studying vegetation changes. Aerial photographs are important because they have an advantage in that remote and difficult areas to travel over the ground can be seen from the air not only with speed but also cheaply at least in comparison to the cost of extensive ground travel. The selected area predominantly rural with very little or no direct influence of urban settlements and industries. The area was also supposed to be accessible from Lusaka. Additionally, the researcher was already familiar with the ecology and landscape of the area. This would therefore aid the researcher and reduce the time necessary for reconnaissance work. It was also anticipated that since the researcher was already familiar with the local customs and traditions of the inhabitants and was able to speak the local language fluently would not face a lot of problems when conducting the study and seeking for help from the local people. This would also help reduce communication problems which were likely to be encountered in such rural communities where most of the inhabitants can only speak vernacular languages rather than English.

With the aid of topographical maps (1530A 1-A4, SD 36-13), aerial photographs and preliminary field reconnaissance, a site in the northern part of Luangwa district was selected for the study because it fulfilled the required criteria. Additionally, the area appeared to be suitable and interesting for a study of thi nature. The area did not appear to present many security problems since it was outside the National Park. Thus restrictions of movements in the area were not expected and wild animal attacks were likely to be minimal:

Methods of investigations

Data for the study were obtained through a variety of source which included library work, field reconnaissance, laboratory work and fieldwork. These components of data collection are discussed in more detail in appendix A2.

CHAPTER FOUR

PRESENTATION OF RESULTS AND DISCUSSION

Bush burning

The household survey (Appendix B2) showed that fire in the study area is started by both man and natural causes such as lightning and friction on trees being rubbed together by wind. Bush burning is a common activity and it has become more pronounced as a result of the widespread use of matches. Bush fires are started for a number of reasons as has already been described in appendix A1. Among those mentioned are clearing the land for a number of purposes, honey and mice hunting which are prevalent activities in the dry season. It was also established from the survey that most of these fires are generally surface fires (Appendix B2).

Vegetation change as a result of burning

An examination of quadrats in which burning was the only activity that is known to have taken place (Appendix D1) revealed that there were a total of 31 woody plant species in the five quadrats. These could be placed into three broad classes namely:- canopy, understorey and shrubs.

Table 4: The distribution of individual woody plant species in different classes

CLASS	TOTAL NO. OF SPECIES	TOTAL NO. OF TREES	% OF TOTAL NO. OF TREES
CANOPY UNDERSTOREY SHRUBS	12 7 12	550 586 474	34.2 36.4 29.4
TOTAL	31	1610	100.0

The table above shows that there were more woody plant species in both the Canopy and shrub classes than in the understorey. The distribution of trees in the three classes showed that there were more trees in the understorey class. It is however difficult to comment on whether this obtained woody plant species composition and tree distribution is typical of a Mopane woodland because the average number of species and trees in a Mopane woodland stand is not known. Fanshawe (1968) however noted in his study that there are more than 300 woody species in Luangwa district. Since the current result is from a much smaller area, no conclusions could be made on the basis of comparison. The dominant woody species in the fire quadrats are Afzelia quanzensis, Acacia nigrescens, Colophospermum Mopane, Dalbergiella nyasae, Lannea discolor, Albizia anthelmintica, Combretum celastroides and Boscia matabelensis. Some of these woody species can be seen on photographs numbers one and two (Plates 1 and 2).

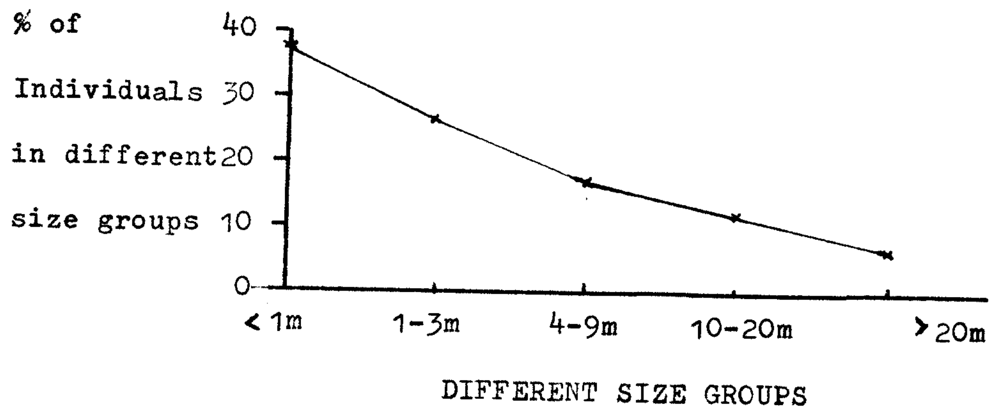
When the number of individuals in different size groups was considered, the result showed that in any stand trees generally decrease from the smaller to the larger classes.

Table 5: The distribution of individuals in different size groups

CLASS	NO. AND % OF INDIVIDUALS IN DIFFERENT SIZE GROUPS									
	> 20m		10-20m		4-9m		1-3m		< 1m	
	No	%	No	%	No	%	No	%	No	%
CANOPY	125	22.7	100	18.2	71	12.9	93	16.9	161	29.3
UNDERSTOREY	0	0	101	17.2	130	22.2	162	27.7	193	32.9
SHRUBS	0	0	0	0	64	13.5	162	34.2	248	52.3
TOTAL	125	7.8	201	12.5	265	16.5	417	25.9	602	37.3

Generally, there is a decrease in the number of trees in the different categories as one moves from the less than one metre category to the more than 20 metre category. This is infact typical of any Savanna plant community. The graph below illustrates this phenomena

Diagram III: The total distribution of trees in different size groups



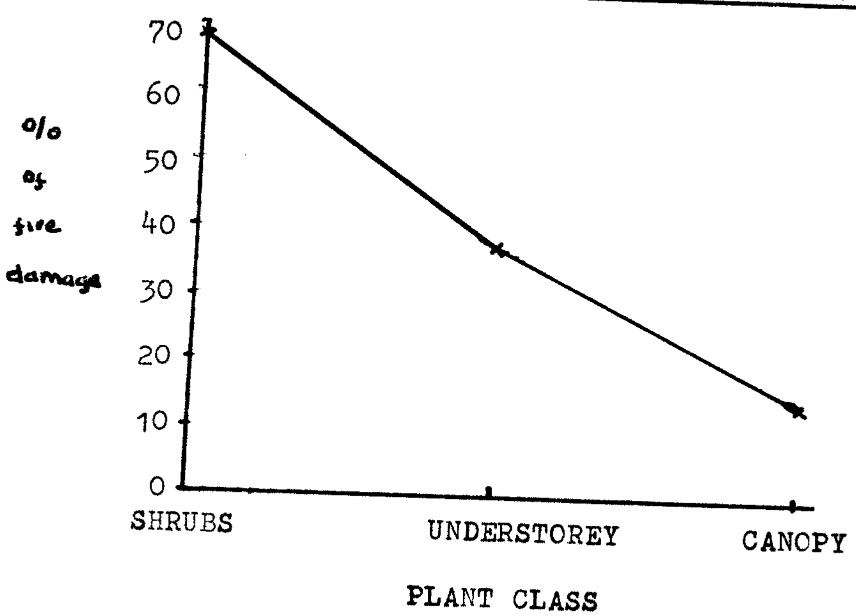
Measures were also taken to examine the damage that fire has inflicted on woody vegetation. The fire damage that was considered was that which left visible marks on the trees. This included stem lesions, burnt growing tips , twigs, burnt bark and basal fire scars.

Table 6: Structural damage as a result of bush burning

CLASS	TOTAL NO AND % OF FIRE DAMAGED TREES	
	No.	
CANOPY	101	18.3
UNDERSTOREY	227	38.7
SHRUBS	329	69.4
TOTAL	557	40.8

The result in the table above shows that fire has inflicted most damage to plants in the shrub layer than the other two classes. This is basically because the area experiences surface fires and these have a tendancy of sweeping across the woodland floor rapidly burning off litter, undergrowth and the above surface parts of low growing plants but rarely affect the crowns of higher trees, thus making the canopy crowns the least affected. The graph below illustrates this finding.

Diagram IV: Structural damage to trees in different classes



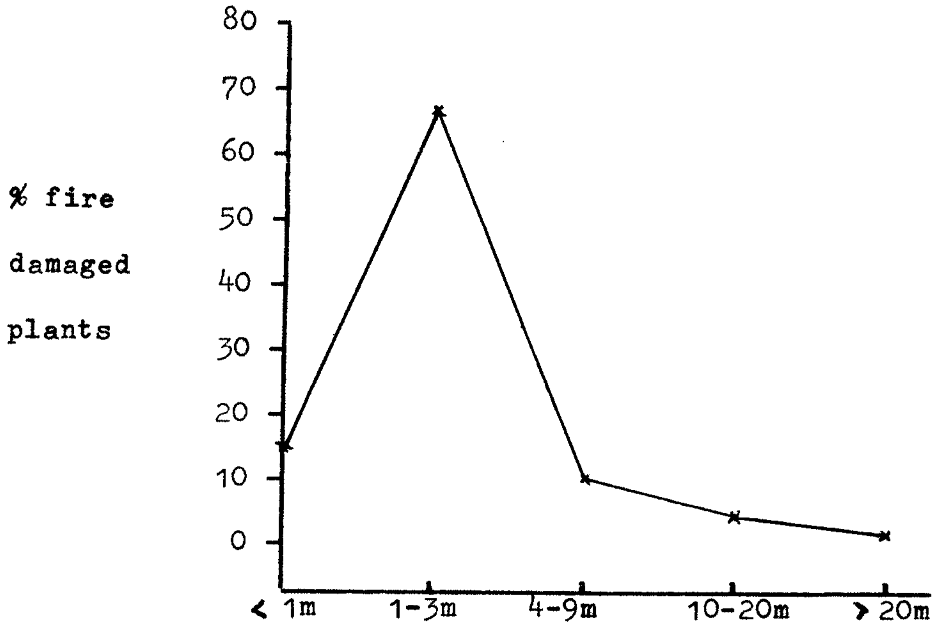
When fire damaged plants were considered in different size groups the results obtained are as shown in the table below:-

Table 7: Fire damaged trees in different size groups

CLASS	> 20m		10-20m		4-9m		1-3m		<1m	
	No.	%	No.	%	No.	%	No.	%	No.	%
CANOPY	11	10.9	17	16.8	23	22.0	31	30.7	19	18.
UNDER-STOREY	0	0	23	10.1	39	17.2	132	58.2	33	14.
SHRUBS	0	0	0	0	13	4.0	276	83.9	40	12.
TOTAL	11	1.7	40	6.1	75	11.4	439	66.8	92	14.

Most damaged trees were registered in the 1-3 metre category. This might have been due to the fact that the study was undertaken in January when fire had already ravaged the study area. Thus some plants in the less than one metre category which survived the burn last dry season had since then grown and were represented in the 1-3 metre category with some structural damage sustained in their early period of growth. On the other hand there were fewer fire damaged plants in the categories greater than three metres because most fires as has already been stated are surface fires which rarely affect the growing parts of tall plants. There were less fire damaged plants in the less than one metre category because most of the plants had just grown and had not yet been subjected to annual bush fires (Plates 3 and 4). This finding is clearly illustrated in the graph below.

Diagrapm V: Total fire damaged woody plants



The species which were most liable to fire damage included Boscia matabelensis, Popowia obovata, Ximemia caffra and Albizia anthelmintica.

Conclusion

Bush burning can be viewed as a time honoured Custom in the study area though little is known and has been written about it and its effects on woody vegetation. Most previous work has concentrated on the deleterious effects of burning without recognizing the reality that in most circumstances some form of burning is inevitable. Burning has generally altered the species composition of the study area through fire damage which has eliminated those species which are not fire resistant. Langlands (1967) also noted that the vegetation of most of East Africa is a sub-climax resulting from continued burning and is maintained by fire.

Cultivation of crops

The dominant system of arable agriculture practised in the study area is a form of shifting cultivation which characterizes the traditional agricultural systems in Zambia commonly known as Chitemene. Of the 30 households who were questioned and had their fields examined, 21 practised shifting cultivation only, four practised the more sedentary methods which utilize crop rotation and five practised both systems side by side, the shifting type for food crops and the sedentary method for cash crops. This result also shows that there is a gradual shift from shifting to more sedentary types of arable agriculture.

Land clearing is based on the Chitemene system. Trees are cut at about 0.5 metres above the ground. A few large trees and those which provide edible fruit are not cut at 0.5 metre level above the ground but merely have their branches cut early in the dry season at about May/June. The cut trees are left to dry and between September and October they are gathered and placed into stacks within the cleared area. These are burnt just before the rains (Plates 5 and 6). 19 of the 30 households used slash and burn as their only method of clearing the land, four practised clear-felling and seven practised both systems. This result reflects a gradual shift from the traditional slash and burn system practised under shifting cultivation to clear-felling and removal of the stumps practised in the sedentary types of agriculture.

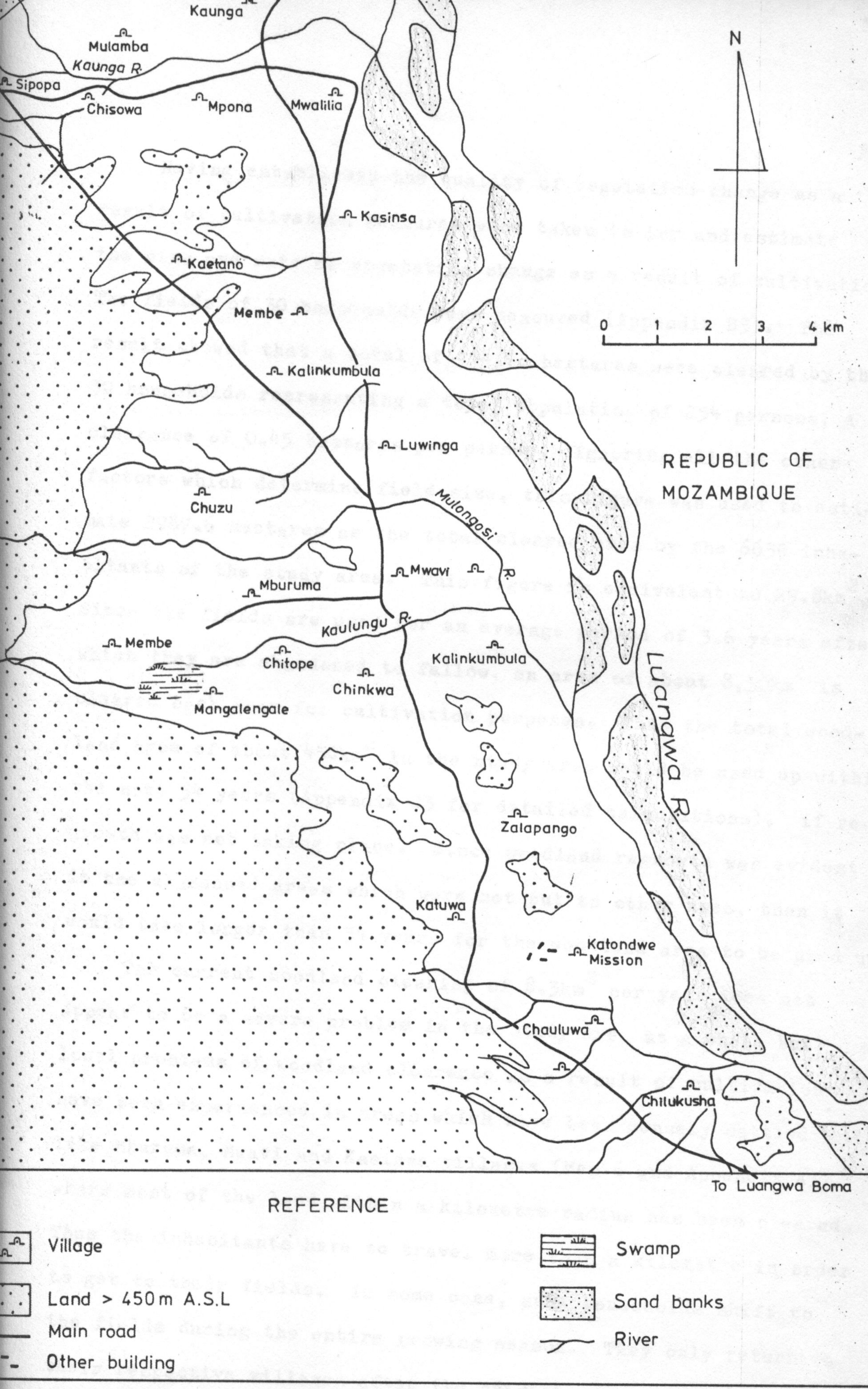
In the Luangwa system, the entire cut-over area is planted unlike in the Northern parts of Zambia where only a small portion of the cleared area is planted (Richards 1939). The aim of cutting trees in the Northern system is to obtain enough ash to fertilize the soil whereas in the study area, the aim is to remove obstructions so that sunlight can reach the crop at the ground level. The tools used are mainly the hoe and axe. Of the 30 households, 22 used the hoe and axe only, five used the hoe, axe and ox-drawn ploughs and/three also hire tractors. Thus the majority of the inhabitants are subsistence farmers who use the axe and hoe as their major tools. Only a few people use ox-drawn ploughs because of the restrictions imposed on cattle rearing as a result of the presence of tsetsefly. At K16 per tractor hour, tractor hiring is too expensive for most inhabitants (Chapter One).

It was also established from the household survey that fields were abandoned when fertility declined to natural regeneration. The length of use before abandonment varied from three to six years as shown in appendix B3. On the average fields are abandoned every 3.6 years. This is done in order to enable the area to regain fertility through natural means.

Vegetation change as a result of cultivation

An examination of quadrats in which cultivation was the dominant activity (Appendix D2) revealed that arable agriculture removes indigenous woody vegetation in favour of arable crops (Plate 7). A woody ecosystem is replaced by that which is dominated by crops. For example, there were 211 tree stumps and 13 trees in the quadrats. The stumps represent trees which were cut to give way to cultivation. The 13 woody plants represent trees in the canopy class which were not cut because they were too large, such as Colophospermum mopane, Albizia harveyi, Kirkia acuminata and Lannea stuhlmannii. The others were left because they provide edible fruit, for example, Adansonia digitata and Hyphaene ventricosa. Only a few woody plants are left in cultivated areas. Thus cultivation brings about changes in species diversity and removes almost all individuals in smaller size groups.

An examination of the 13 trees showed that they all had signs of structural damage which was a result of man's activities to bring about cultivation. The structural damage included cut branches, and leaves, fire scars, removed bark and dug roots (Plate 8). Taking the fire quadrats as the standard, it can clearly be seen that cultivation has fewer woody species than burning. Additionally, only one class is represented which is the canopy. The trees are found only in two different size groups of more than 20 metres and 10 to 20 metres unlike under burning where all the three classes and all size groups are represented. Under burning only 40.8 percent of the trees are damaged by fire where as under cultivation 100 percent damage as a result of cultivation was recorded.



6: SOME MAJOR SETTLEMENTS

Having established the quality of vegetation change as a result of cultivation measures were taken to try and estimate the size and rate of vegetation change as a result of cultivation. The fields of 30 households were measured (Appendix B3). The result showed that a total of 114.76 hectares were cleared by the 30 households representing a total population of 254 persons, a clearance of 0.45 hectares per person. Ignoring all the other factors which determine field size, this figure was used to estimate 2987.6 hectares as the total cleared area by the 6639 inhabitants of the study area. This figure is equivalent to 29.8km^2. Since the fields are used for an average period of 3.6 years after which they are abandoned to fallow, an area of about 8,30km^2 is cleared each year for cultivation purposes. Thus the total woodland area of about 450km^2 in the study area would be used up within the next 54 years (Appendix C3 for detailed calculations), if regrowth was not taking place. Since woodland regrowth was evident in the abandoned areas which were not put to other uses, then it would take longer than 54 years for the woodland area to be used up.

The current woodland clearing of 8.3km^2 per year does not appear to be a severe problem in the study area as a whole but local problems of woodland clearance as a result of cultivation have been experienced in areas which have been densely settled like Mburuma, Mwavi and Kasinsa villages (Map 6 and Appendix A3) where most of the land within a kilometre radius has been cleared. Thus the inhabitants have to travel more than a kilometre in order to get to their fields. In some case, some households shift to the fields during the entire growing season. They only return to their respective villages after the harvest.

The ever increasing population, and the transition to more sedentary agricultural systems and a cash economy will require larger fields since the current ones are too small and this will put more pressure on the woodland area than is the case at the moment in the subsistence dominated agricultural area. This will add to the already existing problems of distance from the villages (Plate 9).

Since the dominant system of agriculture is shifting cultivation, it was necessary to consider what is taking place in the abandoned fields. An examination of fields which were abandoned about six years ago (Appendix D3) showed that woody vegetation which was usually felled by cutting the trees through the bore, regrowth took place from the stump. This was in particular more pronounced in areas which were not subject to intense human activities such as fuelwood and timber gathering, as well as grazing and browsing of domesticated animals (Plate 10). In areas where these activities were heavy, it resulted in the removal of the young stock and also depressed the vig our of trees growing from the stump (Plates 11, 12 and 13).

In order to ascertain whether regrowth was taking place in abandoned fields, quadrats sampled from abandoned fields were compared with those from cultivated fields in terms of woody plant distribution. The result is shown in the table below.

Table 8: A Comparison of tree distribution in the abandoned and cultivated areas

CLASS	TOTAL % OF TREES IN SAMPLED AREAS	
	ABANDONED FIELDS	CULTIVATED AREAS
CANOPY	28	100
UNDERSTOREY	39	0
SHRUBS	37	0
TOTAL	100	100

Since all the three categories are represented in the abandoned fields unlike in the cultivated areas where only the canopy class was represented. This result confirms that regrowth has and is taking place. Additionally there were only seven woody species in the cultivated areas as compared to 17 in the abandoned field.

On considering the number of individuals in different size groups in the abandoned fields, the result showed that regrowth has or is taking place. Almost all the different size groups are represented except in the understorey and shrub layers where trees are generally short and rarely grow beyond the reflected limits in the table.

Table 9: The percentage of the distribution of woody plants in different size groups in abandoned areas

CLASS	> 20m	10-20m	4-9m	1-3m	< 1m
CANOPY	2.3	10.2	19.5	20.3	47.7
UNDERSTOREY	0	1.7	27.3	29.6	41.5
SHRUBS	0	0	3.3	45.3	51.3
TOTAL	.7	3.5	17.2	32.2	46.5

The result shows clearly that regrowth is greater in the smaller size groups of less than three metres. Additionally, it is greater in the shrub layer than the other two classes. It is worth nothing however that the dominant regrowth is from Balanites aegyptiaca, Dalbergiella nyasae, Popowia obovata, Lannea discolar, Afzelia quanzensis and Colophospermum mopane.

Conclusion

Cultivation using the traditional method of shifting cultivation is one of the causes of large scale deforestration in the study area. The absence of industries of any kind means that people have to depend on arable agriculture which also involves the clearing of woody vegetation. Generally cultivation is characterized by the loss of the indigenous woody vegetation and temporary replacement of indigenous woody plants by cultivated ones. Thus cultivation unlike burning removes woody species from the stand whereas fire merely removes the less resistant woody species and thereby gives the woodland a more open appearance. It must be noted however that regeneration of woody vegetation takes place when the fields are abandoned.

Grazing and Browsing of domestic animals

The household survey revealed that along with the development of arable agriculture man has domesticated a number of animal species as a side-line activity to arable agriculture (Appendix B4). Appendix B4 shows that all the 30 households do keep some animals. The animals are reared on a subsistence level. They are not intended for sale but merely give one some form of status in the society. The reared animals include cattle, sheep, pigs and goats. Among these animal species only pigs are carefully raised in enclosures and artifically fed because of their destructive activities to crops during the growing season. The other animals depend on indigenous vegetation.

Table 10: Domestic animal distribution for the 30 households.

HOUSEHOLD	GOATS	CATTLE	PIGS	SHEEP
30	672	52	141	14

Table 10 above shows that the dominant animal species in the study area is the goat (Plate 14). Cattle are few and limited to a narrow belt along the Luangwa river due to the presence of tsetsefly. Pigs are common and can be seen in every village but since they are carefully kept in enclosures for the most part of the year, their effect on indigenous woody vegetation is very slight.

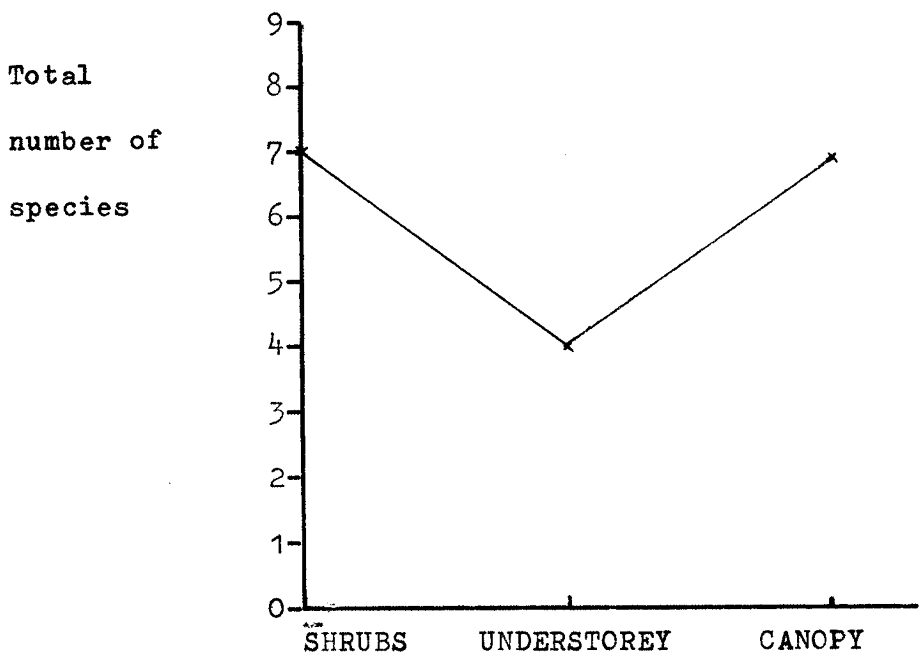
Discussions with the household heads showed that continuous grazing is practised. Seasonal variations in the availability of enough pasture was also noted.

During the wet season, when water is readily available, there is generally enough pasture for all the animals. Thus most animals can be seen grazing and browsing in the fallow areas nearer to the villages but in the dry season when water becomes a problem and most of the woodland area is burnt, most of the domestic animals have to be driven for long distances to dambos or along streams in order to find enough pasture. It is during this season that goats and other domestic animals take to browse as a result of the absence or scarcity of graze.

<u>Vegetation change induced by the grazing and browsing activities of domestic animals</u>

An examination of quadrats in which grazing and browsing was the dominant activity (Appendix D2) showed that there were a total of 18 woody species and their distribution in the three broad classes is diagramatically presented below:-

<u>Diagram VI: Woody species distribution in three different classes</u>



The result clearly shows that there were more species in both the shrub and canopy classes than in the understorey.

Table 11: Woody plant distribution in different classes

CLASS	TOTAL NO OF SPECIES	TOTAL NO. OF TREES	% OF TREES
CANOPY	7	171	31.6
UNDERSTOREY	4	144	26.6
SHRUBS	7	226	41.8
TOTALS	18	541	100

The table above shows that there were more individual trees in the shrub class than in the other two classes. The understorey had the least number of woody plants.

When this result was compared to that obtained in the fire quadrats, the result is presented in the diagram below:-

Diagram VII: Comparison of the distribution of individual woody plants in different classes in the fire and grazing/browsing quadrats

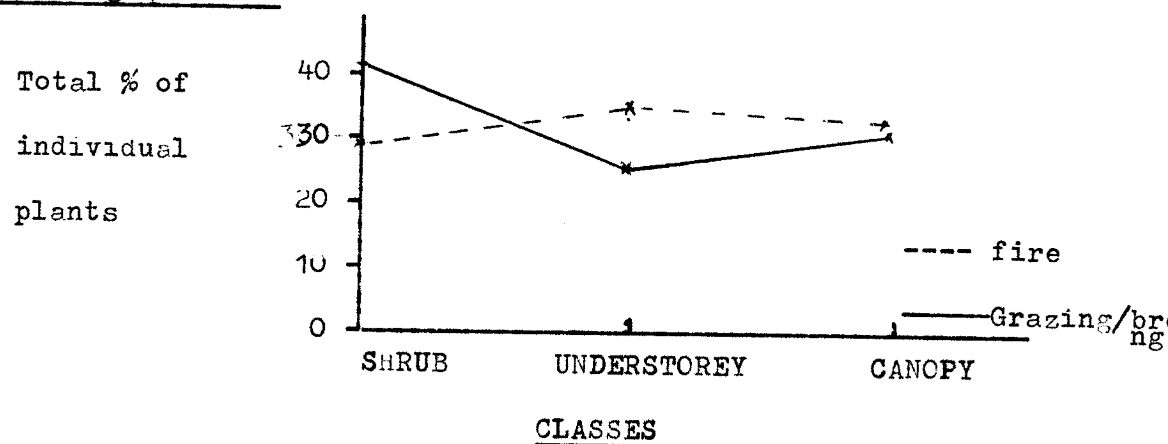


Diagram seven above shows that in the fire quadrats the number of individuals is highest in the understorey, followed by the canopy and least in the shrub layer whereas in the grazing and browsing quadrats the number of individuals in the three classes is least in the understorey class and greatest in the shrub class showing that some plant species are stimulated in growth by the removal of others. i.e. competition is reduced enabling some plants to grow with increased vigour. This distribution cannot however be attributed to grazing and browsing alone, since an analysis of species palatability is not done in this exercise.

On considering the number of individuals in different size groups the result is shown in table 12 below.

Table 12: The distribution of individuals in different size groups

CLASS	>20m		10-20m		4-9m		1-3m		<1m	
	No	%	No	%	No	%	No	%	No	%
CANOPY	17	9.4	23	13.5	15	8.8	49	28.7	67	39.2
UNDERSTOREY	0	0	15	10.4	19	13.2	45	31.3	65	45.1
SHRUBS	0	0	0	0	6	2.7	71	31.4	149	65.9
TOTAL	17	3.1	38	7.0	40	7.3	165	30.5	281	51.9

Table 12 shows that generally there were more individuals in the less than one metre category and the number decreased as one moved towards the more than 20 metre category. When this result was compared with that obtained in the fire quadrats, the result is presented graphically in diagram VIII below.

Diagram VIII: A comparison of the distribution of individuals in different size groups in the fire and grazing and browsing quadrats.

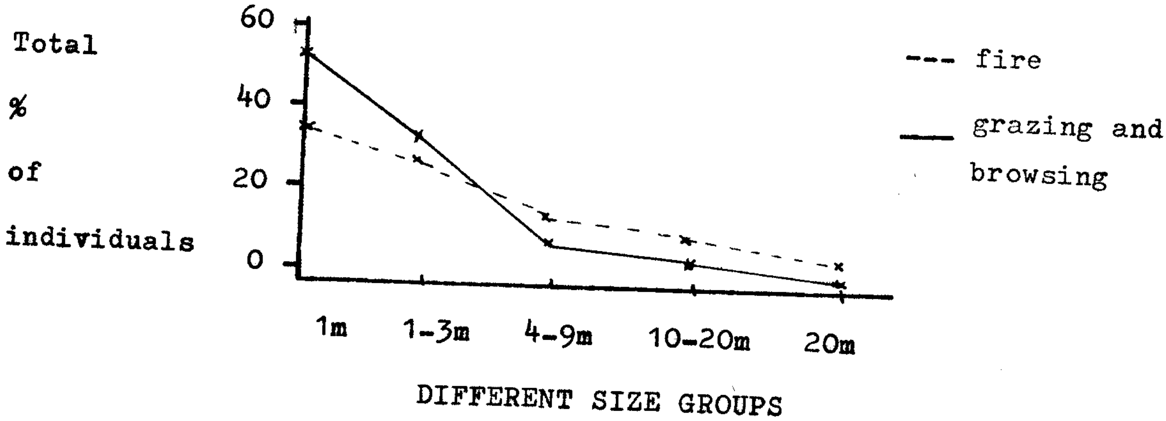


Diagram VIII shows that there are more trees in the fire quadrats in categories more than four metres than in the grazing and browsing categories but there are more plants in the 1-3 metre and less than one metre categories of the grazing and browsing quadrats. Although fire is a common factor to both areas the burning regimes tend to be different (burning in grazing areas is earlier and the fires less intense) and therefore this is likely to have contributed to the differences.

Table 13: Structural dmage to woody plant species resulting from the grazing and browsing activities of domestic animals,

CLASS	TOTAL NO. OF DAMAGED TREES	% DAMAGE
CANOPY	129	75.4
UNDERSTOREY	117	81.3
SHRUBS	196	86.7
TOTAL	442	81.7

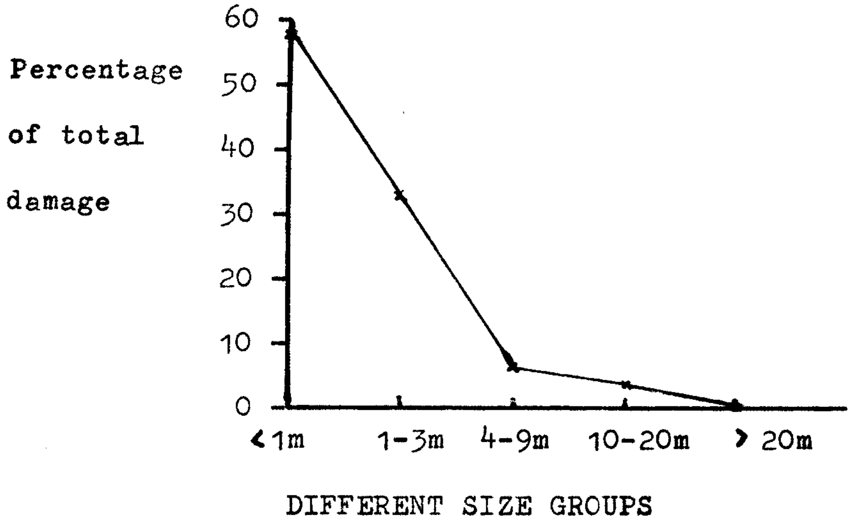
Table 13 above shows that shrubs were themost liable to grazing and browsing damage. This is so because they are generally shorter in height and their branches and crowns can easily be reached by domestic animals especially goats when they stand on their hind legs unlike the canopy whose branches and crowns are very high up. The damage considered here included damaged bark, eaten up growing tips eaten leaves, trampled seedlings and fallen tree branches. In order to study this aspect in detail the damaged plants were considered according to different size groups. The result is shown in table 14 below:

Table 14: Woody plant species damaged by the grazing and browsing activities of domestic animals in different size groups

CLASS	> 20m		10-20m		4-9m		1-3m		<1m	
	No	%	No	%	No	%	No	%	No	%
CANOPY	0	0	11	8.5	12	9.3	44	34.1	62	48.1
UNDERSTOREY	0	0	3	2.6	14	12.0	41	35.0	59	50.4
SHRUBS	0	0	0	0	0	0	59	30.1	137	69.9
TOTAL	0	0	14	3.2	26	5.9	144	32.6	258	58.4

Table 14 reveals that plants in the categories less than three metres are the most liable to grazing and browsing damage. This is probably so, because animals prefer tender and younger plants which they can reach easily rather than tall ones which are generally very difficult to reach. The result also shows that the tender and younger plants in the seedling (<1m) and sapling (1-3) categories in the shrub layer are the most liable to damage by grazing and browsing. It is also worth nothing that plants in the less than one metre category are generally eaten up together with grass during grazing.

<u>Diagram IX: Overall damage by grazing and browsing in different size groups</u>



The graph above clearly illustrates a high incidence of damage in categories less than three metres and a very low incidence in categories greater than three metres. An examination of the quadrats in which grazing and browsing was the dominant activity showed that the species most favoured by domestic animals include <u>Sclerocarya caffra</u>, <u>Afzelia quanzensis</u>, <u>Acacia nigrescens</u>, <u>Balanit aegyptiaca</u>, <u>Colophospermum mopane</u> and any that has been completely removed and is therefore unknown. Among those that showed the least damage were <u>Hyphaene venticosa</u>, <u>Combretum imberbe</u>, <u>Lannea discolor</u>, <u>Cadaba kirkii</u> and <u>Ximenia americana</u>.

<u>Conclusion</u>

It was generally observed from the quadrats and also from photographs which were taken during reconnaissance and field work that grazing and browsing keep the grass short and thus reduced the fire hazard in the dry season (Plate 15). It was also observe from field studies that when the activity occurs in cutover areas tree regrowth is prevented as the shoots are eaten up. In some parts of the study area some shrubs especially the very short ones have been reduced to coppice and continued grazing and browsing maintains them at low levels. There was no evidence from the quadrats however to show that grazing and browsing kill trees. If this was the case, most of the palatable species in areas where the activity is dominant would have been killed and would not have survived to the present day. Evidence from the quadrats merely showed that most plants especially those in the seedling category are killed by fires in the dry season. Also affected by fire is regrowth from the coppice. Although the evidence obtained is not adquate, it may however be postulated that domestic animals especially goats have helped in the destruction of indigenou woody vegetation especially that in the seedling and sub-shrub layers thus making the woodland areas look more open in appearance.

Fuelwood collection

The household survey (Appendix B5) showed that firewood is the dominant source of energy for both heating and cooking of the 30 households, 22 indicated that they used firewood only and eight use both firewood and charcoal. None of the households claimed to use charcoal only. In addition to energy for heating and cooking, firewood is also used for lighting purposes. It is used as torches at ceremonial occasions which include initiations such as

Chisungu and spiritual dances such as *Mashabe*. The dominant position of fuelwood as the main source of energy for heating and cooking is reflected by the absence of electric power in the study area. Oil is very scarce and when available it is usually in small quantities and expensive. Only Katondwe mission and Luangwa Boys Secondary School use small diesel generators.

Firewood is thus the most important and is collected within walking distance from the villages. Firewood collection is a selective activity and is seasonal in nature. It was seen that on the average the 30 households made at least three trips every week in the dry season and only one during the rainy season. Table 15 illustrates this point.

Table 15: The Seasonal nature of firewood collection

SEASON	FIREWOOD COLLECTION TRIPS PER WEEK						AVERAGE NO. OF TRIPS/WEEK
	1	2	3	4	5	6	
WET	17	12	1	0	0	0	1
DRY	0	9	15	6	0	0	3

Vegetation change as a result of firewood collection

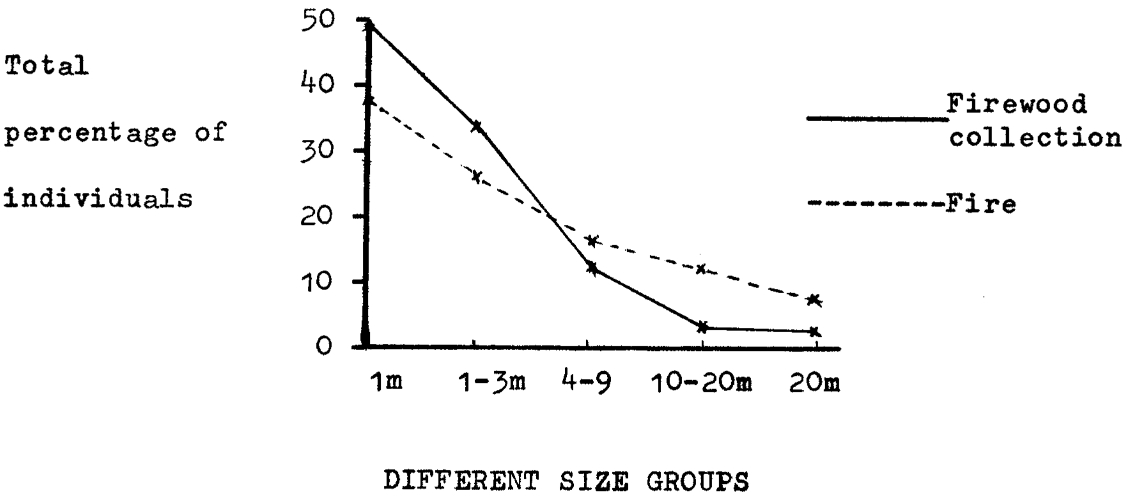
An examination of quadrats in which firewood collection was the dominant activity (Appendix D5) showed that there were 22 woody plant species. This number is less than that obtained in the fire quadrats. There were ten species in the canopy class, six in the understorey and six in the shrub classes. When the distribution of individuals in the three classes was considered the result indicated that the canopy class had 41.9 percent of the individuals the understorey class had 29 percent and the shrub class had 18 percent. Using the chi-square test of significance it was established that this distribution was significant. There were significant differences in the number of individuals in the three classes.

Table 16: The number of individuals in different size groups

CLASS	> 20m		10-20m		4-9m		1-3m		< 1m	
	No	%	No	%	No	%	No	%	No	%
CANOPY	15	6.6	13	5.7	31	13.6	91	39.9	138	60.5
UNDERSTOREY	0	0	3	1.9	23	14.6	58	36.6	74	46.8
SHRUBS	0	0	0	0	7	7.1	35	35.7	56	57.1
TOTAL	15	2.8	16	2.9	61	11.2	184	33.8	268	49.3

Table 16 shows that there were more individuals in size groups less than four metres. This is a typical characteristic of any Savanna woodland stand. Usually the individuals in the less than four metre size groups are not used as firewood. When this result was compared with that obtained under fire, the results shows that under firewood collection there were more individuals in the less than four metre size groups and this suddenly drops as one moves to categories more than four metres. The graph showing the distribution of individuals in the fire quadrats on the other hand drops gently from the less than four metre category to the more than four metre category. The graph below will help illustrate this point.

Diagram X: Comparison of the number of individuals in different size groups of the fire and firewood collection quadrats.



When structural damage as a result of firewood collection was considered, the result obtained is shown in the table below:-

Table 17: Structural damage to woody plant species in different classes

CLASS	DAMAGED TREES	PERCENTAGE DAMAGE
CANOPY	132	45.8
UNDERSTOREY	119	75.3
SHRUBS	65	66.3
TOTAL	316	58.1

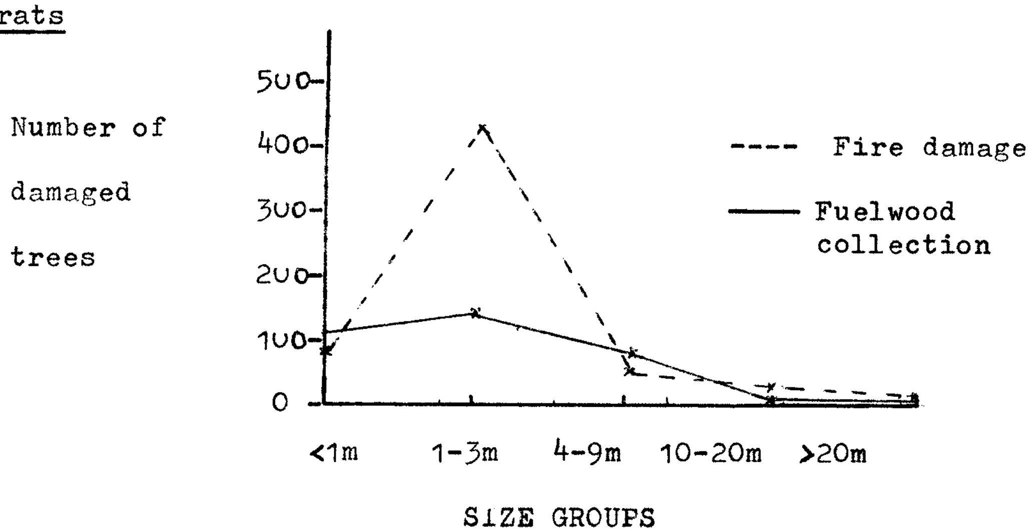
Table 17 above shows that trees in the understorey class were the most affected by firewood collection damage. The least affected were those in the canopy. This is very difficult to explain but it can be seen that firewood collection which involves the cutting of live trees mainly affects the larger trees in the canopy class. Thus when the cut trees fall, they first fall on the understorey thus inflicting some damage before they actually fall to the ground. These damaged branches of both the understorey and the shrubs will eventually be used as firewood.

Table 18: The number of damaged individuals in different size groups

CLASS	> 20m		10-20m		4-9m		1-3m		<1m	
	No	%	No	%	No	%	No	%	No	%
CANOPY	10	76	7	53	23	17.4	64	48.5	28	21.2
UNDERSTOREY	0	0	3	2.5	21	17.7	49	41.2	46	38.7
SHRUBS	0	0	0	0	6	9.2	30	46.2	29	44.6
TOTAL	10	3.2	10	3.2	50	15.8	143	45.3	103	32.6

Generally table 18 shows that there is a decrease in the number of damaged plants due to firewood collection from the less than one metre category to the more than 20 metre category. The explanation **for** this might be that most preferred species are within the shrub layer. The most liable to damage are those in the shrub layer. When this finding was compared to that obtained under fire, the compared results is diagramatically presented below

Diagram XI: A comparison of the distribution of damaged trees in different size groups of the fire and firewood collection quadrats



When the overall result of the two activities was compared graphically it was seen that the trend was similar in that both curves showed the highest incidence of damage in the 1-3 metre category though the damage for the fire quadrats was relatively higher than that of fuelwood collection.

Firewood Consumption

Having established the quality of vegetation change which results from firewood collection, measures were taken to estimate quantitatively the amount of wood consumed each year (Appendix B6) and this was later related to clear-felled areas as a result of the activity in question. The data is shown in the table below:-

Table 19: Household firewood consumption

Total no. of people in the 30 households	Total consumption/ week by 30 households	Average Consumption per week/ person
254	2255.7 kg	8.9 kg

If each person burns an average of 8.9 kg of wood per week, then he will burn a total of 462.8 kg per annum. Thus a population of 6639 people will burn a total of 2971201.4 kg of dry weight wood each year. Since this exercise was conducted during the rainy season when wood use is comparatively low, one would find a figure slightly higher than this for the dry season. Using values from Mihalyi (1972) and Chidumayo (1979) to estimate firewood cut to corresponding clear-felled areas, 2971201.4 kg of dry weight wood is equivalent to 0.59 km^2 of clear-felled area each year (Appendix C2).

Vegetation change due to charcoal production

An examination of the charcoal burning quadrats (Appendix D6) showed that there were a total of 18 woody species. These species was represented in all the three broad classes. The canopy had a total of eight species, understorey had four and the shrub six species. When the number of individuals in different size groups was considered the result is shown in table 20 below:-

Table 20: The distribution of individual woody plants in different size groups

CLASS	> 20m		10-20m		4-9m		1-3m		<1m	
	No	%	No	%	No	%	No	%	No	%
CANOPY	0	0	0	0	0	0	6	4.6	126	95.4
UNDERSTOREY	0	0	0	0	0	0	0	0	38	100.0
SHRUBS	0	0	0	0	0	0	0	0	50	100.0
TOTAL	0	0	0	0	0	0	6	2.7	214	97.3

Table 19 shows that individual trees are found in the 1-3 metre and the less than one metre groups in the case of the canopy trees and only in the less than one metre groups in the case of the understorey and shrubs. This reflects that clear-felling of trees is practised in charcoal production (Plates 16, 17 and 18). It was also seen from the stump counts that there were about 187 visible tree stumps in the sampled areas.

Since it was seen from the quadrat studies that charcoal production introduces deforestation, measures were taken to estimate the area of deforestation which results from charcoal. A survey of the study area revealed that a total of 8 962 bags of charcoal were produced each year. Each bag weighed about 43.5 kg on the average. Thus a total weight of 38 984.7 kg of charcoal was produced each year. Using values from Mihalyi (1972) and Chidumayo (1979) for estimating fuelwood cut and corresponding clear-felled area in Zambia, 38 984.7 kg of charcoal is equivalent to 0.078 km^2 of clear-felled area (Appendix C3).

Thus the combined charcoal production and firewood collection is responsible for an annual woodland clearing of about 0.67 km. This annual clearance of woody vegetation for fuelwood purposes does not appear to present any severe problems in the study area at the moment considering that the total area of about 560 km^2, there are some 76 percent of woodlands. The only serious problem is that of localized deforestation. There is evidence to show that in densely settled villages like Mburuma, Mwavi, Sipopa and Membe woodlands within a kilometre radius from the village centres have been cleared for a number of reasons except around grave yards. Thus in order to collect valued species of firewood the inhabitants have to travel more than a kilometre. This also applies to woodland areas around fish camps along the Luangwa river.

The exercise also showed that among the desired species for fuelwood are Colophospermum mopane, Balanite aegyptiaca, Afzelia quanzensis and Acacia nigrescens. The avoided species include Adansonia digitata, Hyphaene ventricosa, Lannea stuhmannii and Lannea discolor. Some of these species are avoided because they provide edible fruits and in some cases because they do not provide what might be termed a "hot fire". Others are avoided due to traditional customs and beliefs. i.e. There are cultural prohibitions of certain wood species because they are believed to be the home of ghosts, spirits or burning them would bring misfortune to the household.

Vegetation regrowth

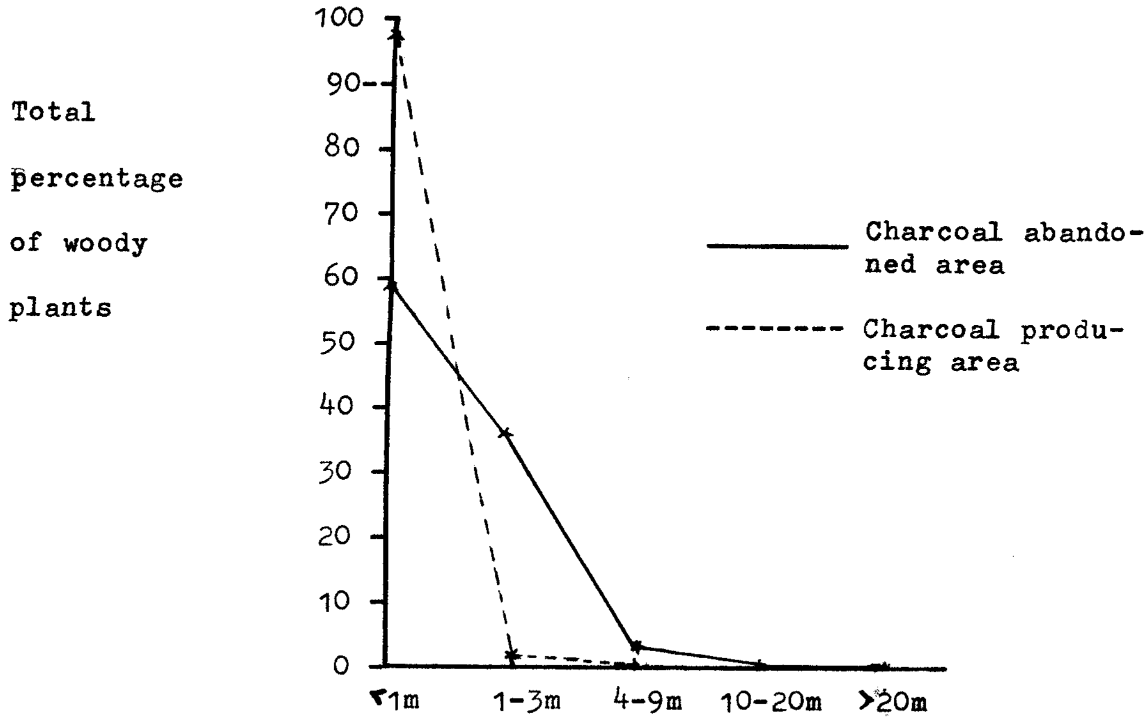
In order to ascertain whether vegetation regrowth was taking place, abandoned charcoal sites were examined (Appendix D7). The summarized result of the distribution of trees in different size groups is presented in table 21 below:-

Table 21: Woody vegetation regrowth in different size groups

CLASS	>20m		10-20m		4-9m		1-3m		< 1m	
	No	%	No	%	No	%	No	%	No	%
CANOPY	0	0	0	0	8	4.4	62	34.3	111	61.
UNDERSTOREY	0	0	0	0	5	4.2	42	35.0	73	60.
SHRUBS	0	0	0	0	0	0	59	43.1	78	56.
TOTAL	0	0	0	0	13	3.0	163	37.2	262	59.

Table 21 shows that regrowth is taking place in the abandoned charcoal production areas though the pace at which it is taking place is rather slow. The considered areas were abandoned some five years ago and since then the only human activity which affects the areas each year is bush burning. It would be expected that woody plants would have grown to categories more than nine metres. This slow regrowth rate can partly be attributed to low rainfall in the area. In order to ascertain regrowth the result from the abandoned charcoal production areas was compared with the result obtained under the charcoal producing areas. The result is diagramatically presented below.

Diagram XII: A comparison of woody plant species in different size groups for charcoal producing and charcoal abandoned areas.



SIZE GROUPS

Diagram XII shows that there has been some regeneration in the abandoned areas. For example, there were no individual woody plants in groups more than three metres in the charcoal producing areas but this class is represented in the abandoned areas. Additionally an examination of the charcoal abandoned sites revealed that regrowth was taking place from the stumps. Despite regrowth taking place, bare spots marking the once charcoal clamp sites are still visible (Plate 19) in the affected areas.

Timber Exploitation for building

The household survey showed that the majority of the inhabitants of the study area use wood as the major structural material for building purposes. Of a total of 125 huts belonging to 30 households, 100 were pole huts and the remaining 25 were brick houses

It must be noted however that even the brick houses use wood in the construction of the roof frame-work. An examination of the huts revealed that the wood required for building is in the form of straight poles of about two metres in length and between five and 25 cm in diameter. This activity is highly selective and only those woods which are considered strong and highly resistant to termite attacks are sought. These include:- *Balanites aegyptiaca*, *Acacia nigrescens*, *Colophospermum mopane*, *Dichrostachys cinerea*, *Afzelia quanzensis*, *combretum imberbe* and *Combretum celastroides*.

Vegetation change as a result of timber exploitation for building purposes.

An examination of the quadrats in which timber exploitation for building purposes was the dominant activity (Appendix D8) revealed the following species composition:-

Table 22: The distribution of woody plants in different classes

CLASS	TOTAL NO OF SPECIES	TOTAL NO. OF INDIVIDUALS	TOTAL %
CANOPY	11	351	56.3
UNDERSTOREY	7	140	22.3
SHRUBS	7	133	21.3
TOTAL	25	624	100.0

Table 22 shows that there were more individuals in the canopy class than the other two classes.

To a certain extent this shows that most of the wood which is cut for building purposes is from the two classes of understorey and shrubs. This is true in that building utilises wood in the form of poles. When this result was compared with that of the fire quadrats, the result is presented graphically below:-

<u>Diagram XIII: A comparison between the fire and wood exploitation, quadrat woody species distribution in different classes.</u>

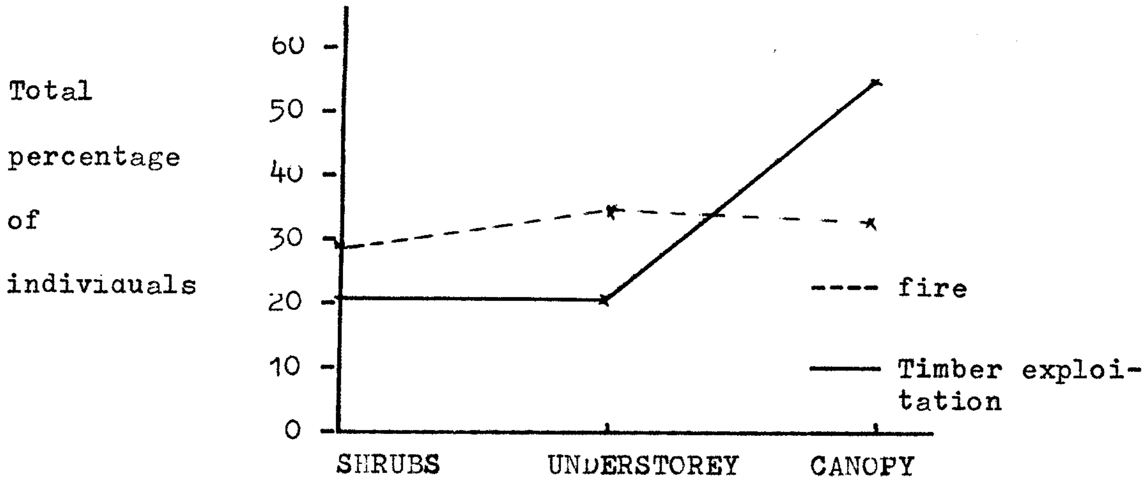


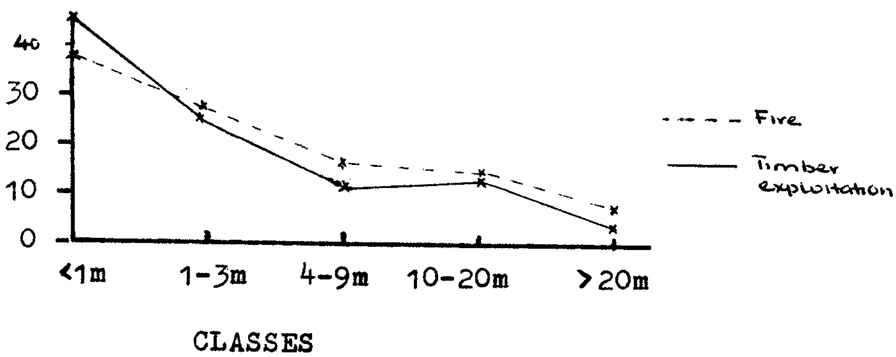
Diagram XIII shows that there were more individuals in the canopy class of timber exploitation than fire and more individuals in the fire quadrats for the other two classes showing that woody plants in the lower classes are the ones which are sought for building purposes.

Table 23: The number of individuals in different size groups

CLASS	>20m		10-20m		4-9m		1-3m		<1m	
	No	%	No	%	No	%	No	%	No	%
CANOPY	36	10.3	65	18.5	46	13.1	74	21.1	130	37.
UNDERSTOREY	0	0	12	8.6	25	17.9	42	30.0	61	43.
SHRUBS	0	0	0	0	0	0	43	32.3	90	67.
TOTAL	36	5.8	77	12.3	71	11.4	159	25.5	281	45.

Table 22 generally shows a decrease in the number of individual woody species as one moves from the smaller to the larger categories. This is a normal characteristic of the woody stands on the savanna. When compared to the fire result it was seen that timber exploitation quadrats have more individual woody plants than the fire quadrats only in the category less than one metre. The graph below illustrates this point.

Diagram XIV: A comparison of the species composition in the fire and wood exploitation for building purposes in different size groups



The overall distribution of individual woody plants in different size groups for the two activities is almost similar with timber exploitation for building purposes with slightly more individuals in the less than the one metre category and fire with more individuals in categories more than one metre.

Table 24: Structural damage as a result of timber exploitation

CLASS	> 20m		10-20m		4-9m		1-3m		< 1m	
	No	%	No	%	No	%	No	%	No	%
CANOPY	21	7.4	48	16.9	33	11.6	71	25.0	111	39.1
UNDERSTOREY	0	0	5	4.9	16	15.7	34	33.3	47	46.1
SHRUBS	0	0	0	0	0	0	41	34.2	79	65.8
TOTAL	21	4.2	53	10.5	49	9.7	146	28.9	237	46.8

Table 24 shows that most wood for building purposes is cut from categories less than nine metres. These are the categories which show most damage. The damage considered here was mainly cut branches and removed bark. Part of the damage reflected in the less than one metre category is a result of building activities such as the construction of granaries, pigeon and chicken pens rather than hut construction. The result also revealed that more individuals are cut from the shrub and understorey classes than from the canopy.

Quantity of wood used in building and the corresponding clear-felled areas

Attempts were made to establish the quantity of timber used in construction. An average sized hut of about 2.7 metres in diameter using poles ranging from about 5 - 25 cm. in diameter requires between 400 and 500 poles. An estimate obtained from pole counts of four abandoned huts revealed that about 400 poles were required for the wall and about 50 for the roof. Thus a total of 450 poles were required for each average sized hut. A household survey showed that there were four huts to each household on the average. It was also established for the examination of the abandoned huts that the average weight of each pole was about 4 kg. Thus a population of 6639 basing the calculations on the obtained information from the 30 households used 5623920 kg of dry weight poles (Appendix C4).

Table 25: Quantity of timber used for building

Total No. of Poles/ hut	Average weight of Pole	Total No. of households	Average No. of huts/ household	Total weigh[t] of wood use[d]
450	4 kg	781.1	4	5623920 k[g]

Using values from Mihalyi (1972) and Chidumayo (1979) to estimate the wood cut and corresponding clear-felled areas 5623920 kg of dry weight wood is equivalent to 1.13 km^2 of clear-felled area. Since each hut is replaced after five years, the annual woodland clearing as a result of timber exploitation is about 0.23 km^2 per year. Since wood is used for other buildings such as chicken pens, goat and cattle kraal, more wood than estimated in this exercise is required. i.e. the total cleared area will be more than 0.23 km^2 per year. Generally, the size of the woodland cleared for timber collection for building purposes does not seem to pose a severe problem at the moment.

Conclusion

An examination of all the quadrats under different human activities with reference to vegetation change is shown in (Appendix D9), the result is summarized in the tables below:-

Table 26: Woody species composition

BURNING	CULTIVATION	FIREWOOD COLLECTION	CHARCOAL BURNING	GRAZING AND BROWSING	TIMBER EXPLOITAT FOR BUILD
31	7	22	18	18	25

The table above shows that there were more species in the fire quadrats, followed by timber exploitation, then fuelwood collection then grazing and browsing and least under cultivation. The low incidence of species in the quadrats where grazing and browsing was dominant can be explained by the fact that the area might have been subject to other human activities before grazing and browsing became dominant.

When the distribution of woody species was considered according to the three broad classes for the six human activities it was seen that the canopy had more species than the other two classes except under burning and grazing and browsing where the number of species was the same. Table 27 brings out this aspect.

Table 27: Woody species distribution in different classes for the major human activities in the study area

ACTIVITY	CANOPY	UNDERSTOREY	SHRUBS
Burning	38.7	22.6	38.7
Cultivation	100	0	0
Firewood collection	45.5	27.3	27.3
Charcoal Burning	44.4	22.2	33.3
Grazing and Browsing	38.9	22.2	38.9
Building Timber	44.0	28.0	28.0

Similarly, when the number of individual woody plants in different size groups was compared, the result is presented in table 28 below:-

Table 28: The number of individual woody plant species in different size groups for the major human activities

HUMAN ACTIVITY	% OF INDIVIDUALS IN DIFFERENT SIZE GROUPS				
	> 20m	10-20m	4-9m	1-3m	< 1m
BURNING	7.8	12.5	16.5	25.9	37.3
CULTIVATION	61.5	38.5	0	0	0
FIREWOOD COLLECTION	2.8	2.9	11.2	33.8	49.3
CHARCOAL BURNING	0	0	0	2.7	97.3
GRAZING AND BROWSING	3.1	7.0	7.3	30.5	51.9
BUILDING TIMBER	4.2	10.5	9.7	28.9	46.8

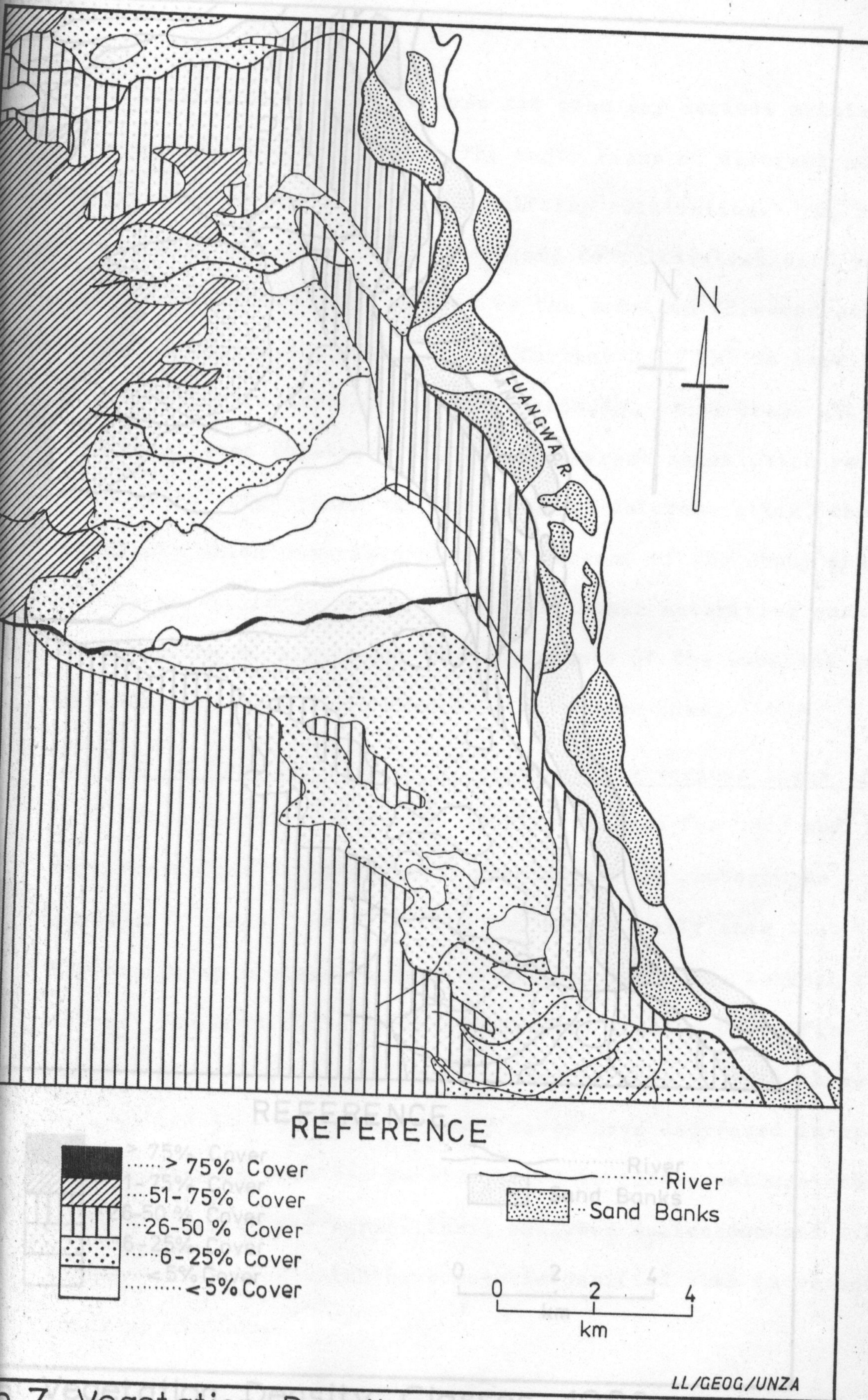
Table 28 above shows clear ly that clear cutting of woody plants is practised under cultivation where all individuals below ten metres are cleared and under charcoal burning where all individuals above the three metre category are cut. The other human activities are selective and are represented by woody plants in all the five different size groups.

When structural damage as a result of the various human activities was compared, the results showed that the highest incidence of damage was recorded under cultivation, followed by charcoal burning and the least incidence was under bush burning. The table below will help illustrate this point. It must however be noted that the structural damage shown does not imply the killing of woody plants affected but merely give the affected woody plants various kinds of scars, stem lesions, partially damaged growing tips which may or may not lead to the eventual death of the affected plant. Such a poor early history in the case of seedlings precludes the development of a well shaped sound tree in the future stand.

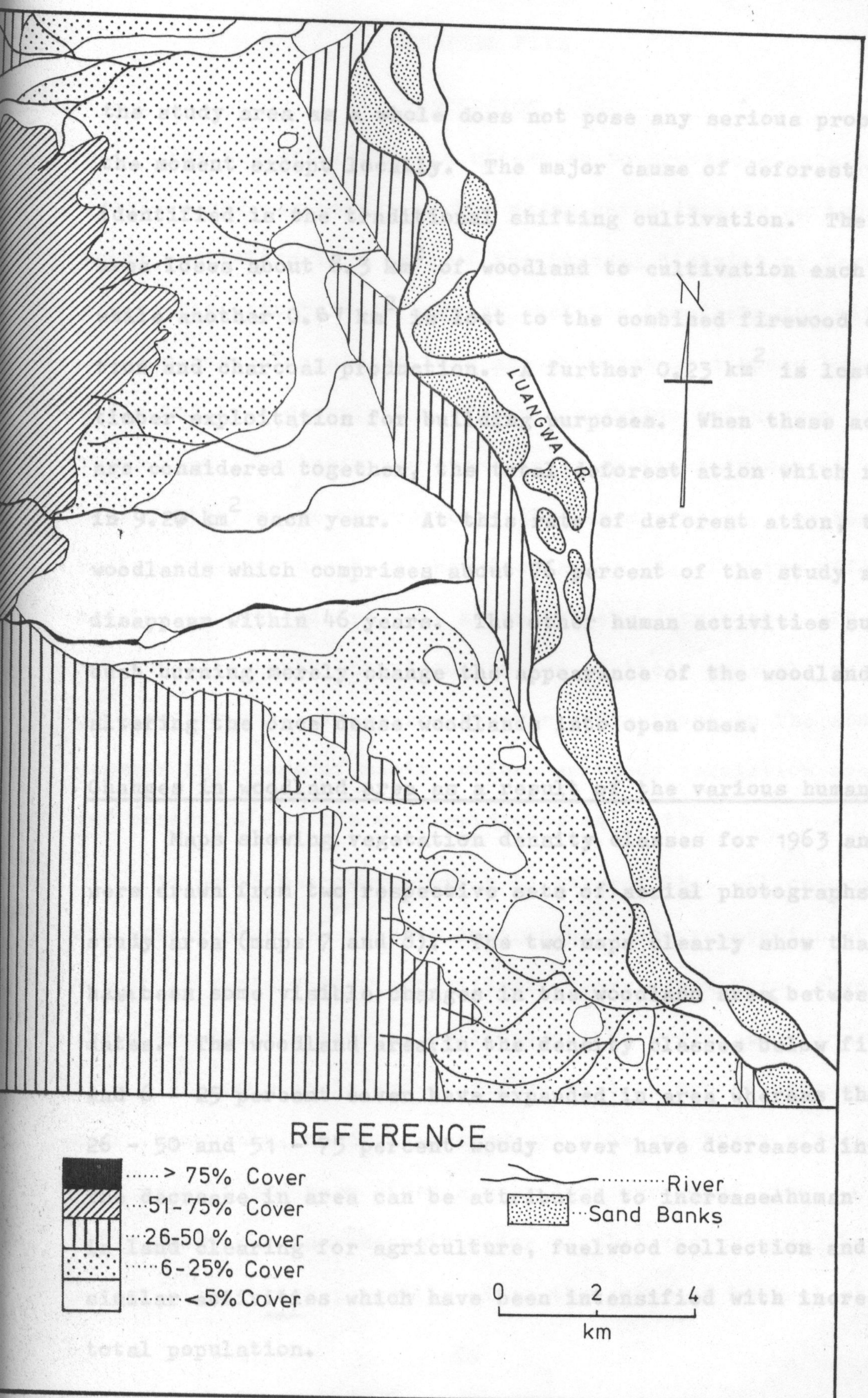
Table 29: Structural damage to woody plant species as a result of the major human activities.

HUMAN ACTIVITY	% OF DAMAGED PLANTS
BUSH BURNING	40.8
CULTIVATION	100.0
GRAZING AND BROWSING	81.7
FIREWOOD COLLECTION	58.1
CHARCOAL PRODUCTION	85.0
TIMBER EXPLOITATION	81.1

Deforestation as a result of the varied human activities in



Map 7. Vegetation Density Classes - 1963



p 8· Vegetation Density Classes - 1980

the study area as a whole does not pose any serious problems at the moment except locally. The major cause of deforestation identified is the traditional shifting cultivation. The study area loses about 8.3 km^2 of woodland to cultivation each year, while another 0.67 km^2 is lost to the combined firewood collection and charcoal production. A further 0.23 km^2 is lost to the timber exploitation for building purposes. When these activities are considered together, the total deforestation which results in 9.20 km^2 each year. At this rate of deforestation, the unused woodlands which comprises about 76 percent of the study area will disappear within 46 years. The other human activities such as bush burning merely change the appearance of the woodland area by altering the once dense woodlands into open ones.

<u>Changes in woodland area as a result of the various human activities</u>

Maps showing vegetation density classes for 1963 and 1980 were drawn from two respective sets of aerial photographs for the study area (maps 7 and 8). The two maps clearly show that there have been some visible changes in the woodland area between the two dates. The woodland areas in the density classes below five percent and 6 - 25 percent cover have expanded in area whereas those in the 26 - 50 and 51 - 75 percent woody cover have decreased in area. The decrease in area can be attributed to increased human activities in land clearing for agriculture, fuelwood collection and other similar activities which have been intensified with increased total population.

CHAPTER FIVE

CONCLUSION

The current study has attempted to provide a detailed description and assessment of the major human impacts on indigenous woody vegetation in a part of the Luangwa district of Zambia. An effort has been made to suggest what the immediate and ultimate consequences of man's actions are although most space has been dedicated to a description of man's negative influences on woody vegetation. Emphasis has been placed on the detrimental effects because they cause or probably will cause problems for man. Generally, coverage has been one-sided since the positive effects are usually publicised and well known but the detrimental effects are not and they merit attention because of their possible grave consequences for man. There are however indications in the study to suggest that some of man's actions on woody vegetation are inevitable and essential for his very existence on earth.

It would be however wrong to suggest that all changes that are taking place as regards indigenous woody vegetation are a result of man's varied activities. There are natural changes which are taking place as well, but on the whole natural changes take place on a scale and at a rate that is not disast rous to man. Generally, natural changes are slow and their effects can only be felt and seen after a very long period of time. On the other hand, man is responsible for accelerated changes that are taking place which generally widen the scope of natural changes in ways that lower the potential of the woodland to sustain man. For example, one of the most extreme effects of man's actions on indigenous woody vegetation is illustrated by his continued maintenance of cultivated lands. Here man has exerted maximum control of natural vegetation but despite this, his dominance is far from being absolute and this is illustrated by the time and effort involved in weed control.

Generally it must be noted however that when cut over areas are abandoned, they are often reoccupied by woodland communities though in most instances quite different in woody species from the ones there when the woodland was first cut. Similary, grazing and browsing also help maintain a vegetation quite different from that which would occupy the site without the activity. Here most of the palatable species will gradually be replaced by those which are avoided by the grazing and browsing animals. Additionally, the vegetation is kept short thus reducing the occurrence of severe fires in the dry season. Fire has also helped modify the appearance of the woodland. The once closed woodlands have been reduced to open ones. Though the study did not specifically identify the fire resistant species, there were indications to show that most of the woody species in the study area have developed structures which enable them/to survive the annual bush fires during the long dry season.

Recommendations

Since the overall woodland clearence due to the varied human activities in the study area is not currently a serious problem except locally, attempts must be made to ensure that protective and precautionary measures are taken to protect the indigenous woody vegetation from the continued human activities. Emphasis must be placed on the need for protective measures to ensure that man's activities on indigenous woody vegetation do not start a chain of events which are likely to destroy the woody vegetation since the situation is not yet drastic. Additionally, all development projects to be undertaken in the study area must be designed in such a way as to minimise disturbance to the harmony in nature.

Furtherwork

It may be appreciated that in view of the time limitations imposed on the study an attempt was made to examine each identified activity as fully as possible. This study can be seen as a pioneer sample study since it was based on only a small area. Thus there is need to conduct the same sort of study in the wider context of the Mopane woodland and also in the Munga and typical plateau Miombo woodlands.

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APPENDIX A

ILED LITERATURE REVIEW, METHODOLOGY AND VILLAGE POPULATION DATA

APPENDIX A1

Bush Burnings

The impact of man upon indigenous vegetation through the medium of fire has always been an important factor in the terrestrial environment. Charred fossils have indicated that before the advent of man, naturally ignited fires had periodically ravaged land vegetation (Daubenmire, 1974). To this was eventually added the effect of man who, for a number of reasons, periodically set fire to vegetation (Stewart, 1956). As civilisation has spread man-initiated fires have become far more numerous than those started by natural forces like lightning (Daubenmire, 1974). On the whole, these fires have been controlled from spreading by the presence of roads, cultivated fields and densely settled areas like towns, together with agencies such as fire prevention and control services (Sauer, 1956).

Agents that start fire

The natural agents that start fire include lightning, volcanoes and friction on wood. Stewart (1956) noted that of the natural agencies which start fire only volcanoes and lightning are frequently observed igniting vegetation. Fires started by lightning are widespread over the earth (Graham, 1956) and occur regularly whereas those started by dead branches of wood being rubbed together by wind are difficult to verify (Stewart , 1956). Additionally, fires started by volcanic activity are limited in occurrence to areas which are subject to active volcanic activity. While natural fires are occasional, man has accidentally as well as deliberately promoted fire which has influenced the vegetation pattern on every continent (Eckholm, 1976). It must be noted however that long before man learned how to manufacture flames, he almost certainly learned to tend and transport fires started by natural agents (Eckholm, 1976).

<u>Some reasons for burning</u>

Man has set fire to indigenous vegetation for a number of reasons. Bartlett (1956), Langlands (1967), Storrs (1968), Tivy (1971) and Chidumayo (1979a) have all shared the view that fire is started for the following reasons:-

(i) To clear the woodland area for arable agriculture.

(ii) To improve grazing by preventing vegetation from becoming too thick and promote the growth of new shoots.

(iii) To deprive game of cover or to drive game from cover in hunting in the traditional African Societies.

(iv) To drive away or kill predatory animals, ticks, mosquitoes, snakes, rats and other pests from areas, surrounding settlements.

(v) To repel the attacks of enemies or to burn them out of their refuges in traditional society where sophisticated weapons were not available.

(vi) To protect the villages from great fires by controlled burning. Thus the woodland area surrounding villages is burnt early in the dry season.

(vii) To facilitate travel. It is easier to travel on burnt ground than through densely vegetated areas.

(viii) To gratify sheer love of fires. This involves burning without any apparent reason whatsoever.

(ix) Lastly are accidental fires. These are a result of careless and thoughtless actions such as those caused by campers who do not control their cooking fires and smokers throwing away lighted cigarettes and matches.

The fire problem

Tivy (1971) noted that fire is common in parts of the world with a prolonged warm, dry season during which desiccated and very combustible plant debris accumulates. The climatic conditions prevailing in a particular area may increase the inherent risk of fire.

Fire has altered the land most profoundly and extensively in Africa (Eckholm, 1976). He noted that at least a third of the continent is covered with savanna grasslands, many of which would be forested had they been left unmolested by man. Thus centuries of burning have created an enormous new ecological zone between the remaining forests and the drier natural grasslands. Some authors have estimated that by 1948 the forests of Tropical Africa had been reduced to just a third of their former domain (Vos, 1975).

Zambia's tropical type of climate which is characterized by a long dry season ranging from about six to eight months in the northern and southern portions of the country respectively, is ideal and encourage seasonal bush fires. Thus the vegetation of Zambia like that of many other countries with similar climatic conditions are subject to recurrent bush-burning every dry season.

Experimental work on fire

A number of experimental studies on the effect of fire on certain vegetation types have been conducted. For example Trapnell (1959) considered the effect of burning woodland and dry evergreen forest at Ndola in Zambia. Mac Gregor (1937), Charter and Keay (1960) considered the effect of fire on grassland, wooded grassland and lowland seasonal rainforest at Olokemeji in Nigeria. And Onochie (1961) has studied the effect of fire on woodland vegetation in Amara forest, Lagos in Nigeria. In each country, these studies were conducted in adjacent plots of similar vegetation occuring on similar sites. These plots were subjected to different burning regimes which usually include complete protection, annual early and late burning. In all these studies attention has been directed to the effects upon biological composition and succession on the flora. Fire has been shown in these studies to exert repressive and selective influences on vegetation.

The general effects of fire on vegetation depend on the frequency, intensity, timing and extent of the burn. Frequent burns of high intensity late in the dry season when plants and vegetation litter are at their driest and are highly inflamable are the most damaging (Mihalyi, 1972). Here fire produces physiognomically and floristically simpler ecosystems by encouraging those species which are fire tolerant at the expense of the remaining majority (Tivy, 1971). Regular burns tend to reduce the number of plant species that can grow in a given area (Langlands, 1976). This results in a predominance of one or two fire resistant species.

Literature on burning has indicated that most young, succulent, seedlings and sprouts are either damaged or killed by fire of any kind. In this respect Davison (1959) noted that bush fires, no matter at what time of the year they occur do a certain amount of damage to vegetation.

Mackel and Pullan (1972) noted that fire generally attacks and harms the bark killing the cambium and damages branches, leaves, twigs and buds of most plants. Among the fire resistant plants are perennial plants with underground food storage organs from which renewed growth can take place after surface burning. On the other hand perennial grasses often have new growth stimulated by the removal of old surface parts.

The selective nature of fire on the plant community is well illustrated in the work of Trapnell (1959) who observed and noted that certain fire tender plant species with special characteristics such as thick fire resistant bark and fire tolerant foliage are not destroyed by fire. Generally the work of Trapnell in Miombo woodland type in Zambia has demostrated that late annual burning has resulted in the total destruction of trees whereas controlled early burning is not harmful. Its only effect is that of removing grass and leaf litter. Burning plots and trials scattered around the country and general observations have shown burning early in the dry season as a management method because it takes place when the grass is not completely dry and trees have just begun to lose their leaves. Such a burn is not harmful to trees (Storrs, 1968).

Nye and Greenland (1965) observed that burning affects the soil. Immediately the soil surface is heated there will be a change in the microbiological population of the soil. Additionally, the physical and chemical properties of the soil colloids and the availability of nutrient ions will be affected. These changes in soil may cause a very different microflora to develop from that originally presented in the affected areas.

Concluding remarks

It has become apparent that fire is and has been a potential factor in altering and degrading the woodland ecosystems. Tivy (1971) contends that fire has modified the composition of vegetation for a longer time than any other human influence. Dorst (1972) observed that activities such as grazing are usually accompanied by fire. Fire here has a tendency of destroying most living plants which are then replaced by annual herbaceous plants. The use of fire was pre-industrial mans best weapon for transforming habitats and is still practised.

However it is probable that natural fire is absent or very rare in most parts of thewworld and indeed in Zambia. Volcanic fires are only limited to areas where volcanic activity is active. In the case of Zambia, it is therefore absent. Lightning though visible during the rainy season does not usually start fires and when it does it is invariably accompanied by substantial rain which extinguishes the fire once it begins. On the other hand, man continue to light fires where possible and where no authoritative restraint is practised. Often simple pleasure in spectacular destruction is the only motive.

Cultivation of Arable Crops

The dominant subsistence agricultural system over a wide area of the earth's surface is shifting cultivation (Nye and Greenland, 1965). It is commonly practised in developing countries (F.A.O., 1957). It is practised by people of widely varying origins and cultures on a very wide range of soils, amid so many types of vegetations that it shows great variations in the types of crops grown, the length of cropping and fallowing periods and the methods of cultivation (Nye and Greenland, 1965; Bennet, 1975; Vos, 1975). It is therefore difficult to say where it begins or ends. Generally, shifting cultivation is an agricultural system which is characterized by the rotation of fields rather than crops. It utilizes short periods of cropping of up to three or four years alternating with long periods of fallow of up to 20 years or more but often as short as six to eight years (Pelzer, 1954). This is done in order to allow for soil fertility to be restored by the recovery of natural vegetation.

In Zambia, the traditional and subsistence agricultural system is commonly known as Chitemene. Like many other systems in Africa, it shows great variations in the methods employed and crops grown in different parts of the country. Trapnell and Clothier (1937) attempted to describe some of these systems in Zambia.

The nature of shifting cultivation in Zambia

Shifting cultivation (F.A.O., 1957) involves the cutting of trees on the selected plot either at breast height or merely lopping off branches. The cut debris is piled up and left to dry. This is later collected and made into piles which are later burnt just before the rains start. Bennett (1975) noted the difference between the Chitemene system practised in the northern parts of Zambia and those practised in the other parts of the developing world. In the Chitemene of Northern Zambia, the woodland tribes rely for fertility on the ash of trees which they fell and burn to make their gardens. Thus brushwood is generally hauled in from an area much greater than that cultivated in order to obtain the necessary supply of ash. Trapnell and Clothier (1937) writing on the traditional agriculture systems in Zambia, Richards (1939) writing on the Bemba system, Allan (1965) and Vos (1975) both considering the traditional agricultural systems in Africa have all shared Bennett's view. These people have described the cutting of trees in the <u>*Chitemene*</u> system as more than a method of clearing the land, since the people concerned rely for fertility on the ash of the trees which they lop or fell to make fields. For example Richards (1939) observed that in Mbala about 2.5 hectares of woodland were cut just to make 0.5 hectres of millet garden. Peters (1950), working on the Serenje plateau noted that 2-5 hectares of woodland were cleared each year by a household to make only 0.4 hectares of field. In this system almost universally reliance is placed entirely on bush fallow for the maintenance of soil fertility (Bennett, 1975). No fertilizers or animal manures are applied, since even if livestock are kept, in most cases very little or no use is made of their dung (Pelzer, 1954).

Shifting cultivation has however been denounced in many parts of the world as being ecologically unsound because of its reliance on space. Increasing populations cannot enable it to work effectively, thus agriculture is becoming more sedentary. It is in these new sedentary types that manure and fertilizers are used in order to increase the yields.

<u>Ecological impacts of Shifting Cultivation</u>

Shifting cultivation is a highly distructive system to indigenous woody vegetation cover under high population (F.A.O., 1957). Under low population pressure and availability of adequate land, shifting cultivation has been, and still is an efficient means of food production soley for the purpose of providing subsistence (Vos, 1975). Practiced in this way the system did little harm to the woodlands since the fallow periods were long enough to restore the soil fertility nearly to its original level (Clark and Haswell, 1970). In "modern" times increased population densities combined with intensive cultivation of cash crops in addition to the production of food crops has often led to much more intensive shifting cultivation with shorter fallow periods (Bennett, 1976). This has consequently resulted in a decline in soil fertility and it has become apparent that the traditional system is unsatisfactory under such conditions.

Vegetation cover begins to suffer from excessive clearing. The reduction in vegetation cover without providing a substantial artificial equivalent greatly accelerated the rate of erosion that take place (Gourou, 1956). It would be wrong and misleading to assume that man, through cultivation is the only cause of erosion. Erosion is a normal part of the natural process of base levelling and has been the source of some of the richest alluvial terraces and plains in the world (Gourou, 1956). Under natural conditions, the rate of erosion is controlled by the presence of vegetation cover in the form of stable communities. Under these conditions erosion proceeds so slowly as not to interfere greatly with the normal process of soil formation. It is when the natural cover is removed without providing a substantial artificial equivalent that the rate of erosion is increased (Morgan, 1969). Sheet erosion is subsequently followed by gully erosion, run-off will be increased and the water table lowered due to the low infiltration (Mouttapa, 1973). Eventually land becomes useless to man for cultivation since vegetation cannot grow (Sears, 1956).

Concluding remarks

The spread of agriculture is still the biggest single cause of woodland clearing today. Most of the farm land in every country was once atleast modestly tree covered with the exception of irrigated deserts and grassland plains like the highveld in south Africa. (Eckholm, 1976). Bartlett (1956) noted that shifting cultivation followed by repeated fire in woodland clearing gives rise to artificial grasslands. This assertion was later confirmed by Wilson and Webster (1966) who observed that natural regeneration was less effective in restoring fertility in the Savanna zone because the spread of fire destroyed the plant growth, thus reducing the woodland into a grassland. Vos (1975) concluding on the effects of cultivation on vegetation in Africa noted that one of the spectacular results of shifting cultivation is that the areas of closed forests south of the Sahara have shrunk by atleast 100 million hectares as a result of increased population pressure. Similary the Zambian Forestry Department (1975, p 4) commented:-

> 'Zambia is extremely fortunate in that there is at present sufficient land to allow for shifting cultivation. The three percent per year annual growth in population means that this happy state of affairs cannot continue indefinitely. The policy of the government has been to leave unchanged the traditional communal land ownership system in the rural areas. This has worked very well in the past but with the growth of population and the introduction of a cash economy, the system is breaking down and change will have to be made'.

Many traditional systems of agriculture have degenerated or collapsed altogether under the impact of explosive population growth, cash cropping, loss of land, social disruption, labour migration and other changes (Vos, 1975). This makes it clear that we can no longer be complacent about the continuance of a practise which is so destructive to both the soils and woodlands. Unfortunately little progress has been made so far towards constructively modifying the system of shifting cultivation since the elimination of such an old practice would require the breaking down of traditions which have been appropriate for centuries. Additonally, the problem of providing attractive agricultural systems is far from easy. Although most of the shifting systems of agriculture have become destructive to land under conditions of high population density communities where land can be left in fallow for sufficient time.

Grazing and browsing of domestic animals

Graham (1956) noted that along with the development of arable agriculture, man has domesticated a number of animal species such as goats, cattle, sheep, pigs, and chickens. In subsistance economies in Africa, some of these animal species are carefully husbanded but, for most of them, man has depended largely on indigenous vegetation for their sustenance. These animals are allowed to wander freely in the woodland.

The effect of grazing and browsing on vegetation is conditioned by a number of factors such as the kind of animal that is introduced in a particular locality, the grazing incidence of that animal species, the season or time of the year when the activity takes place and lastly, the nature of the grazing land (Pratt and Gwynne, 1977). Generally browsing has been found to be more harmful to woodlands than grazing because browsing involves the eating of vegetation other than herbs (Daubenmire, 1974).

Grazing and Browsing Animals

There are many species of domestic animals, each one of which is a selective feeder and has to choose from what is available what to feed on. Some of these animals depend mainly on grass whereas others prefer herbs, shrubs, etc. Hopkins (1965) noted the difference between grazing and browsing, by domestic animals. He observed that each wild animal is a selective feeder, but as a whole they are in a state of ecological balance with vegetation. Each time the balance is upset some animals migrate (Dorst, 1972). When wild animals are replaced by domestic animals, this ecological balance is upset because there will be grazing pressure on certain plant species which are actively selected. Cattle are the main grazing animal and goats are the main browsers of the domestic animals in most parts of Africa.

Grazing and browsing variation and intensity

Grazing and browsing varies in the course of the year (Hopkins, 1965). During the wet season, there is usually sufficient grazing land to support all animals in the areas with a savanna type of climate because there will be fresh growth. In the dry season most savanna areas will have been burnt and thus there will be insufficient graze for most animals. When the vegetation has been subject to annual bush fire, the animals can either migrate to areas where they can find graze or change their feeding habits to browsing (Lawton and Gough, 1970).

Grazing and browsing intensity on the other hand refers to the amount of grazing and browsing prevalent in an area (F.R.I., 1972). The greater the number of animals, the greater will be the damage done to vegetation of the affected area. Dorst (1972) observed that grazing and browsing intensity is high in some parts of the world because man tends to increase the number of domestic animals. She noted that this occurs frequently in many pastoral societies. For example the Masai of East Africa, the Fulani of West Africa, and the Ila, Tonga, Mambwe and Ngoni of Central Africa. Cattle in these societies are not only a source of food but a symbol of wealth and power.

Thus very few animals are killed since the people concerned value large herds. In the case of India, especially in the Indo-Ganges plains, cows are held sacred. Thus killing a cow in such a society is a very serious offence. The effect of such beliefs, is the high intensity of grazing and browsing in the affected areas. Thus grazing and browsing intensity varies according to season, prevailing climatic conditions and traditional beliefs.

Ecological impacts of grazing and browsing

Grazing and browsing become an important destructive or selective habitat factor when their intensity is such as to injure or prevent the successful growth and reproduction of plants (Tivy, 1971). Areas which are subject to light, intermittent and carefully controlled grazing and browsing do not show any change in appearence and look very much like the original woodland although there may be some difference in species composition (Graham, 1956). Whenever this type of grazing and browsing is controlled according to the season and intensity, it may help natural regeneration by lessening the herbaceous cover and indirectly stimulating the growth of woody plants which are not affected by the activity (F.R.I., 1972). This also helps to keep down the height of grass and thus reduces the fire hazard in the dry season. With heavy grazing as a result of either more or longer grazing and browsing periods, there will be a decrease in the preferred species and a consequent deterioration in the value of the grazing lands (Tivy, 1971). This is so because edible plants will gradually be replaced by inedible ones. In woodlands which are frequently pastured, the activity may eliminate reproduction by many tree species (Daubenmire, 1974). In such areas the activity maintains a vegetation which would not occupy the site without it.

The trampling of the grazing and browsing animals may help dislodge the soil particles and destroy the protective plant cover, thus leading to soil erosion (Tivy, 1971). Additionally, trampling may result in soil compaction which in turn may reduce percolation of water. This increases run-off, thus accelerating soil erosion which may render seed germination more difficult.

Annual plants and seedlings are the most vulnerable to grazing and browsing. These may be destroyed completely or their numbers may be drastically reduced and their regeneration limited or under extreme conditions prevented. Generally, perennial herbaceous plants with underground storage food organs such as bulbs, and the grass family plants are better equipped to withstand grazing and trampling. These plant species are not only resistant to grazing and browsing but their growth may infact be stimulated by it (Tivy, 1971).

Domestic animals differ in their eating methods and their preferrences to particular plants (Daubenmire, 1974). Cattle graze mainly on herbaceous species while goats and sheep browse on trees and shrubs. This makes plant resistance or susceptibility to various types and intensities of grazing and browsing dependent on the type of animal involved and the palatability and growth forms of the particular plant species involved (Hopkins, 1965).

Goats and sheep are included among browsers but sheep are the least harmful of the two as they take to browsing only when an abundance of edible plants is not available (F.R.I., 1972). Goats are adaptable in their feeding habits. In total they utilize a wide range of plants and plant parts. Apart from forage, goats eat flowering plants, and twigs, nibble off the shoots of trees and young growth (Pratt and Gwynne, 1977). They also noted that when there is little food in the pastureland, goats take the bark and roots of plants which they scrape with their feet. During this period goats browse and graze almost anything edible within their reach. They can also stand high on their hind legs and then climb into low trees in search of browse. By so doing they break down small lower branches of trees. Furon (1958) concluded his work on goats by stating that goats represent a grave danger and are the cause of the disappearence of vegetation and serious erosion. For example, in St Helena Vos (1975) noted that goats have destroyed forested habitats in only a few decades after their introduction.

The advantage of goats lies in the fact that they are able to prevent weed enchroachment. They achieve this by consuming large numbers of bush seeds which are broken down during their passage through the gut so that only the few which are excreted intact are able to germinate. As a result the goat can be seen as a potent factor in controlling the existing vegetation and also in preventing bush regeneration in areas of low and erratic rainfall (French, 1970). Hopkins (1965) observed that in areas around villages where goats are abundant, most of the plants within their reach may have been eaten with the resulting loss of the herb stratum and the consequent prevention of tree regeneration.

Cattle on the other hand prefer grass. They are the least harmful of the grazing animals (F.R.I., 1972) but when they are raised in great numbers, they do some damage to vegetation by crushing and trampling the young growth. Cattle grazing is generally limited to herbaceous plants, though seedlings and saplings of woody plants are sometimes eaten away together with grass.

Concluding remarks

It has been postulated that the traditional nomadic pastoral systems as practised in Africa were well adapted to grassland ecosystems (Dasman, Milton and Freeman, 1973). Generally the nomads keep their animals on the move thus permitting selective grazing but usually not allowing a heavy concentration of animals to remain in one place. In this way grazing and browsing is light and the plant community can easily recover. The rapidly rising human populations have resulted in the sedentarization or semi-sedenterization of many animal herders thereby putting more pressure upon the vegetation (Vos, 1975). This pressure in turn disturbs the natural balance in the ecosystem as the intensity of grazing animals is changed. Increasing grazing intensity will eventually lead to regressive changes. Allan (1965) considered some of these regressive changes to be widespread throughout the African continent.

Fuelwood Collection

The editorial Board of the F.R.I. (1972) noted the importance of fuel as one of the necessities of modern life and is indispensible both in the home and industry as a source of heat. Any material that burns readily in air can be considered suitable as fuel. Wood is one of the most important solid fuels and has been used from times immemorial. The current popular fuels, such as coal, petroleum and natural gas are themselves only the inflammable components of vegetation of past geological ages left over in a concentrated or readily available form. Although in many industrial countries wood has been almost entirely supplanted as fuel by coal, oil and natural gas, large quantities of it are still utilized as fuel in many parts of the developing world.

In Zambia firewood is mainly the energy source for the rural people and charcoal is the usual energy for the Urban people in the medium and low income groups. As a result of this dependence on fuelwood deforestration has occured in varying degrees in many places where people have gathered in groups to form villages or towns. In recent times, the consequences of population growth, agricultural production, industrial raw materials requirements and other forces of modernization have led to an acceleration of fuelwood scarcity problems in many rural and urban areas of the third world countries where fuelwood is an important energy source.

Sources of Fuelwood

Fuelwood is obtained from woodland sources on nearly all lands surrounding rural and most urban areas (Devres et al, 1980).

Most wood is collected from unmanaged woodlands or from the tree stands or clumps of bushes scattered amongst cultivated agricultural fields. In some cases government owned forest and woodland reserves and other protected areas are exploited to the allowed degree. In most developing countries only a small proportion of wood is obtained from man-made forest estates. In most cases very large man-made forest estates simply do not exist because of the vast natural woodlands around most rural settlements. Devres et al (1980) observed that exploitable wood resources, especially firewood are practically speaking within a fifteen kilometre radius of the community since most firewood supplies are gathered on foot by each household for its own use.

Nature of Fuelwood

Fuelwood includes charcoal and firewood. All charcoal is produced from the cutting of live trees whereas firewood can be divided into two sub-groups. Firstly, the collection of dead material and secondly, the cutting of live trees. Openshaw (1974) noted that most firewood used at the village level is composed of dead trees, branches, twigs and shrubs as opposed to the cutting of live trees. The only exception is in areas where firewood shortages are increasingly apparent. Thus with decreasing availability of dead material live trees are cut for the purpose.

Local preferrences for specific firewood species exist. These are based on the burning qualities, availability and traditional practises relating to the indigenous woody species found in the area. The most desirable species for firewood are those which dry rapidly, burn strongly, provide a "hot" fire and emit little smoke (Metzger and Williams, 1966). Generally, firewood collection is a selective activity. Harrison (1954, P229) commented:-

> 'Man had to find out many things about the fuels he adopted... Whether they lighted quickly and burnt brightly, or were slow to kindle and gave much smoke; whether they needed careful tending, or could be relied upon to burn steadily and long; and whether the heat they gave was fierce or feeble'.

People everywhere have definite criteria for evaluating firewood bearing in mind which species are best for a particular purpose. Some trees are not burned because of the prevailing cultural prohibitions on certain woody species (Metzger and Williams, 1966).

Availability of Fuelwood

Deveres et al (1980) noted the gradual dwindling availability of firewood due to population growth, expansion of agricultural lands, overgrazing of livestock, drought, and the commercial and domestic over-exploitation of resources without attention to future needs. But when firewood availability is viewed in the context of the global overall setting, adequate wood resources exist, as Knowland and Ulinski (1979, p2) stated:-

> 'Even though most developing countries still have sufficient forested lands that their total annual wood production or natural growth considerably exceeds the total wood fuel needs of their people, local shortages can be severe'.

Such local shortages of firewood are becoming more numerous and widespread in most developing countries as the areas with large firewood supplies and those with great firewood demands continue to grow farther apart. Many rural communities have exploited firewood resources in the surrounding areas, usually with little thought to renewing them in adequate quantities to meet the ever increasing demand for firewood. Knowland and Ulinski (1979, p2) observed:-

> 'Trees and forests are essentially capital stocks that produce an annual return of wood. Once a community begins to exceed the growth capacity of its local tree resources or begin to live off tree capital rather than tree income, a rapid and exponentially accelerating cycle of depletion begins'.

As a result of such depletion, firewood collection trips which used to take only a few minutes now require more time in rural areas. The preferred tree species are being depleted and are later substituted by less desirable woods (Eckholm 1976). When this happens fuelwood collection ceases to be a selective activity. This coupled with the urban demand for firewood will eventually lead to severe local wood shortages.

Deforestation as regards localized firewood shortages is not a new problem. It has been going on for a long time. The current fuelwood crisis represent only an increased awareness of the present impact of an on going process initiated a long time ago. Eckholm (1976), concluded that the firewood crisis does not provoke attention in the world today because those directly suffe-ring its consequences are mostly illiterate and poor. Additionally, wood shortages lack the photogenic visibility of famine.

Availability and price of alternative fuels

The alternative fuels to firewood available in most rural communities are primarily other local materials such as dung, grass or crop residues (Devres et al, 1980). Charcoal is sometimes available to rural communities but costs money, so it is used only when necessary and when people can afford it. Most non-traditional fuel alternatives are not available to rural households in most developing nations. This is a result of their scarcity and also because most rural people cannot afford to buy them. Additionally, they do not have the equipment for them such as stoves. Eckholm (1976, p112) wrote.

> 'Nothing, for example would be better than a dirt-cheap device for cooking dinner in the evening with solar energy collected earlier in the day. But actually developing such a stove and introducing it to hundreds

> of millions of the world's most tradition based and penniless families in another story. While some solar cookers are already available, the cost of a family unit is just too expensive and prohibitive for many.......'

Thus very few of the other non-traditional fuels are attractive to rural households nor are technological innovations possible in most rural areas at present because of the very low income levels of the rural dwellers.

While short term availability and potential of alternative energy forms may look dim. It must however be noted that many developing countries have indigenous energy resources not being fully utilized at the present time. These include H.E.P., coal and gas. The development of these resources and of distribution systems for the energy they provide will require massive investment and a good deal of time.

Seasonality of fuelwood exploitation

Firewood collection in most developing countries is concentrat in the dry season (Devres et al, 1980). This is the period when labour is readily available because it is during the agricultural off-season. Additionally, the wood source areas are more accessible than in the rainy season. Collier (1975, p43), writing on the situation in Mexico commented.

> 'Wood gathering, while a year-round activity, is most intense in the months of Spring when the trails are dry and the days long enough for women to make up to three trips a day for wood. In other seasons, rains and slippery trails make more than one trip per day unpalatable, and other household activities are given greater attention'.

A similar situation prevails in Zambia as regards fuelwood collection. In the case of charcoal there is often a distinct seasonality in production activities. In Zambia, the seasonal nature for its production turns mostly on subsistence Farming activities. During the dry season when there is no work in the fields, some people will be making charcoal. Thus some small Farmers burn charcoal in the slack farming season.

Ecological impacts of fuelwood collection

Firewood collection has affected the ecological balance of many rural communites usually detrimentally. One effect which has been noted is the denudation of land which may result from tree cutting. Erosion of the land which results from this activity has been observed in many countries, for example, in China, Niger and in North Africa (Heizer, 1963). The strong demand for charcoal has resulted in the denudation not only of forest lands but also of shru and woodland zones in many countries. The consequent shortage of wood leads to the use of smaller trees and less desirable species. This in turn leads to an increased disregard for official wood cutting regulations. Land degradation will result from such intensive firewood and charcoal production pressures.

Wood Exploitation for Building

The editorial board of the F.R.I. (1972) noted that timber was one of the most important structural materials used by man for building purposes in the early days. Iron and steel came into use much later. As the requirements for building material increase and became varied, Iron and Cement came to occupy a dominant position. However, it was not long before the importance of timber as a structural material was once again realized even in countries which are the greatest producers of steel and cement. In most rural communites of the third world where wood is in abundance, timber is still the major and primary structural material for building.

Nature of Wood exploitation for building

Wood exploitation for building purposes is a selective activity (Eckholm, 1976). Only woods that are considered strong and durable are sought. The Editorial Board of the F.R.I. (1972) noted that in the choice of the structural timber, the following four factors are considered:

(i) the strength for the load required to be borne. For example in the case of a hut, the wall poles must be strong enough to support the roof.

(ii) the durability of the structure and also the wood.

(iii) the dimensional stability of wood or its capacity to retain its shape.

(iv) Availability of wood in the locality at a reasonable cost For rural human dwellings only a specific size of wood is cut, most of the large sized trees being left untouched. In the case of animal dwelling much larger sizes of wood are sought. The wood sought for building purposes is in the form of poles.

Ecological effects of wood exploitation for building

Generally in areas where there is little demand for polewood which is usually a result of a small population, the cut over areas are given adequate time to regrow from the stumps. But in areas which have high population, densities, there will be great demand for polewood to the extent that the woodlands will not be given adequate time to regenerate. Thus heavy demand for polewood can easily remove the young stock of trees and depress the vigour of shoots growing above the stump (Tivy, 1971). Boaler (1966) observed that selective cutting of trees results in changes in the botanical composition of the woodland and where pressure is very heavy, regressive changes are likely to occur to woodland.

These include the loss of species which will eventually change the habitat until the whole appearance of the woodland is changed. Boaler (1966) also noted that in some instances the heavy use of the woodland area may gradually lead to its clearance, thus producing a reduction in vegetation cover and causedwidespread changes in the soil.

Zambia is experiencing a rapidly growing population of 3.4 percent per annum (1980 census). Most human dwellings in the rural areas are made of polewood (Kay, 1971), thus making wood the primary structural material. In areas where wood has become scarce, there has been a gradual shift to brick houses. This change to brick houses is not limited to areas experiencing wood shortages only but is affecting all areas as a result of the government's call for better and more permanent dwellings.

Concluding remarks

Man's use of the woodland is selective except for total clearance of the woody vegetation parts as an operation leading to an agricultural enterprise. Of the Zambian hard woods, those of Miombo and Mopane are generally sought because they are believed to provide strong and durable timber. Since trees are usually felled from the bole areas where demand is light, rapid regrowth can be expected from the stump. One heavy demand for timber is that for polewood, as is the case in most rural areas of Zambia, can steadily lead to the removal of the sought stock and repress the vigour of the tree growing by cutting from above. Pressure of use results in changes in the species composition of the woodland.

APPENDIX A2

Field Reconnaissance

A preliminary examination of the study area was conducted in August 1981. This involved a rapid traverse of the study area. The idea was to acquaint the researcher with the most general and obvious features of the study area. Here the general appearance of the landscape, soils, relief, drainage, indigenous vegetation and the human economic activities were noted. Attempts were also made to look at the pattern of land utilization in agriculture, forestry and settlement. Thus reconnaissance provided an opportunity to learn more about the human impacts and collect information for later use in the assessment of the various impacts most pertinent to the study area.

Library work

A multi-pronged approach was adopted in the identification and collection of literature relevant to the study. This included a review of relevant bibliographies and library card files. The main sources of information included District note books, Government Department publications and Reports, Chief's record books for current population data, archival sources, topographical maps and generally books containing studies conducted in other areas on a similar subject. The aim of library work was to collect specific information relevant to the study.

Laboratory work

It included the identification of impacts, sampling and measuring procedures involved which were eventually used in the execution of the project in the field. The various aspects of Laboratory work are discussed in the sections below:-

Identification of areas for field observations

Attempts were made to isolate as far as possible, the effects of each identified human activity on woody vegetation. For each activity an attempt was made to locate three types of areas listed below:-

(i) Areas where each of the following activities was predominant:- cultivation, fuelwood collection, timber exploitation for building purposes and grazing and browsing of domestic animals.

(ii) Areas where each of the activities in (i) is known to have taken place but has now stopped. For example, abandoned fields in the case of cultivation.

(iii) Areas which were known to have been subject to fire only and none of the other indentified activities.

It was believed from field reconnaissance and literature review as well as discussions with the inhabitants that all the three types of areas had been subject to annual bush fires, thus making fire a common factor. It was not possible to find all the three types of areas listed above either in the laboratory or in the field. The most difficult areas to locate were those in which the activity had stopped. This was so because once one activity stopped another immediately followed. For example, immediately a field was abandoned, activities such as grazing and browsing of domestic animals followed. Areas where timber exploitation for building and fuel purposes stopped, cultivation immediately succeeded. This made it difficult to isolate such areas. Additionally, it was very difficult to find areas in which both firewood collection and charcoal production occured simultaneously. Thus the two activities were separated.

Methods of sampling and quadrat selection

The woody vegetation in each of the three types of areas was sampled. Sampling was used in order to avoid the difficulty of collecting and processing large amounts of data. Thus time and effort would be saved considering the time limitations placed on the exercise. Five quadrats were examined in each of the three types of areas involving each identified activity.

It is only under fuelwood in which 10 quadrats were examined, five for charcoal and five for firewood. The figure of five quadrats for each activity was chosen because it was recognized that the plant community is rarely homogenous throughout as to species and their distribution. Since there are variations samples large enough in each category had to be selected to include some variations and have them fairly represented in the data. Although the figure of five is not large enough, it was considered adequate for the time available for the exercise. It was planned to examine a total of 55 quadrats but only 40 were actually done because areas where firewood collection, grazing and browsing had stopped could not be identified in the study areas as has already been explained. The distribution of the 40 quadrats was as follows:-

(a) Five quadrats were selected for the areas where fire was believed to be the only activity that has been known to have taken place.

(b) 25 quadrats were selected for the areas where the activities are dominant. i.e. five quadrats for each of the five identified activities.

(c) 10 quadrats were selected for the areas where the activity was known to have taken place in the past but had now stopped.

In the selection of quadrats for field observations, near vertical aerial photographs at an approximate scale of 1:30 000 for 1963 and 1980 were used. The two sets of photographs were selected on the basis of being the earliest and latest covers available for the study area at the time the field plan was being drawn. These two sets of aerial photographs were scrutinized in order that some of the changes in the indigenous woodland ecosystem through time could be identified. A grid network was drawn on tracing paper. The grid squares were 3.3 by 3.3cm. using the scale 1:30 000. Thus each square represented one square kilometre. The tracing paper was then superimposed on a print lay down of the aerial photographs for 1980. Covering the study area. The grid was numbered in the usual two digit system of co-ordinates. A table of random numbers was used to obtain pairs of co-ordinates. Each pair of co-ordinates was located on the grid to identify the south-west corner of each quadrat. A random method for picking sites for quandrats was used because this method gave each site an equal chance of being selected as a possible location for a quadrat. The method has no human element of bias. Thus the selection of one site does not affect the chance of selecting the other sites.

Topographical map sheets No.1530 A1 and parts of A2 and A3 drawn by the Survey Department, Lusaka, at a scale 1:50 000 were used as base maps. All the relevant co-ordinate points were marked on the aerial photographs with chinagraph pencil. These points were later transferred to the base map. The end result was a map showing the distribution of the south-west corner of quadrats. Land devoted to cultivation was easily identified from aerial photographs through the study of shape, texture, pattern and tone of photographic images. Attempts were also made to distinguish areas in fallow. These areas could not easily be mistaken for crops because both sets of photographs were taken in August when there were no crops in the fields. To ensure that the areas had been under fallow or cultivation for at least three years, aerial Photographs on a scale 1:30 000 for the year 1977 were used to cross-check the areas selected from the 1980 photographs. For any area to be included in the sample, it had to have the same land use on both the 1977 and 1980 sets of photographs. The method did however present some problems in that certain details could not readily be obtained from aerial photographs due to the small photograph scale of 1:30 000. Areas where activities such as fuelwood collection, timber exploitation for building and grazing and browsing were taking place or had stopped could not be identified in the laboratory. Thus such areas were identified and selected in the field.

<u>Quadrat demarcation and measurement</u>

The 40 quadrats were demarcated in the field using wooden pegs of about 0.5 metres high. The measurements were made with the aid of measuring tape. Costing (1956) noted that coniferous forest vegetation has often been done satisfactorily by the 10 x 10 metres quadrats but due to the density of species on the savanna, it was felt that much larger quadrats were necessary. Thus quadrats of 30 x 30 metres were considered large enough for a successful study of the savanna woods. Within each selected quadrat the woody vegetation was examined in terms of species composition, the number of individuals of each species in different size groups and the structural damage to each individual as a result of the identified major human activities. These parameters were selected as useful indicators of vegetation change and the impact of human activity.

Household studies

Measures were taken to establish quantitatively the impact of each activity on woody vegetation in order to supplement the information obtained from quadrats. To achieve this, households were selected for questioning about various aspects of wood use. A stratified random method of sampling using household size as the strata was adopted in choosing households. Household size was important in this exercise because most human activities depends on household size. For example, fuelwood consumption depend on household size. The smaller the household, the less the consumption and vice versa. A stratified random selection method was adopted in order to eliminate the human element of bias and so that all categories of a population under consideration were fairly represented in the sample. 30 households were selected for the investigation. The figure 30 was chosen because it seemed manageable considering the limited time which was allocated to field work and was considered large enough for such a study. The classes for household size which were selected were:-

(i) Large household - above 10 persons

(ii) Medium household - 6-10 persons

(iii) Small household - below 6 persons

The above listed classes were based on field reconnaissance and discussions with the inhabitants which showed the household size ranging from two to 15 persons. Thus 10 households were selected from each category ensuring that each group was fairly represented in the sample. Households were selected at random. Firstly, the names of all the villages in the study area were obtained and written on small pieces of paper. The villages were arranged according to the three sub-regions described in chapter one. Each sub-region had a box and the papers were put into the boxes. Then using a random method, two papers were picked from each box and these were the villages from which the households were to be selected.

The respective headmen and village party officials were visited and names and sizes of households in the six selected villages were obtained then arranged into three classes of household size. The papers with the names and household sizes were then placed into three respective boxes. Ten papers were picked randomly from each box and these were the households to be questioned on various aspects of wood use. The range of information which was collected from the household heads is shown in appendix B1. This information was supplemented by information collected through the methods described below. The information listed in appendix B1 was collected from the household heads through questioning, discussions, observations and measurements where possible.

Firewood Consumption

Measures were taken to quantify as accurately as possible the quantity of wood consumed over a period of one week by a sample of 30 households. For this exercise bundles of firewood collected by the households were initially weighed and then every morning subsequently for a period of one week. Any additions to the bundle were not allowed and when the bundle was almost used up, then a weighed quantity was added to the pile. The result was recorded in a table on a daily basis. A number of head-loads of firewood were also weighed and the average weight of a headload found.

Charcoal production

Since most of the charcoal produced in the study area is for sale, measures were taken in which the study area was patrolled. All persons who were seen cutting wood for charcoal production purposes were interviewed. The interview and discussions were all centred on aspects of charcoal production. The aim was to find out the quantity of charcoal produced each year. In addition to this, a number of charcoal bags were also weighed in order to establish the average weight of a bag of charcoal.

Size of cultivated areas

Fields of the 30 households were measured in order to establish quantitatively their sizes. Paced distances were used. These were later converted to metres before the actual field sizes were calculated in square metres then hectares. Attempts were also made to examine the system of agriculture used.

Quantity of timber exploited for building

The houses of the 30 households were examined closely with a view to establishing the nature of the structural material which was used for building. The quantity of wood used was then estimated in terms of poles used, size of poles and average weight. The result was later related to the total number of huts in the villages which used wood as their structural material.

Comparison of the present impacts on vegetation

Attempts were made to compare the present impacts on woody vegetation resulting from each identified activity. In order to achieve this objective, species composition, the number of individuals in different size groups and the structural damage to individual plants were compared between quadrats to ascertain the major cause of woodland change in the study area.

Changes in woodland area

Measures were taken to determine whether the area of woodland was changing as a result of the varied human activities. The 1963 and 1980 aerial photographs were used for the exercise. Ground work was only conducted where necessary in order to ascertain or check certain features which were not clear on aerial photographs. The extent of woodland according to density classes was mapped for the two dates. The density of woodland was determined using a standard transparent Density Scale for estimating the percentage of woody cover. The density classed used were:-

(a) Less than 6% woody density cover

(b) 6-25% woody density cover

(c) 26-50% woody density cover

(d) 51-75% woody density cover

(e) over 75% woody density cover

The selection of these classes was based on the study of vegetation density of the study area from the aerial photographs. A comparison was then made of the extent and density of woody vegetation cover at the two dates to determine the changes that have occurred. The result was then related to population size.

APPENDIX A3

VILLAGE POPULATION DATA

	VILLAGE	POPULATION 1963	POPULATION 1969	POPULATION 1980
1	MBURUMA	140	144	487
2	NYANGOMBE	57	-	-
3	FELEMANGA	132	45	77
4	CHISOWE	170	212	255
5	NYAMUMBA	52	37	71
6	LUWINGA	75	19	112
7	CHUZU	111	135	239
8	MPINGA	57	8	45
9	MANYANSA	98	-	-
10	NDLAKAZI	64	53	111
11	MWAVI	246	190	321
12	KALINKUBULA	164	211	326
13	ZALAPANGO	213	181	123
14	CHIKUMA	161	164	214
15	CHIKUWAMBA	26	77	113
16	SIMAKANDA	31	37	46
17	A. NGOZI	45	-	-
18	CHIWERA	183	231	219
19	MPONA	203	171	156
20	BALAKASAU	63	46	95
21	SIPOPA	186	260	358
22	CHIKOKOLA	60	26	33
23	MULAMBA	62	39	51
24	MKANDO	49	49	75
25	MALENGA	40	-	-
26	KANAVENTI	56	43	109
27	KASINSA	327	137	301
28	KATONDWE	84	162	236
29	FELEMANGA MWANZA	100	-	-
30	KAETANO	20	-	-
31	CHILIMANGA	108	88	134
32	DIMBO	24	-	-
33	MPINGO	100	82	135
34	BORGIA	83	49	83
35	KACHUNDA	65	-	121
36	SHONKOMOKA	63	50	137
37	MPOTA	100	57	-
38	CHILUKUSHA	290	239	427
39	CHISAMBE	32	-	-
40	CHIULI	52	-	-
41	CHANULE	158	-	-

42	CHINYAMAWI	25	-	-
43	KAOMBO	40	-	-
44	N. CHAUTA	16	-	-
45	THAULO	15	-	-
46	KANJELE	74	-	-
47	MUNSELE	60	-	-
48	MANGALENGALE	147	80	127
49	LUVELA P.	13	-	-
50	KAUNGA	45	24	43
51	MEMBE	90	85	182
52	MWALILIA SCHOOL	-	8	-
53	CHITOPE	140	78	143
54	MLANGA/MPHEMPHA	5	-	-
55	MATUKUTUKU	-	10	36
56	MUNDELA	-	60	121
57	ELESANI	-	23	48
58	PAUL	-	7	-
59	JOHN	-	31	-
60	MACHIKICHOLI	-	7	-
61	RICE	-	5	-
62	CHIOLYA	-	17	-
63	MANYENDA	-	130	143
64	KAPEZA	-	6	16
65	CHIMUNA	-	51	-
66	CHITOBA	-	35	51
67	KAPWAPWA	-	168	213
68	GALA/BATALA	-	29	48
69	NYAMANKALO	-	12	57
70	MTABWA	-	-	97
71	CHINKWO	-	-	104
	TOTAL	5020	4108	6639

NOTE

It is worth noting that population figures for the 1963 and 1969 censuses for the study area were not directly given in the reports. Since the village populations were given, I extracted the villages in the study area with their respective populations. As for 1980, the figures were collected from the Chief's record books, headmen and Unip Party Officials. The 'no entry' on the table above does not signify a lack of data but reflects the fact that a number of villages have been established in the area between 1963 and 1980. Others have merged whereas others are no longer in existence or have moved out of the study area.

APPENDIX B

HOUSEHOLD RESULT SHEETS

APPENDIX B1

Range of data obtained from the households

(a) Household information

(i) Name of the head of the household

(ii) Number of individuals in the household

(iii) Ages of individuals in the household

(iv) Length of time in residence at village

(v) Major occupation of the head of household

(b) Cultivated land information

(i) Methods of cultivation employed

(ii) Methods of land clearing

(iii) Approximate size of cultivated land

(iv) Kinds of tools used in cultivation

(v) Frequency of land clearing for cultivation

(vi) Rate of field abandonment

(c) Livestock information

(i) Kinds of animals reared

(ii) Number of each animal type per household

(iii) Animal feeding habits during the year

(iv) Grazing and browsing sites available

(v) Grazing and browsing land variations in the year

(d) Fuelwood information

(i) Types of fuelwood used

(ii) Quantity used/day/week/month/year

(iii) Frequency of fuelwood collection

(iv) Alternative sources of fuel

(v) Variations in wood use during the year

(vi) Preferred species for fuelwood

(vii) Avoided species for fuelwood

(e) Building timber information

(i) Uses of timber in building

(ii) Kinds of wood used in building

(iii) Quantity of wood used for each construction

(iv) Frequency of putting up structures

(v) Sources of building timber

(vi) Preferred species

(vii) Avoided species

APPENDIX B2

BUSH BURNING INFORMATION

HOUSEHOLD	AGENT THAT START FIRE	REASONS FOR STARTING FIRE	FREQUENCY OF FIRE	KIND OF FIRE
1	Man and Lightning	Land clearing, Mice and honey hunting	Every dry season	Surface
2.	"	"	"	"
3	"	"	"	"
4	"	"	"	"
5	"	"	"	"
6	Man, lightning, friction on trees	"	"	"
7	Man and others	"	"	"
8	"	"	"	"
9	Man and lightning	"	"	"
10	"	"	"	"
11	"	"	"	"
12	"	"	"	"
13	"	"	"	"
14	Man and others	"	"	"
15	"	"	"	"
16	"	"	"	"
17	Man and lightning	"	"	"
18	Man and friction on trees	"	"	"
19	Man and others	"	"	"
20	"	"	"	"
21	"	"	"	"
22	Man and lightning	"	"	"

23	Man and lightning	Land clearing, Rice and honey hunting	Every dry season	Surface
24	"	"	"	"
25	"	"	"	"
26	Man and others	"	"	"
27	"	"	"	"
28	Man and lightning	"	"	"
29	"	"	"	"
30	"	"	"	"

APPENDIX B3

CULTIVATED LAND INFORMATION

HOUSEHOLD	FIELD SIZE (HECTARES)	TYPE OF AGRIC. SYSTEM	METHODS OF LAND CLEARING	TOOLS USED	RATE OF FIELD ABANDONMENT (YEARS)
1	0.62	Shifting	Slash and burn	axe and hoe	5
2	0.80	"	"	"	4
3	0.56	"	"	"	4
4	1.36	"	"	"	5
5	2.68	"	"	"	4
6	1.46	"	"	"	3
7	8.21	Sedentary	Clear cutting of trees	axe, hoe & ox-drawn plough	Permanent
8	2.94	Shifting	Slash and burn	axe and hoe	4
9	4.42	Shifting & Sedentary	Clear cutting + slash & burn	axe, hoe & ox-drawn plough	4
10	10.88	Sedentary	Clear cutting of trees	"	Permanent
11	3.26	Shifting	Slash and burn	axe and hoe	5
12	1.58	"	"	"	3
13	1.86	"	"	"	5
14	5.28	Shifting & Sedentary	Clear cutting & slash & burn	"	4
15	2.63	Shifting	Slash and burn	"	4
16	4.50	Shifting & Sedentary	Slash & burn and clear cutting	"	3
17	1.68	Shifting	Slash and burn	"	3

18	5.52	Shifting & Sedentary	Slash and burn & clear cutting	axe, hoe, ox-drawn ploughs	6
19	1.98	Shifting	Slash and burning	axe and hoe	5
20	10.80	Sedentary	Complete removal of trees	axe, hoe, tractor & ox-drawn ploughs	Permanent
21	2.18	Shifting	Slash and burn	axe and hoe	4
22	2.18	"	"	"	3
23	2.36	"	"	"	4
24	3.48	"	"	"	4
25	5.40	Shifting & Sedentary	Slash & burn clear cutting	axe, hoe & ox-drawn plough	5
26	12.60	Sedentary	Complete removal of trees	axe, hoe, ox-drawn plough & tractors	Permanent
27	3.24	Shifting	Slash and burn	axe and hoe	3
28	4.50	"	Slash and burn & clear cutting	"	4
29	2.70	"	Slash and burn	"	5
30	3.10	"	"	"	5
TOTAL	114.76	-	-	-	-
MEAN	0.45	-	-	-	3.6

APPENDIX B4

DOMESTIC ANIMAL RECORD SHEET

HOUSEHOLDS	ANIMALS REARED			
	GOATS	CATTLE	PIGS	SHEEP
1	12	-	4	-
2	8	-	-	-
3	24	-	10	-
4	24	-	-	-
5	30	-	-	-
6	14	-	2	4
7	15	-	18	-
8	19	-	4	-
9	32	6	12	-
10	42	13	9	-
11	18	-	3	-
12	17	4	6	-
13	27	-	-	-
14	37	3	13	-
15	19	-	-	5
16	26	3	-	-
17	36	-	4	-
18	27	5	-	-
19	21	-	-	-
20	15	6	2	-
21	11	-	5	-
22	17	3	6	5
23	32	5	14	-
24	15	-	-	-
25	33	4	-	-
26	21	2	3	-
27	17	-	7	-
28	21	3	15	-
29	13	-	5	-
30	19	5	-	-
TOTAL	672	52	141	14

APPENDIX B5

FUELWOOD INFORMATION

TYPE OF FUELWOOD	FREQUENCY OF FUELWOOD COLLECTION Trips/wk		LIGHTING	ALTERNATIV SOURCES OF FU
	DRY SEASON	WET SEASON		
Firewood	3	1	Candle	None
"	3	1	Candle	"
"	3	1	Candle	"
"	3	2	Candle	Charcoal
"	3	1	Candle	None
"	3	2	Paraffin	"
'irewood and charcoal	2	1	Paraffin	"
'irewood	4	2	Candle	"
"	2	2	Candle	"
'irewood and charcoal	2	3	Paraffin	"
irewood	4	1	Candle	"
"	3	2	Candle	"
"	2	1	Candle	"
irewood and charcoal	3	1	Paraffin	"
irewood	2	2	Paraffin	"
"	4	1	Candle	"
"	3	1	Candle	"
irewood and charcoal	2	2	Paraffin	"
irewood	4	1	Candle	"
irewood and charcoal	3	1	Paraffin	"
irewood	2	2	Candle	"
"	3	1	Candle	"
"	3	2	Candle	"
"	3	1	Candle	"
irewood and charcoal	2	2	Paraffin	"
"	4	1	Candle	"
irewood	3	1	Candle	"
irewood and charcoal	4	1	Paraffin	"
irewood	2	2	Candle	"
"	3	2	Candle	"

APPENDIX B6

FIREWOOD CONSUMPTION

OUSEHOLDS	NO. OF PERSONS PER HOUSEHOLD	FIREWOOD WEIGHT (kg) FIRST DAY	SEVENTH DAY	TOTAL CONSUMPTI PER WEEK/HOUSEH (kg)
1	4	51	3	48
2	2	45	9	36
3	3	39	2	37
4	2	33	0	33
5	3	38	0.5	37.5
6	5	48	1	47
7	5	59	3	56
8	4	82	12	60
9	3	33	0	33
10	4	47	1	46
11	6	90	16.8	73.2
12	10	86	3.1	82.9
13	9	77	13.3	63.7
14	9	85	0.7	84.3
15	7	79	0	79
16	10	83	3	80
17	8	82.5	7.5	75
18	8	99.7	7.3	92.4
19	7	71.0	1	70
20	8	94.3	7.8	86.5
21	13	121.2	18.0	103.2
22	12	96.7	6.7	90
23	11	109.1	9.1	100
24	12	85.3	8.2	77.1
25	14	112.3	2.4	109.9
26	13	136.0	16	120
27	12	99.8	2.6	97.2
28	11	103.0	9.5	93.5
29	14	111.1	11.0	100.1
30	15	137.2	3.5	133.7
otal	254	2434.2	178.5	2255.7
ean	8.5	-	-	8.9

APPENDIX C

CALCULATION OF TOTAL CLEARED AREAS AS A RESULT OF VARIOUS HUMAN ACTIVITIES.

APPENDIX C1

Estimated total cleared area for cultivation

Since it was not possible to measure all the cultivated fields in the study area due to time limitations, measures were taken to estimate the total area cleared for cultivation purposes by measuring fields belonging to 30 households who were selected using a stratified random method of sampling. The result showed that the 30 households cleared a total area of about 114.76 hectares every 3.6 years on the average. Thus each individual in the 30 households representing a population of 254 persons was entitled to 0.45 hectares every 3.6 years. Thus a population of 6639 will clear 6639 x 0.45 hectares every 3.6 years. This is equivalent to an annual clearance of 6639 x 0.45 ÷ 3.6 per year. This figure is then divided by 100 in order to convert the hectares to square kilometres.

$$\frac{6639 \times 0.45}{3.6 \times 100} \text{ km}^2$$

$$= \frac{2987.55}{360} \text{ km}^2$$

$$= 8.29875 \text{ km}^2$$

$$= \underline{8.30 \text{ km}^2}$$

APPENDIX C2

Estimate for firewood cut and corresponding clear-felled area

It is indicated in the text, that all households in the study area use firewood for heating and cooking purposes. The amount of firewood used by each household could be estimated only within the broad limits without considering the factors which determine the amount required and the variations in wood use during the course of the year. 30 households were used in this exercise. It was established from the exercise that the 30 households representing a total population of 254 persons burned 2 255.7 kg. of dry weight wood each week. Thus each individual burned about 8.9 kg. of wood per week. Thus a population of 6639 will burn a total of about 8.9 x 52 x 6639 kg. per year. Using values from Mihalyi (1972) and Chidumayo (1979). 8.9 x 52 x 6639 kg. will correspond to:-

$$\frac{8.9 \times 52 \times 6639}{1000 \times 1 \times 50 \times 100} \text{ km}^2$$

Note: 52 used to convert weekly to annual use.

1000 converting kilograms to tonnes

1 converting tonnes to cords

50 converting cords to hectares

100 converting hectares to square kilometres

$$= \frac{2971201.4}{5\ 000\ 000} \text{ km}^2$$

$$= \underline{0.594 \text{ km}^2}$$

$$= \underline{0.59 \text{ km}^2}$$

APPENDIX C3

<u>Estimate for wood cut for charcoal production and corresponding clear-felled area</u>

It was very difficult to establish the quantity of charcoal consumed in the study area because it would have involved visiting all the households since most of the households do not use charcoal for either heating or cooking purposes. Most of the charcoal produced is sold to institutions outside the study area. Thus measures were taken to establish the total amount of charcoal produced. The exercise revealed that about 8 962 bags are produced each year. The average weight of each bag was about 43.5 kg. Thus the total weight of charcoal produced was 43.5kg x 8962 bags. Using values from Mihalyi (1972) and Chidumayo (1979) for estimating wood cut and corresponding clear-felled areas 43.5 x 8962 kg is equivalent to

$$\frac{43.5 \times 8962}{1000 \times 1\ 50 \times 100} \text{ km}^2$$

$$= \frac{389847}{5\ 000\ 000} \text{ km}^2$$

$$= 0.0779694 \text{ km}^2$$

$$= 0.078 \text{ km}^2$$

$$= \underline{0.08} \text{ km}^2$$

APPENDIX C4

<u>Estimate for wood cut for building purposes and the corresponding clear-felled area</u>

It is indicated in the text that the number of houses using polewood as the major structural material and the quantity of wood used for an average sized hut could be estimated only within the broad limits because the number of poles used is determined by the size of the hut and also the size of poles used. Since it was not possible to examine all the huts in the study area a sample based on 30 households was used to estimate the total number of huts in the study area and the quantity of wood used.

The household survey showed that there were on the average 4 hut per household using wood as the major structural material. The average sized hut was about 2.7 metres in diameter. It used about 400 poles of about 2 metres in height and between 5 and 25cm in diameter for the walls. 50 similar sized poles but slightly longer were required for the roof framework. Each dry pole on the average weighed about 4kg. It was also established that each hut is replaced after five years.

Using the above information and that obtained from the estimation of cultivated areas concerning population, the total number of poles used was estimated and later values from Mihalyi (1972) and Chidumayo (1979) were used to estimate the corresponding clear felled area as a result of timber exploitation for building purposes was approximately:

$$\frac{4 \times 450 \times 781.1 \times 4}{1000 \times 1 \times 50 \times 100 \times 5} \ km^2$$

NOTE

In the numerator

4 = average number of huts/household

450 = average number of poles/household

781.1 = total number of households

4 = average weight of each pole

In the denominator:

the values are as for firewood except for the 5 which is the rate of hut replacement.

$$= \frac{5623920}{25\ 000\ 000} \ km^2$$

$$= 0.2249568 \ km^2$$

$$= \underline{\underline{0.23 \ km^2}}$$

APPENDIX D

QUADRAT RESULT SHEETS

APPENDIX D1

AREA III - BURNING IS THE ONLY ACTIVITY KNOWN TO HAVE TAKEN PLACE

NO.	SPECIES COMPOSITION	NO. OF INDIVIDUALS OF EACH SPECIES IN DIFFERENT SIZE						STRUCTURAL DAMAGE TO EACH SPECIES
		> 20m	10-20	4-9	1-3	< 1m	TOTAL	
	CANOPY							
1.	Adansonia digitata	7	4	-	2	3	16	Fire scars
2.	Colophospermum mopane	37	21	17	13	19	107	Fire scars, branches felled by elephants
3.	Hyphaene ventricosa	9	5	2	3	27	46	Fire scars, cut leaves
4.	Acacia nigrescens	26	14	3	21	23	87	Fire scars, damaged leaves
5.	Lannea stuhlmannii	5	2	-	2	3	12	"
6.	Sclerocarya Caffra	-	5	7	11	13	36	"
7.	Combretum imberbe	8	3	2	9	11	33	Fire scars
8.	Kirkia acuminata	4	3	5	-	-	12	Damaged leaves broken branches
9.	Afzelia quanzensis	29	31	23	15	36	134	"
10.	Albizia harveyi	-	4	2	3	1	10	"
11.	Lococarpus capassa	-	5	1	1	4	11	"
12.	Pteroscarpus antunesii	-	3	9	13	21	46	Broken branches
	UNDERSTOREY							
13.	Dalbergiella nyasae	-	27	21	36	15	102	Dug roots, removed bark
14.	Lannea discolor	-	33	22	31	33	119	Broken branches
15.	Albizia anthelmintica	-	41	23	17	41	122	Fire scars
16.	Balanites aegyptiaca	-	-	21	23	19	63	Burnt bark

17.	Combretum celastroides	-	-	32	21	28	81	Burnt bark
18.	Acacia nilotica	-	-	8	15	23	46	Fire scars
19.	Cronton gratissimus	-	-	3	19	31	53	"
	SHRUBS							
20.	Dichrostachys cinerea	-	-	21	17	36	74	Stem lesions, burnt tips
21.	Boscia matabelensis	-	-	17	29	35	81	Fire scars
22.	Popowia obovata	-	-	9	18	43	70	"
23.	Abution angulatum	-	-	-	15	31	46	"
24.	Ximenia caffra	-	-	12	25	22	59	Stem lesions, fire scars
25.	Xeromphis obovata	-	-	-	7	3	10	"

APPENDIX D2

AREA I - CULTIVATION IS DOMINANT

NO.	SPECIES COMPOSITION	NO. OF INDIVIDUALS OF EACH SPECIES IN DIFFERENT SIZE GROUPS						STRUCTURAL DAMAGE TO EACH SPECIES
		> 20m	10-20m	4-9m	1-3m	< 1m	TOTAL	
	CANOPY							
1.	Adansonia digitata	4	-	-	-	-	4	Part of bark removed
2.	Hyphaene ventricosa	1	3	-	-	-	4	Fire scars, cut leaves
3.	Albizia harveyi	-	1	-	-	-	1	Cut branches, Fire scars
4.	Combretum imberbe	1	-	-	-	-	1	Cut branches, ring bark
5.	Colophospermum mopane	1	-	-	-	-	1	"
6.	Kirkia acuminata	1	-	-	-	-	1	"
7.	Lannea stuhlmannii	-	1	-	-	-	1	Fire scars, cut branches

Note There were a total of 211 stumps in the five quadrats. These could not readily be identified at species level because they were not growing at the time of research.

15.	Dichrostachys cinerea	-	-	-	23	3	26	Visible signs of regrowth
16.	Flacourtia inclica	-	-	-	2	1	3	"
17.	Triumgetta annua	-	-	-	-	7	7	"

<u>Note</u> It was not possible to count climbers.

APPENDIX D4

AREA I - GRAZING AND BROWSING IS DOMINANT

NO.	SPECIES COMPOSITION	NO. OF INDIVIDUALS OF EACH SPECIES IN DIFFERENT SIZE GROUPS						STRUCTURAL DAMAGE TO EACH SPECIES
		>20m	10-20m	4-9m	1-3m	<1m	TOTAL	
	CANOPY							
1.	Adansonia digitata	4	2	-	-	-	6	Fire scars
2.	Colophospermum mopane	9	5	-	13	21	58	Damaged leaves
3.	Hyphaena venticosa	4	3	-	11	25	43	Cut leaves
4.	Afzelia quanzensis	-	7	5	9	13	34	Broken branches, damaged leaves
5.	Scleroscarya caffra	-	-	3	1	2	6	"
6.	Combretum imberbe	-	2	-	-	-	2	NONE
7.	Acacia nigrescens	-	4	7	15	6	32	Broken branches, damaged leaves
	UNDERSTOREY							
8.	Balanites aegyptiaca	-	8	2	-	-	10	Damaged leaves, burnt branches
9.	Dalbergiella nyasae	-	7	12	19	27	65	Damaged leaves
10.	Lannea discolor	-	-	3	9	15	27	Fire scars
11.	Acacia nilotica	-	-	2	17	23	42	Damaged leaves, broken branches
	SHRUBS							
12.	Abutilon angulatum	-	-	1	14	31	46	Broken branches
13.	Triumgetta annua	-	-	-	18	39	57	Fire scars
14.	Achyranthes aspera	-	-	3	9	15	27	"

15.	Popowia obovata	-	-	-	3	13	16	Broken branches
16.	Ximenia americana	-	-	-	8	17	25	Damaged leaves
17.	Flacourtia indica	-	-	-	2	11	13	Eaten up leaves
18.	Cadaba kirkii	-	-	2	17	23	42	NONE

APPENDIX D5

AREA I - FIREWOOD COLLECTION IS DOMINANT

NO.	SPECIES COMPOSITION	NO OF INDIVIDUALS OF EACH SPECIES IN DIFFERENT SIZE GROUPS						STRUCTURAL DAMAGE TO EACH SPECIES
		>20m	10-20m	4-9m	1-3m	<1m	TOTAL	
	CANOPY							
1.	Adansonia digitata	3	1	-	2	-	6	Fire scars, cut branches
2.	Hyphaene ventricosa	-	5	2	11	2	20	Cut leaves
3.	Lannea stuhlmannii	1	2	6	9	11	29	Cut branches, removed bark
4.	Acacia nigrescens	-	-	3	19	23	45	Fire scars
5.	Afzelia quanzensis	-	-	7	13	27	47	Fire scars, cut branches
6.	Colphospermum mopane	9	2	9	18	25	63	Cut branches
7.	Combretum imberbe	2	1	-	-	-	3	Fire scars
8.	Pterocarpus antunesii	-	-	4	16	31	51	Damaged branches
9.	Sclerocarya caffra	-	2	-	3	14	19	Cut branches
10.	Kirkia acuminata	-	-	-	-	5	5	NONE
	UNDERSTOREY							
11.	Acacia nilotica	-	-	-	4	9	13	Cut branches
12.	Balanites aegypiaca	-	-	-	18	36	54	"
13.	Lannea discolor	-	-	3	12	15	30	Fire scars
14.	Diospyros Kirkii	-	3	14	17	2	36	"
15.	Combretum celastroides	-	-	2	5	11	18	"
16.	Dalbergiella nyasae	-	-	4	2	1	7	Cut branches, burnt bark

SHRUBS

17.	Flacourtia indica	-	-	-	-	3	3	Fire scars, cut branches
18.	Boscia matabelensis	-	-	-	16	24	40	Damaged leaves
19.	Dichrostachys cinerea	-	-	4	3	6	13	"
20.	Ximenia americana	-	-	3	7	16	26	"
21.	Cadaba kirkii	-	-	-	9	3	12	Fire scars
22.	Achyranthes aspera	-	-	-	-	4	4	Removed bark

APPENDIX D6

AREA I - CHARCOAL PRODUCTION IS DOMINANT

NO.	SPECIES COMPOSITION	NO. OF INDIVIDUALS OF EACH SPECIES IN DIFFERENT SIZE GROUPS						STRUCTURAL DAMAGE TO EACH SPECIES
		>20m	10-20m	4-9m	1-3m	<1m	TOTAL	
	CANOPY							
1.	Agzelia quanzensis	-	-	-	2	19	21	Cut stem, fire scars
2.	Acacia nigrescens	-	-	-	1	14	15	Fire scars
3.	Colophospermum mopane	-	-	-	-	23	23	Removed leaves
4.	Kirkia acuminata	-	-	-	-	4	4	NONE
5.	Pterocarpus antunesii	-	-	-	3	16	19	Removed leaves
6.	Sclerocarya caffra	-	-	-	-	19	19	"
7.	Lochocarpus capassa	-	-	-	-	22	22	"
8.	Combretum imberbe	-	-	-	-	9	9	"
	UNDERSTOREY							
9.	Balanites aegyptiaca	-	-	-	-	13	13	Removed leaves, cut stem
10.	Acacia nilitica	-	-	-	-	3	3	"
11.	Combretum celastroides	-	-	-	-	7	7	"
12.	Lannea discolor	-	-	-	-	15	15	"
	SHRUBS							
13.	Cadaba kirkii	-	-	-	-	4	4	Removed leaves
14.	Ximenia americana	-	-	-	-	2	2	Fire scars
15.	Flacortia indica	-	-	-	-	13	13	"
16.	Boscia matabelensis	-	-	-	-	21	21	"
17.	Triumfetta annua	-	-	-	-	7	7	Fire scars, removed leaves
18.	Dichrostachys cinerea	-	-	-	-	3	3	" "

APPENDIX D7

AREA II - ABANDONED CHARCOAL BURNING SITES

NO.	SPECIES COMPOSITION	NO. OF INDIVIDUALS OF EACH SPECIES IN DIFFERENT SIZE GROUPS					TOTAL	REGROWTH
		> 20m	10-20m	4-9m	1-3m	< 1m		
	CANOPY							
1.	Colophospermum mopane	-	-	-	42	36	75	Visible signs of regrowth
2.	Combretum imberbe	-	-	-	3	7	10	"
3.	Agzelia quanzensis	-	-	-	-	27	27	"
4.	Lonchocarpus capassa	-	-	4	9	16	29	"
5.	Lannea stuhlmanii	-	--	3	5	13	21	"
6.	Kirkia acuminata	-	-	1	3	12	16	"
	UNDERSTOREY							
7.	Balanites aegyptiaca	-	-	33	17	19	39	Regrowth taking place
8.	Combretum celastroides	-	-	2	14	39	55	"
9.	Lannea discolor	-	-	-	11	15	26	NONE
	SHRUBS							
10.	Cadaba kirkii	-	-	-	3	9	12	Regrowth taking place
11.	Achyrathes aspera	-	-	-	23	17	40	"
12.	Triumfetta annua	-	-	-	14	23	37	"
13.	Ximenia americana	-	-	-	12	11	23	"
14.	Flacourtia indica	-	-	-	2	5	7	"
15.	Dichrostachys cinerea	-	-	-	5	13	18	"

APPENDIX D8

AREA I - WOOD EXPLOITATION FOR BUILDING IS DOMINANT

NO.	SPECIES COMPOSITION	NO. OF INDIVIDUALS OF EACH SPECIES IN DIFFERENT SIZE GROUPS					TOTAL	STRUCTURAL DAMAGE TO EACH SPECIES
		> 20m	10-20m	4-9m	1-3m	<1m		
	CANOPY							
1.	Acacia nigrescens	10	7	3	5	12	37	Fire scars, cut branches
2.	Adansonia digitata	3	7	-	-	-	10	Removed bark, cut branches
3.	Agzelia quanzensis	5	2	3	7	14	31	Cut branches, fire scars
4.	Colophospermum mopane	13	4	3	2	7	29	" "
5.	Combretum imberbe	2	6	4	2	1	15	Fire scars, removed bark
6.	Hyphaene ventricosa	-	11	-	16	19	46	Cut leaves
7.	Kirkia acuminata	3	1	1	4	2	11	Cut branches, fire scars
8.	Lannea stuhlmannii	-	7	4	3	3	17	" "
9.	Lochocarpus capassa	-	6	12	5	18	41	" "
10.	Pterocarpus antunesii	-	9	5	17	23	54	" "
11.	Sclerocarya caffra	-	5	11	13	31	60	" "
	UNDERSTOREY							
12.	Balanites aegyptiaca	-	-	6	2	9	17	Cut branches
13.	Combretum celastroides	-	-	4	2	1	7	Damaged leaves
14.	Dalbergiella nyasae	-	3	1	1	7	12	Fire scars, cut branches
15.	Lannea discolor	-	6	9	12	19	46	Fire scars
16.	Erythrina abyssinica	-	-	-	13	15	28	Dug roots, fire scars
17.	Albizia anthelmintica	-	3	-	9	6	18	Cut branches
18.	Acacia nilotica	-	-	5	3	4	12	"

SHRUBS

19.	Triumfetta annua	-	-	-	16	33	49	Cut stem
20.	Achyranthes aspera	-	-	-	3	7	10	Damaged leaves
21.	Flacourtia indica	-	-	-	2	5	7	Cut stem, fire scars
22.	Boscia matebelensis	-	-	-	8	9	17	" "
23.	Dichrostachys cinerea	-	-	-	5	3	8	" "
24.	Popowia obovata	-	-	-	2	14	16	" "
25.	Ximenia americana	-	-	-	7	19	26	NONE

APPENDIX D9

COMPARISON OF SPECIES COMPOSITION IN FIVE AREAS AFFECTED BY FIVE DIFFERENT ACTIVITIES

SPECIES	BUSH BURNING	CULTIVATION	FUELWOOD COLLECTION		GRAZING & BROWSING	TIMBER EXPLOITATION FOR BUILDING
			FIREWOOD	CHARCOAL		
CANOPY						
Adansonia digitata	16	4	6	-	6	10
Acacia nigrescens	87		45	15	32	37
Agzelia quanzensis	134		47	21	34	31
Albizia harveyi	10	1	-	-	-	-
Colophospermum mopane	107	1	63	23	48	29
Combretum imberbe	33	1	3	9	2	15
Hyphaene ventricosa	46	4	20	-	43	46
Kirkia acuminata	12	1	5	4	-	11
Lannea stuhlmannii	12	1	29	-	-	17
Lonchocarpus capassa	11		-	22	-	41
Pterocarpus antunessii	46		51	19	-	54
Sclerocarya caffra	36		19	19	6	66
UNDERSTOREY						
Albizia anthelmintica	122		-	-	-	18
Acacia nilotica	46		13	3	42	12
Balanites aegyptiaca	63		54	13	10	17
Combretum celastroides	81		18	7	-	7
Dalbergiella nyasae	102		7	-	65	12

Cronton gratissimus	53		-	-	-	-
Diospyros kirkii	-		36	-	-	-
Lannea discolor	119		30	15	27	46
Erythrina abyssinica	-		-		-	28
SHRUBS						
Abutilon angulatum	46		-	-	46	-
Adenium obesum	14	-	-	-	-	-
Achyranthes aspera	12		4	-	27	10
Boscia matabelensis	81		40	21	-	17
Cadaba kirkii	28		12	4	42	-
Dichrostachys anerea	74		13	3	-	8
Flacourtia Indica	31		3	13	13	7
Popowia obovata	70		-	-	16	16
Triumfetta annua	18		-	7	57	49
Ximenia caffra	59		-	-	-	-
Ximenia americana	31		26	2	25	26
Xeromphis obovata	10		-	-	-	-
Total No. of Individuals	1610	13	544	220	541	624
Total No. of Species	31	7	22	18	18	25

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